



DRAFT



Low-emissions economy

Draft report

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April 2018

The New Zealand Productivity Commission

Te Kōmihana Whai Hua o Aotearoa¹

How to cite this document: New Zealand Productivity Commission. (2018). Low-emissions economy: Draft report. Available from www.productivity.govt.nz/inquiry-content/low-emissions-draft-report

Date: April 2018

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Disclosure

The Chair of the Productivity Commission, Murray Sherwin, has a financial interest in the forest sector via part ownership of a forestry block.

ISBN: 978-1-98-851916-6 (print)

ISBN: 978-1-98-851917-3 (online)

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NZ Productivity Commission

¹ The Commission that pursues abundance for New Zealand.

Terms of reference

NEW ZEALAND PRODUCTIVITY COMMISSION INQUIRY INTO THE OPPORTUNITIES AND CHALLENGES OF A TRANSITION TO A LOWER NET EMISSIONS ECONOMY FOR NEW ZEALAND

Issued by the Minister for Climate Change Issues, the Minister of Finance, and the Minister for Economic Development (the "referring Ministers"). Pursuant to sections 9 and 11 of the New Zealand Productivity Commission Act 2010, we hereby request that the New Zealand Productivity Commission ("the Commission") undertake an inquiry into how New Zealand can maximise the opportunities and minimise the risks of transitioning to a lower net-emissions economy.

Context

New Zealand is part of the international response to address the impacts of climate change and to limit the rise in global temperature, requiring a transition of the global economy to one consistent with a low carbon and climate resilient development pathway.

New Zealand has recently formalised its first Nationally Determined Contribution under the Paris Agreement to reduce its emissions by 30 percent below 2005 levels by 2030. The Paris Agreement envisages all countries taking progressively ambitious emissions reduction targets beyond 2030. Countries are invited to formulate and communicate long-term low emission development strategies before 2020. The Government has previously notified a target for a 50 per cent reduction in New Zealand greenhouse gas emissions from 1990 levels by 2050.

New Zealand's domestic response to climate change is, and will be in the future, fundamentally shaped by its position as a small, globally connected and trade-dependent country. New Zealand's response also needs to reflect such features as its high level of emissions from agriculture, its abundant forestry resources, and its largely decarbonised electricity sector, as well as any future demographic changes (including immigration).

The government is already taking action to support meeting the 2030 target. This includes reviewing the New Zealand Emissions Trading Scheme (NZ ETS), encouraging the up-take of electric vehicles and other energy efficiency technologies, and developing links with emerging international carbon markets. It has also founded the Global Research Alliance to fund research into emissions mitigation in pasture based livestock systems.

However in the long-term - 2030 and beyond - New Zealand will likely need to further reduce its domestic emissions in addition to the use of forestry offsets and international emissions reduction units, although these will continue to remain an important part of the country's climate change response for meeting targets at least cost.

This has the potential to influence the direction and shape of the New Zealand economy as the country seeks to balance the need to reduce domestic greenhouse gas emissions with preserving and enhancing economic wellbeing.

Taking action to transition to a low net emissions economy would involve a gradual change to the country's pattern of economic activity in order avoid a potentially costly and disruptive economic shift in the future. How such a change occurs, however, will not necessarily be linear.

Scope and aims

The purpose of this inquiry is identify options for how New Zealand could reduce its domestic greenhouse gas emissions through a transition towards a lower emissions future, while at the same time continuing to grow incomes and wellbeing.

Two broad questions should guide the inquiry:

What opportunities exist for the New Zealand economy to maximise the benefits and minimise the cost that a transition to a lower net-emissions economy offers, while continuing to grow incomes and wellbeing?

To answer this, the inquiry will need to examine New Zealand's current patterns of economic activity and the ways in which these are contributing to the country's greenhouse gas emissions.

It will then need to consider the different pathways along which the New Zealand economy could grow and develop so as to achieve New Zealand's emissions targets, as well as respond to the physical effects of a changing climate.

The inquiry will then need to analyse the respective opportunities and risks offered by these pathways, and identify which pathways offer the best outcomes in terms of both growing incomes and wellbeing and reducing domestic net-emissions.

This will require the Commission to consider how patterns of economy activity may need to change, including over what timeframe and at what cost, to achieve the potential benefits of these future pathways, and what strategies the government could use to maximise these benefits through regulatory systems, behavioural change, and economic incentives.

As part of analysing these pathways, the inquiry should also examine how they could affect broader economic objectives for increasing wellbeing and achieving higher living standards, including sustainability, economic growth (including productivity growth), increasing equity, social cohesion, and resilience to risk.

How could New Zealand's regulatory, technological, financial and institutional systems, processes and practices help realise the benefits and minimise the costs and risks of a transition to a lower net emissions economy?

The inquiry should examine the range of current and potential government interventions that could both support a transition to a lower net emissions economy and support growth of incomes and wellbeing.

In particular the inquiry should include the following:

- a. the role of the NZ ETS in supporting New Zealand to transition to a lower net emissions economy, building on the Ministry for the Environment's Stage II review
- b. the role of other market-led solutions, direct regulation (such as minimum fuel efficiency standards) and non-regulatory interventions (including aspirational targets) in a low net emissions transition
- c. how the science and innovation systems (including research and design) could better support the development of low emissions technologies, and whether there are any barriers (regulatory or otherwise) to the deployment and uptake of these technologies
- d. whether there are any barriers in New Zealand to undertaking domestic investment to reduce net emissions, and what the government could do to reduce or remove these barriers ((e.g. green bonds, public private partnerships, risk-sharing finance, climate-related disclosure requirements)
- e. how to encourage efficient land-use decisions that take into account the costs and benefits of greenhouse gas emissions and abatement (including how costs and benefits may be affected by applying carbon prices or other interventions to different activities) and concerns about international competitiveness
- f. how to maximise New Zealand's comparative advantages in a carbon constrained world, including the timeframes for any relative advantages from market premiums or market access risks.

Report and recommendations

The inquiry should explore New Zealand and international research and experience related to both the questions above. However, the focus should be on practical applications relevant to New Zealand's circumstances.

The inquiry should have a long-term focus, while being cognisant of New Zealand's 2030 and 2050 emissions reduction targets.

The final report should provide credible recommendations for how New Zealand should manage a transition to a lower net emissions economy, while still maintaining or improving incomes and wellbeing.

Exclusions

This inquiry should not focus on the suitability of New Zealand's current, or any future emissions reduction target. In addition, the inquiry should not focus on the veracity of anthropogenic climate change, and should only consider the implications of a changing climate to inform consideration of different economic pathways along which the New Zealand economy could grow and develop.

Consultation

Given that climate change is an economy wide-issue, the Commission should consult with a broad range of stakeholders including: central and local government, the Climate Change Iwi Leadership Group, relevant industry and NGO groups, scientific and academic bodies and the general public.

This inquiry is intended to complement and take account of existing policy work (particularly the Stage II review of the NZ ETS) and other current evidence gathering groups exploring issues related to climate change, including the Biological Emissions Reference Group, the Forestry Reference Group, and the GLOBE-NZ commissioned work by Vivid Economics.

Timeframes

The Commission should present a final report to referring Ministers by 30 June 2018.

HON PAULA BENNETT, MINISTER FOR CLIMATE CHANGE ISSUES

HON STEVEN JOYCE, MINISTER OF FINANCE

HON SIMON BRIDGES, MINISTER FOR ECONOMIC DEVELOPMENT

Office of Hon James Shaw

Minister for Climate Change
Minister of Statistics

Associate Minister of Finance



22 DEC 2017

Dear Murray

It was a pleasure to meet you, Graham and the team to discuss the Productivity Commission's progress on the inquiry into a low emissions economy.

This Government is committed to taking decisive action on climate change and transitioning New Zealand to a low emission economy by 2050. This week the Prime Minister and I announced the Government's intention to consult the public in 2018 on a Zero Carbon Bill. The Zero Carbon Bill will set a more ambitious target for emissions reductions by 2050, and establish an independent Climate Change Commission to provide advice and scrutiny to ensure that future governments are taking actions consistent with meeting this target.

It is clear that New Zealand needs to do more to meet our commitments under the Paris Agreement. As I set out in my letter to you in May, the Paris Agreement commits all countries, including New Zealand, to achieve a net-zero emissions economy by the second half of this century.

While the Government is yet to define the level of the emissions target for 2050, it would be helpful for the Commission to take into consideration the Government's intention to set a more ambitious emissions target for 2050. This may include setting a zero net emissions target for 2050. I have discussed this with my colleagues the Minister of Finance and the Minister for Economic Development who support this approach.

As a developed country, New Zealand will be expected to take the lead on actions to reduce emissions and to transition to a zero net emissions economy sooner than others. I encourage your inquiry to consider the full range of potential benefits and opportunities which might arise from New Zealand taking the global lead on reducing emissions.

Finally, I have been encouraged to see that you received such a high number of detailed and considered submissions in response to your issues paper. I believe this reflects the importance that New Zealanders place on making progress on such an important issue as climate change.

I look forward to receiving the final report of the Commission's inquiry.

Yours sincerely

A handwritten signature in blue ink, appearing to read 'James Shaw', with a long horizontal flourish extending to the right.

Hon James Shaw
Minister for Climate Change

About the draft report

This draft report aims to assist individuals and organisations to participate in the inquiry. It outlines the background to the inquiry, the Commission's intended approach, and the matters about which the Commission is seeking comment and information.

This draft report contains the Commission's draft findings and recommendations. It also contains a limited number of questions to which responses are invited but not required. The Commission welcomes information and comment on any part of this report and on any issues that participants consider relevant to the inquiry's terms of reference.

Key inquiry dates

Submissions due on the draft report	8 June 2018
Engagement with interested parties on the draft report	May-August 2018
Final report to the Government	August 2018

Why you should register your interest

The Commission seeks your help in gathering ideas, opinions and information to ensure this inquiry is well informed and relevant. The Commission will keep registered participants informed as the inquiry progresses.

You can register for updates at www.productivity.govt.nz/subscribe-to-updates, or by emailing your contact details to info@productivity.govt.nz.

Why you should make a submission

Submissions provide information to the inquiry and help shape the Commission's recommendations in the final report to the Government. Inquiry reports will quote or refer to relevant information from submissions.

How to make a submission

The due date for submissions in response to this report is **8 June 2018**. Late submissions will be accepted, but lateness may limit the Commission's ability to consider them fully.

Anyone can make a submission. Your submission may be written or in electronic or audio format. A submission may range from a short letter on one issue to a substantial response covering multiple issues. Please provide relevant facts, figures, data, examples and documents where possible to support your views. The Commission welcomes all submissions, but multiple, identical submissions will not carry more weight than the merits of your arguments. Your submission may incorporate relevant material provided to other reviews or inquiries.

Your submission should include your name and contact details and the details of any organisation you represent. The Commission will not accept submissions that, in its opinion, contain inappropriate or defamatory content.

Sending in your submission

Web: www.productivity.govt.nz/make-a-submission

Email: info@productivity.govt.nz

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The Commission appreciates receiving an electronic copy of posted submissions, preferably in Microsoft Word or searchable PDF format. Please email the files to info@productivity.govt.nz.

What the Commission will do with the submissions

The Commission seeks to have as much information as possible on the public record. Submissions will become publicly available documents on the Commission's website. This will occur shortly after receipt, unless your submission is marked "in confidence" or you wish to delay its release for a short time. Please contact the Commission before submitting "in confidence" material, as it can only accept such material under special circumstances.

Other ways you can participate

The Commission welcomes feedback about its inquiry. Please email your feedback to info@productivity.govt.nz or contact the Commission to arrange a meeting with inquiry staff.

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Commonly used terms

Term	Description
Agriculture	Activities including pastoral farming (ie, livestock farming), horticulture and arable farming.
Carbon dioxide equivalent (CO ₂ e)	CO ₂ e equalises the warming potential of different types of greenhouse gases, using carbon dioxide as the base for comparisons.
Emission leakage	This refers to the situation whereby reducing emissions in location A through a reduction in output leads to an increase in output in location B and an increase in its emissions. Where location B is a higher-emitting producer than location A, total emissions may rise.
Fugitive emissions	Fugitive greenhouse gas (GHG) emissions are emissions that escape as by-products of another process such as coal mining or oil and gas production. Fugitive GHG emissions are distinct from the GHG emissions caused when these fossil fuels are combusted. The use of geothermal energy also produces fugitive emissions.
Global Warming Potential (GWP ₁₀₀)	The most commonly-used metric (also used under the UNFCCC) to compare the warming potential of different greenhouse gases. GWP ₁₀₀ compares the cumulative warming of a greenhouse gas over a 100-year period with the warming of carbon dioxide.
Gross emissions	The total of a country's emissions across all sources, <u>excluding</u> offsets (and emissions) from land use, land-use change and forestry.
Industrial processes and product use	A category used for UNFCCC reporting, this refers to emissions from industrial activities (eg, from steelmaking) that are not a direct result of consuming energy, and emissions from using greenhouse gases in products (eg, from the use of refrigeration systems).
Intergovernmental Panel on Climate Change	An international scientific and intergovernmental body that assesses and evaluates global research on climate change. Every five to seven years, the IPCC publishes an "assessment report", synthesising the most recent climatic research and data.
Kyoto Protocol	Adopted in 1997 (and entered into force in 2005), the Kyoto Protocol is a global climate treaty, alongside the UNFCCC. A key focus of the Protocol is the obligation on developed countries to reduce their emissions. These countries are required to set non-binding emissions reduction targets for two commitment periods between 2008 and 2020. The Protocol will soon be superseded by the Paris Agreement.
Land use, land-use change, and forestry (LULUCF)	A category used for UNFCCC reporting, this refers to emissions (and offsets) resulting from changes in the stock of greenhouse gases stored in different types of land (eg, forestry, grassland). For example, CO ₂ emissions released after a forest is deforested are reported under the LULUCF category.
Long term	2050 and beyond.
Low-emission vehicles	Vehicles that produce zero, or near-zero greenhouse-gas tailpipe emissions (eg, battery EVs, plug-in hybrid EVs, and hydrogen fuel cell vehicles).

Term	Description
Medium term	2030 to 2050.
Nationally determined contributions (NDCs)	NDCs communicate a country's pledged short-term contribution to emissions reductions, to achieve the goal of the Paris Agreement. Under the Agreement, countries are required to submit a new or updated NDC by 2020 and every five years after that.
Net emissions	The total of a country's emissions across all sources, <u>minus</u> offsets from land use, land-use change and forestry.
Net-zero	Net-zero emissions describes a situation whereby the amount of greenhouse gases emitted into the atmosphere is equal to the amount sequestered or offset (eg, by forestry).
New Zealand Emissions Trading Scheme (NZ ETS)	New Zealand's main tool for reducing emissions, the NZ ETS is an emissions trading system requiring all sectors (excluding agriculture) to purchase and surrender emissions units (called New Zealand Units) in order to emit greenhouse gases.
New Zealand Units (NZUs)	The "currency" or permits used to trade in the NZ ETS. Each NZU represents one tonne of CO ₂ e.
Sequestration	The process whereby forests remove CO ₂ from the atmosphere and store it through photosynthesis. Sequestration can offset greenhouse gas emissions.
Short term	The present to 2030.
The Paris Agreement	The most recent global climate change agreement, signed by 195 parties. The agreement sets out a goal of limiting temperature rise to 2°C (with an ambitious target of 1.5°C), through reaching net-zero emissions in the second half of this century.
United Nations Framework Convention on Climate Change (UNFCCC)	Adopted in 1992, the UNFCCC is an international climate change treaty, that provides the framework for global mitigation efforts, including negotiating specific climate-change agreements (eg, the Paris Agreement), and the reporting of greenhouse gas emissions.

Acronyms and abbreviations

Term	Description
AGS	Afforestation Grants Scheme
CCC	UK Committee on Climate Change
CCGT	combined-cycle gas turbine
CCRA	Climate Change Response Act 2002
CCS	carbon capture and storage
CH ₄	methane
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
DER	distributed energy resources
DR	demand response
DSO	distribution system operator
EA	Electricity Authority
EDB	electricity distribution business
EECA	Energy Efficiency and Conservation Authority
ETS	Emissions Trading Scheme
EV	electric vehicle
F-gas	fluorinated gas
GDP	Gross Domestic Product
GHG	greenhouse gas
GIB	green investment bank
GWP	global warming potential
HFC	hydrofluorocarbon
HWP	harvested wood product
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
kt	kilotonne
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment

Term	Description
NLTF	National Land Transport Fund
MBIE	Ministry of Business, Innovation and Employment
MPI	Ministry for Primary Industries
Mt	megatonne
MW	megawatt
MWh	megawatt hour (= 1 000 kWh)
NDC	nationally determined contribution
NZAGRC	New Zealand Agricultural Greenhouse Research Centre
NZPC	New Zealand Productivity Commission
NZU	New Zealand Unit
NZVIF	New Zealand Venture Investment Fund
NZX	New Zealand Stock Exchange
N ₂ O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
PCE	Parliamentary Commissioner for the Environment
PFC	Perfluorocarbon
R&D	research and development
RMA	Resource Management Act 1991
RSNZ	Royal Society of New Zealand
SF ₆	sulphur hexafluoride
TCFD	Task Force on Climate-related Financial Disclosures
TWh	terrawatt hour (= 1 000 GWh or 1m kWh)
WMA	Waste Minimisation Act 2008
WtE	waste-to-energy
WWTP	wastewater treatment plant

Overview

New Zealand is committed to being an active participant in the international response to the challenge of climate change and to making substantial reductions in its greenhouse gas (GHG) emissions. In 2017, the Government asked the Productivity Commission to “identify options for how New Zealand could reduce its domestic greenhouse gas emissions through a transition to a lower emissions future, while at the same time continuing to grow incomes and wellbeing” (TOR, p. 2). In 2018, Hon James Shaw, as the incoming government’s Minister for Climate Change, asked the Commission to include the target of achieving net-zero emissions by 2050 in its analysis.

This draft report responds by providing insights into how and where emission reductions can be achieved and the types of policies required to drive the transition. It explores the challenges, opportunities, benefits and costs of alternative transition pathways and makes specific policy recommendations. This inquiry does not canvas the science relating to climate change. Nor does it provide advice on the overall targets set by the New Zealand Government. Rather, the report focuses on how the nation can best make its transition to a low-emissions economy by 2050 and beyond.

The Commission’s issues paper of August 2017 observed that “the shift from the old economy to a new, low-emissions, economy will be profound and widespread, transforming land use, the energy system, production methods and technology, regulatory frameworks and institutions, and business and political culture” (p.1). At this point in the inquiry process, after an extensive period of research, engagement and analysis, the Commission finds nothing to alter that view.

Decarbonising economies and societies underpinned for a century or more by fossil fuels inevitably means substantial change. It requires old technologies and even old industries to be replaced by new. How challenging the transition proves to be critically depends on what and when new technologies emerge. It also depends on which existing capital and skills will lose their value and when, to be replaced by new and different capacities.

But this is a 30-year transition. Looking back through history, other examples show profound change occurring over timeframes of that order or less, with the wellbeing of communities benefitting enormously from changes that, at first, appeared to be highly disruptive and threatening.

This report is concerned with how governments can establish the conditions – institutions, laws, prices, policies and regulations – that encourage shifts to lower emissions and ease the frictions (economic and social) that can accompany such change.

New Zealand’s role in the global climate challenge

New Zealand has among the highest per capita GHG emissions in the world. This is despite having an electricity system that is overwhelmingly powered by renewables. The explanation for such high per person emissions lies substantially with the agricultural sector in which a very high proportion of production is exported and which accounts for nearly half of New Zealand’s total emissions. Rapid population growth and an associated rapid growth in the light vehicle fleet have contributed the fastest growth in emissions in recent years.

While per person emissions are high, total emissions are very small: they make up less than 0.2% of global emissions. Actions in New Zealand will not make an appreciable difference to the global climate-change trend. This exemplifies the public policy challenge of climate change. It is a classic example of the “tragedy of the commons”, in which individuals have incentives to maximise personal value to the detriment of the whole. The commons in this case is a truly global resource – the shared atmosphere upon which life depends – and its limited ability to absorb GHG emissions without giving rise to climate disruptions that are potentially enormously damaging to life on the planet. So, while it is small, New Zealand’s size does not justify inaction. Indeed, quite the opposite. Around 30% of global emissions come from small emitters – collectively, small economies do matter and a global, concerted effort by all is needed to solve this issue.

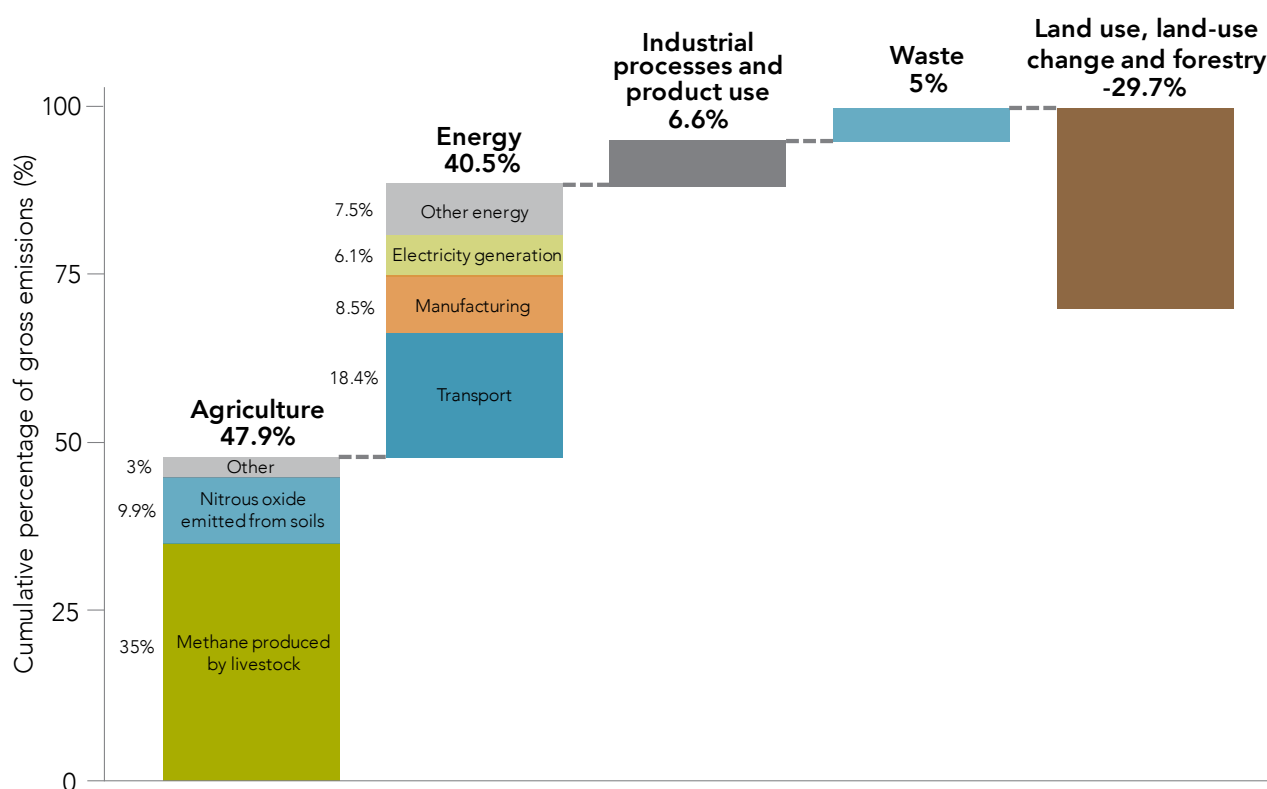
Further, by achieving a successful transition to a low-emissions economy, New Zealand has a major opportunity to influence others. In so doing it can reduce the risk of other countries failing to pursue mitigation pathways because they either do not know how to, or do not think it can be done while continuing to grow incomes and wellbeing. This is likely to be particularly relevant in areas where New Zealand has expertise and experience (eg, pastoral GHG mitigation). New Zealand's capacity to influence will be the greater if it can point to its own credible and substantial mitigation progress.

New Zealand's emissions sources and opportunities

New Zealand's emissions profile differs markedly from other developed countries. Nearly half of its emissions are from agriculture (more than any other developed country) (see Figure 0.1). Transport is the second biggest emissions source and has been by far the greatest contributor to rising emissions. Therefore, not surprisingly, reducing emissions from the transport and agriculture sectors receives high attention in this report.

New Zealand is also fortunate to have enough forestry to offset just under a third of gross emissions – a high proportion by international standards. Yet this influence can only be temporary. New forest plantings provide time for reductions in emissions elsewhere. Planting rates have dropped sharply since the planting boom in the 1990s, and many of these forests are shortly due for harvest. The result is that carbon dioxide (CO₂) offsets from forestry will decline without a significant increase in new planting.

Figure 0.1 New Zealand's GHG emissions and removals by source, 2015



Overcoming myopia and managing uncertainty

New Zealand has had climate change policies in place to combat climate change for some time, but it has not generated action to lower its emissions. This reflects the problems that lie at the heart of climate change policy – time inconsistency in policy settings and uncertainty about the future.

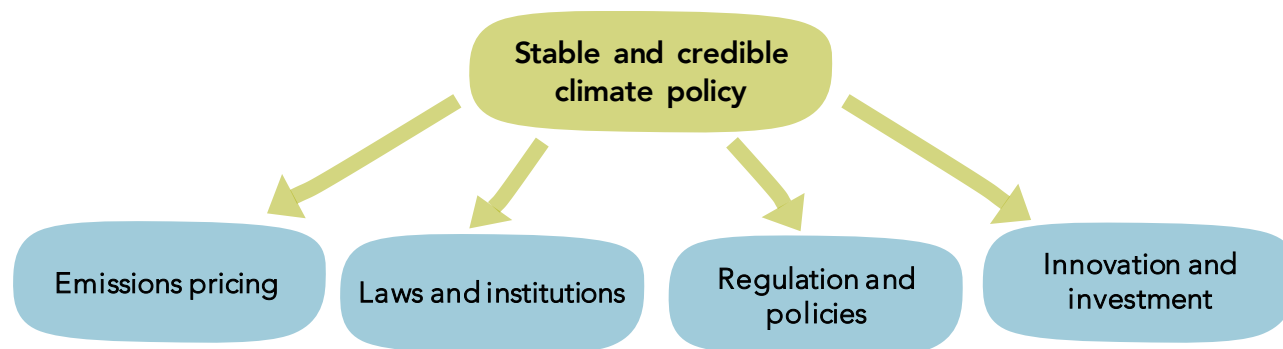
While the costs of change are immediate and real, the benefits may not be clear for many years. The temptation can be to push the responsibility onto others – most likely future generations. This makes the formulation of enduring policy solutions hard. And without durable and ambitious policies, the signals for firms and households to move their production and consumption towards less emissions-intensive options will be weak, at best.

The private sector and civil society must be able to plan and take long-term decisions with confidence. Businesses, households and consumers will be better able to manage the risks of moving to a low-emissions economy and plan for the behavioural and structural changes required in a stable and credible policy environment. This requires:

- A **strong signal** from the Government making a long-term commitment to the transition to a low-emissions economy, and providing transparency about future policy intentions to achieve this.
- Getting **emissions pricing** right, to send the right signals for investment and mitigation.
- Creating **laws and institutions** that support stable policy settings, with clear targets and accountability for action, and that act as a commitment device for future governments to continue the development and implementation of a long-term policy response to climate change.
- Ensuring other **supportive regulations and policies** are in place, to address non-price barriers, encourage the transition, and manage serious adverse impacts on lower-income households and affected businesses.
- Harnessing the full potential of **innovation** through significantly more public resources devoted to supporting research, and the deployment and adoption of low-emissions innovations.
- Supporting **investment** in low-emissions technology, infrastructure, and other activities, by greater transparency and by mobilising new sources of finance.

Together, these provide the enabling environment, which will shape the incentives on producers and consumers, to reduce emissions.

Figure 0.2 Achieving a low-emissions economy



Getting emissions pricing right

An emissions price is the price an emitter pays for each unit of GHG they release to the atmosphere. Properly designed and implemented, emissions pricing is a powerful policy instrument to reduce emissions. A single emissions price provides a strong incentive to reduce emissions at least cost. It decentralises decisions to invest, innovate and consume across the economy to people who have the best information about opportunities to lower emissions given their circumstances. An emissions price is also pervasive through the whole economy – shaping resource and investment decisions across all emitting sectors and sources. Ensuring that emissions are appropriately priced is an essential step in New Zealand’s approach to climate-change mitigation.

Several tools exist to apply emissions pricing – including taxes, market-based schemes such as “cap and trade”, and hybrid combinations – and each tool can be designed in a variety of ways. For the purposes of credibly moving towards a low-emissions economy, gaining certainty over the quantity of emissions that will be permitted is vital. The Commission considers that the New Zealand Emissions Trading Scheme (NZ ETS) should remain the centrepiece of New Zealand’s emissions reduction efforts as it has the potential to provide this much-needed policy certainty. However, the NZ ETS needs to be made credible and effective.

Higher emissions prices, and greater clarity about future prices, are needed

The emissions price created through the NZ ETS needs to rise considerably. Previous prices have been so low as to make the scheme ineffectual in changing firm and household behaviour. Just what level of pricing will be required cannot be derived with precision. However, specialised modelling and other available evidence suggests that New Zealand's emissions price will need to rise to levels of the order of \$75 a tonne of CO₂ equivalent (CO₂e) and possibly over \$200 a tonne over the next few decades to achieve the domestic emissions reductions needed to meet New Zealand's international commitments. Robust and transparent domestic caps on the supply of New Zealand Units (NZUs) (one NZU is a permit to emit one tonne of CO₂e) are needed to drive a higher emissions price to materially influence production and consumption decisions.

Expectations about future emissions prices are important for driving investment in new technologies. To ensure clear and credible investment signals, the Government should introduce mechanisms that provide guidance about the path of future emissions prices. Key steps include setting rolling five-year forward caps for the NZ ETS, to provide certainty about the supply of NZUs. A second important step will be auctioning NZUs to achieve the cap, but with mechanisms to discourage prices from moving outside of a wide band. There will be movements in NZU prices to which market participants will respond. These movements will be influenced by the supply of units in the market, which the Government has some control over, but also other influences (such as technological changes) over which it has little control. The wide bands proposed should have the effect of limiting "noise" from short-term volatility.

Land-use change, agriculture and emissions pricing

Land use will need to change substantially if New Zealand is to transition to a low-emissions economy. In particular, modelling undertaken for the Commission indicates that land planted in forests will need to increase by between 1.3 million and 2.8 million hectares, mostly converted from marginally profitable beef and sheep farms. Growth in horticulture (from a relatively small base) will likely also play a significant role in reducing agricultural emissions. The needed rate of land-use change is comparable to the rate at which, over the last 30 years, beef and sheep farming converted to forestry, dairying and other uses.

Opportunities to reduce agricultural emissions, particularly from dairying, will also be important. Scope exists for further modest reductions in emissions intensity, through higher productivity and wider adoption of current low-emissions practices. Research into new technologies has the (uncertain) potential to further reduce agricultural emissions in the medium to long term. Yet the potential payoff to successful research justifies scaling up current efforts.

An emissions price that covers all land use, including agriculture, should be the main driver of land-use change. A well-designed and stable NZ ETS will incentivise land-use change, including more afforestation, as well as a search for, and adoption of, low-emissions practices and technologies in agriculture. To reflect the trade-exposed nature of the sector and current technological limits, the entry of agriculture into the NZ ETS should be supported with free allocation of NZUs for a transitional period.

The Government can best support the rural transition through ensuring emissions-pricing policy is stable, with a measured phase-out of free allowances for agricultural producers. This will improve incentives for adjustment and help avoid significant economic and social dislocation in the transition to a low-emissions rural economy over the next three decades.

Stable and enduring laws and institutions

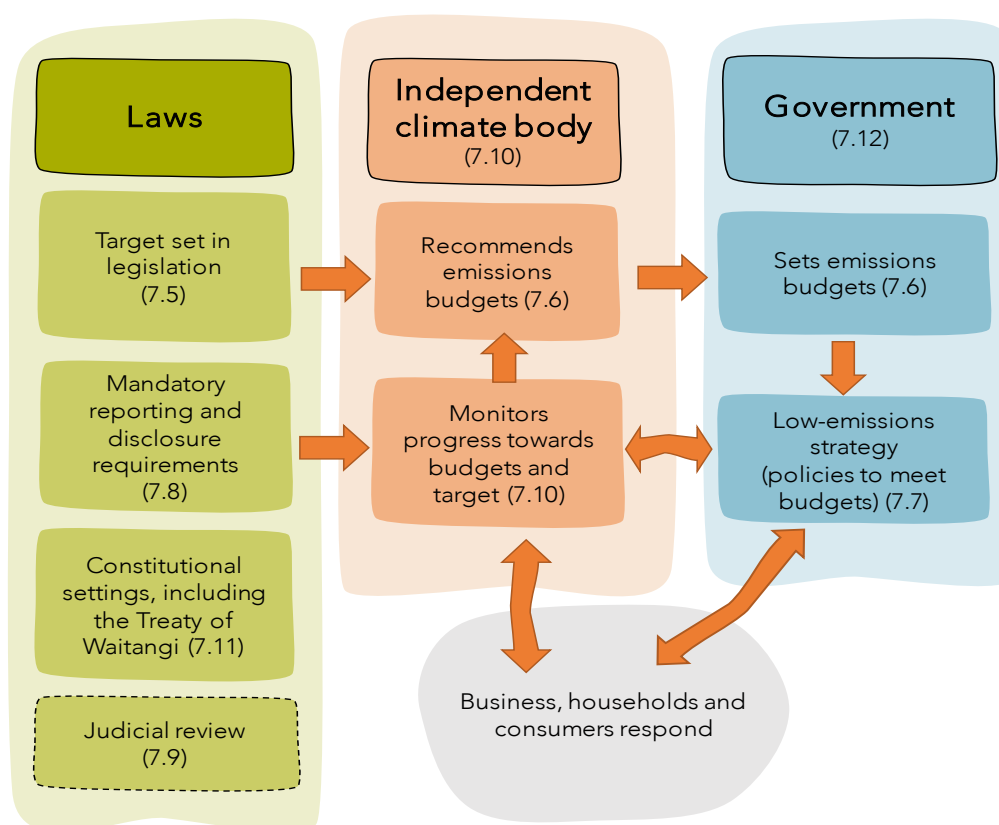
New Zealand has lacked clear and stable climate-change policies. This lack of clarity and political agreement about longer-term goals has weakened incentives for change and undermined confidence in existing policies.

If firms and households are to invest in low-emissions technologies, they need confidence that their returns will not unnecessarily be put at risk. Stability and confidence about longer-term objectives and policy settings are critical to promoting the transition to low emissions. At the same time, governments will need to have policy flexibility in how they deliver on these longer-term objectives, especially as new technologies emerge that can lower emissions or remove them from the atmosphere. The Commission considers that this

balance of stability and flexibility would best be provided through the following legislative and institutional changes (see Figure 0.3).

- Legislated and quantified long-term GHG emissions-reduction targets, to clearly signal the direction of policy travel. Targets should be informed by science, which is central to the credibility of the climate-change statutory and institutional framework.
- A system of successive “emissions budgets” that translate long-term targets into clear short-to-medium-term emissions-reduction targets. The budgets provide visible stepping stones to achieving the long-term targets and help reinforce steady action on, and accountability for, achieving them. The emissions budgets would also guide the determination of caps in the NZ ETS.
- An independent expert advisory body (a Climate Commission) to provide objective analysis and advice to the Government on the scale of emissions reductions required over the short to medium term (ie, by recommending emissions budgets) to meet long-term targets, reflecting scientific evidence as well as considerations of economic and social impacts. A Climate Commission might also identify regulatory and other barriers, or opportunities and priorities, to reduce emissions, and will regularly assess New Zealand’s progress towards meeting agreed budgets and targets. Effectively, a Climate Commission would be the custodian of New Zealand’s climate policy and long-term climate-change objectives.

Figure 0.3 Laws and institutions to support the low-emissions transition



To have their full and desired effect on national emissions levels, these institutional and statutory features will need to obtain broad and enduring political support along with ongoing leadership to navigate the long and uncertain journey to a profoundly different low-emissions future.

This report also recommends that mitigation targets should clearly distinguish between short-lived and long-lived GHGs (although there should be a single cap within the NZ ETS). Emissions of some gases (such as CO₂) can stay in the atmosphere for centuries. Emissions of long-lived GHGs must be reduced to net-zero at a minimum. Other GHGs (such as methane (CH₄)) dissipate comparatively quickly. They will need to reduce, but not to net-zero, to stabilise temperature.

Supporting regulation and policies

While stable policy and emissions pricing are needed to change behaviour and promote investment, they will not be sufficient on their own to promote a fair and efficient transition, or to maximise the opportunities from this transition for New Zealand. A range of complementary regulation and policies are needed to support the creation and use of mitigation technologies, assist behaviour change by firms and households, and manage risks.

Transforming New Zealand's vehicle fleet

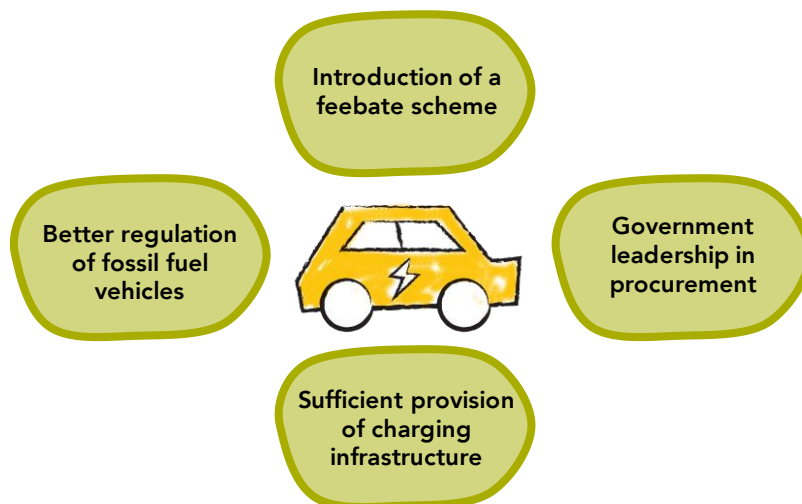
New Zealand's transport system is dominated by private road transport. Compared to other developed countries, vehicle ownership rates are high, public transport use is low, and the vehicle fleet is old with poor fuel economy. Rapid population growth, along with a decline in prices for fossil-fuel vehicles, has been associated with a rapidly expanding light-vehicle fleet.

Consequently, transport is one of the largest and fastest-growing sources of emissions in New Zealand. Transport is also a sector where lower-emissions alternatives to fossil-fuel vehicles are both available (eg, public transport, active transport, trains) and emerging (eg, electric and other low-emission vehicles), and where there is scope to improve the efficiency of vehicle use (eg, through congestion charging).

Electric vehicles (EVs) offer some of the most promising mitigation opportunities for New Zealand, but their uptake faces several barriers such as high prices relative to fossil-fuel vehicles, anxiety about their limited travel range, and poor public understanding of their benefits. The Government can offset some of these barriers by:

- introducing a "feebate" scheme, through which importers would either pay a fee or receive a rebate, depending on the emissions intensity or fuel efficiency of the imported vehicle;
- providing funding support for EV infrastructure projects, to fill gaps in the charging network that are commercially unviable for the private sector; and
- raising awareness and uptake of low-emissions vehicles through leadership in procurement.

Figure 0.4 Supporting electric vehicle uptake



For the bulk of light vehicles to be electric by 2050, nearly all vehicles entering the fleet would need to be EVs by the early-2030s. Yet, even with a rapid uptake in EVs and low-emissions vehicles, fossil-fuel vehicles are likely to make up a significant share of New Zealand's private vehicle fleet for some time. To help reduce emissions from these sources, the Commission recommends that imports of new and used fossil-fuel vehicles be required to meet rigorous emissions standards. New Zealand is one of a handful of developed countries without vehicle emissions standards, and risks becoming a dumping ground of high-emitting vehicles from other countries that are decarbonising their fleets. The Commission is also seeking feedback on whether further steps are needed, such as phasing out all fossil-fuel vehicle imports by a specified date.

For heavy vehicles, aviation and shipping, electrification is more challenging. Hydrogen vehicle technology is developing and could provide a useful alternative to EVs. Biofuels also have the potential to deliver significant emissions reductions for these modes. Yet, commercial, technology, and coordination barriers pose challenges to the large-scale production of biofuels. A higher emissions price in the NZ ETS would create a greater incentive to both develop and then switch to biofuels.

Land transport policy in recent years has prioritised roads over other options. There are restrictions on the types of transport that can receive funding from the National Land Transport Fund (NLTF) and different methods are used for assessing the value of different transport modes. Future land transport policy should put emissions-reduction goals more centrally in government planning, adopt a more mode-neutral approach to assessing and funding new projects, and make greater use of demand-management techniques such as congestion pricing.

Accelerating afforestation

Afforestation has a critical role to play (though only over the short to medium term) in moving towards a low-emissions economy. Significant new forest planting is needed for New Zealand to reduce its net emissions at a lower emissions price than would otherwise be the case. Policy and regulatory settings need adjustment if these ambitious afforestation goals are to be feasible.

Higher NZ ETS prices will encourage more planting but alone may not be sufficient to mobilise the scale of investment required. The administration of the NZ ETS needs to be simplified to make it easier for forest owners to take part, and to provide recognition for carbon sequestered in harvested wood products. Only a minority of eligible forest owners currently participate in the NZ ETS, as many find participation too costly and risky compared to the benefits of earning NZUs. The amount and pace of new planting required is beyond what New Zealand has experienced over the past 30 years.

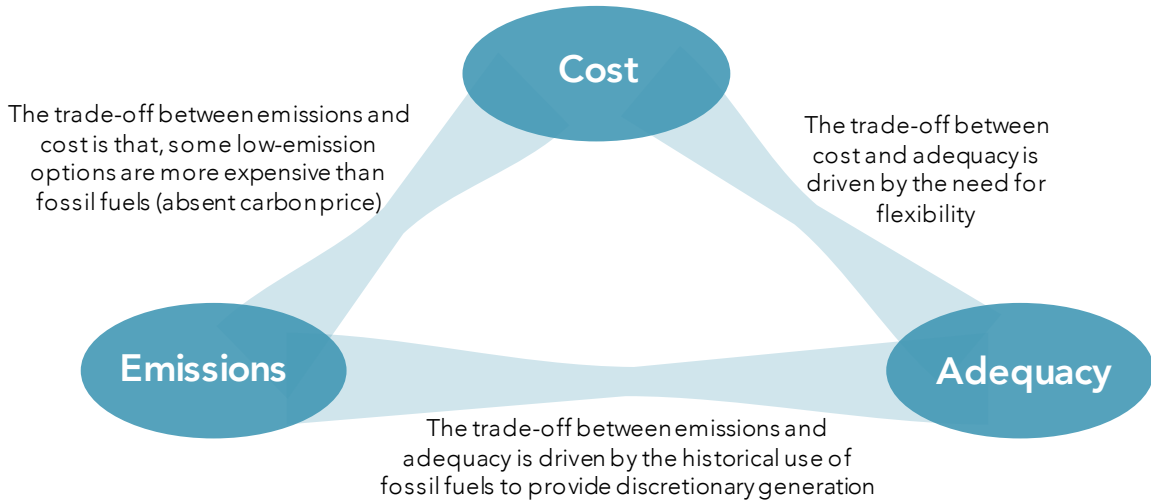
Balancing cost, emissions reductions and adequacy in electricity supply

An efficient and well-functioning electricity system will play a central part in the transition to a low-emissions economy. New Zealand's largely decarbonised electricity sector is a major advantage, and considerable scope exists to further increase the supply of electricity from renewable sources, such as wind (the cost of which has been falling rapidly) and geothermal energy (which still produces some emissions). This will create opportunities elsewhere in the economy to replace the use of more emissions-intensive energy sources.

Trade-offs exist between cost, emissions and adequacy in the electricity system (see Figure 0.5). No options currently exist for completely eliminating emissions from electricity generation without creating significant challenges elsewhere. For example, substantially reducing emissions by removing thermal generation would increase costs and reduce security, especially where there are peaks in demand or shortfalls in hydropower supply ("dry year shortfalls"). If costs are pushed too high, this could discourage other sectors in the economy from shifting away from fossil fuels. Yet, technological development should see cheaper low-or no-emissions generation options emerge over time. By 2050, economic options such as in tidal or biomass generation, or carbon capture and storage (CCS), may have emerged. The price of wind power may also fall to the point where holding surplus renewable generating capacity is an efficient option for reducing the need for thermal generation. On the demand side, evolving technology will enable better management of peaks and incorporation of distributed energy resources (eg, solar, wind and batteries).

Given technological uncertainty and the importance of electricity prices for the adoption of low-emissions technologies in other parts of the economy, the Government should not favour particular electricity generation technologies. It should also be cautious about setting stringent targets for electricity-sector emissions before technology becomes available to further reduce emissions at reasonable cost. The Government should, instead, through the NZ ETS, rely mostly on effective emissions pricing to guide investment in new electricity generation.

Figure 0.5 The cost–emissions–adequacy trade-off

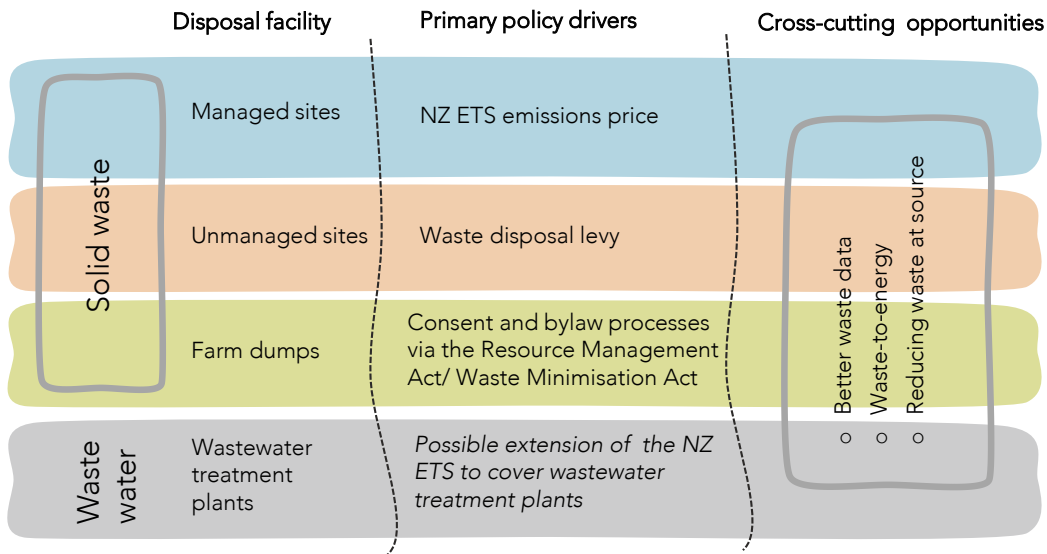


As the share of electricity generated from distributed sources increases and demand is more responsive, additional steps may be needed to manage growing complexity, and risks to system stability, and ensure a level playing field for different types of service providers. In particular, the regulatory framework governing the electricity market should be updated to allow consumers to become more informed and active buyers and sellers of electricity.

Better pricing and controlling waste emissions

New Zealand has the highest waste emissions per person among countries in the Organisation for Economic Cooperation and Development (OECD). A higher NZ ETS price should encourage greater efforts to reduce GHG emissions from waste. However, only around one-third of waste emissions are covered by existing waste-management or climate-change policies. The waste disposal levy should be extended to all known solid waste sites and increased over time to encourage better waste management. Local authorities should also be given greater support to regulate farm dumps and other unknown waste disposal sites, such as through the Resource Management Act and the Waste Minimisation Act. Figure 0.6 summarises the opportunities for reducing waste emissions in New Zealand.

Figure 0.6 Opportunities for reducing waste emissions



Ensuring regulation supports, rather than frustrates, the transition

Regulation is a pervasive feature of modern life and can either support or frustrate the transition to the low-emissions economy. The Commission has identified areas where regulatory reform may be needed to remove barriers to the transition or maximise opportunities to reduce emissions.

- Carbon capture and storage (CSS) is a rapidly-evolving and potentially significant technology for reducing the stock of emissions in the atmosphere. Whether and when CCS will become viable in New Zealand is unclear, but current regulatory frameworks are not adequate for managing the risks associated with CCS (such as leakage of carbon from underground storage facilities) or providing sufficient rewards (eg, recognition of CCS activities not linked to industrial processes). New legislation should be drafted to provide better control of CCS and set New Zealand up properly to maximise the possible benefits from the technology.
- Milk processing is one of the most significant sources of process-heat emissions. Under current legislation, Fonterra must accept all supply from shareholders regardless of its impact on the company's or national emissions. The Commission seeks feedback on whether there would be a net benefit in giving Fonterra discretion to refuse new supply where this could inefficiently increase the use of fossil fuels in milk collection and processing.
- It is important that the Building Code does not present barriers to building technologies and materials with lower embodied emissions. As such, forthcoming reviews of the Building Code should assess how much the Code enables the adoption of low-emissions construction and materials.

Support for households facing significant transition costs

The mitigation policies recommended in this report could increase the costs of household energy, food and transport. The adverse impact of such increases on the real incomes of vulnerable households can be offset through the tax and welfare system. Existing policies, such as tax credits and benefits, should be adequate to compensate lower-income households for these increased costs, provided both are regularly adjusted in line with inflation. Interventions to raise the quality of rental housing would provide health benefits and create opportunities for lower-income households to substitute away from the use of fossil fuels for heating.

Interventions that respond to significant shocks to communities resulting from emissions-reduction policies (eg, the loss of a major employer) should focus on the labour-market and skills needs of individuals, and be targeted to those who will have the most difficulty gaining new employment. The Commission has previously found that the current education and training system is not well set-up to meet the needs of people seeking mid-career retraining and needs reform (NZPC, 2017).

Harnessing the full potential of innovation and investment

The emergence of new technologies to avoid, capture and mitigate GHG emissions is the closest thing to a "silver bullet" to enable humanity to meet the challenge of climate change. In many cases, New Zealand will be a "technology taker", adopting and adapting new processes from overseas. But areas exist in which New Zealand will need to be actively involved in developing solutions, such as reducing emissions from agriculture.

New Zealand is already actively involved in research and international efforts to lower agricultural emissions; it could make a valuable contribution to other countries' work to mitigate climate change and raise agricultural productivity. There are also multiple examples of "clean technology" firms emerging in New Zealand. Innovation policies and processes should give greater attention to these areas, in particular by giving current innovation institutions – such as Crown Research Institutes and Callaghan Innovation – clear mandates and funding to support these opportunities.

The Commission has found fragmentation and weaknesses in the national innovation system. The current government investment in science and innovation to support a transition to a low-emissions economy lacks a clear strategic focus and priority commensurate with the imperative to be successful in achieving the objective and to taking bold action. Current investments are also inadequate in size and scope.

New Zealand should establish the transition to a low-emissions economy as a high priority within its national innovation system, recognising the importance of that goal and that it will require extensive economic transformation and restructuring. The Government should provide major public backing and funding support for innovation and technology adoption so they can play a central role in the transition, alongside effective emissions pricing. The Government should also take steps to strengthen the weaker parts of the

national innovation system (such as its objectives, identification of innovation opportunities and knowledge transfer and sharing) and align the various complementary parts so they work well together in the transition to a low-emissions economy. The scope should include not only science and research, but broader innovation, knowledge dissemination and learning, skills, infrastructure, regulation and finance.

Box 0.1 **The benefits of supporting innovation**

Strong government support for innovation as part of an overall low-emissions strategy is likely to:

- make more emission reductions possible at lower cost;
- lower the emissions price necessary for achieving target emission reductions;
- create economic opportunities in the form of attractive business investments, high-skill jobs, and the potential for profitable export opportunities; and
- enhance New Zealand's reputation internationally through developing innovative, low-emissions technologies that help the world as well as New Zealand to reduce GHG emissions.

New Zealand retains several policies that subsidise the ongoing use of fossil fuels, such as concessionary tax deductions for petroleum-mining activities or research and development funding for the oil industry. These policies run counter to the goal of reducing national GHG emissions and should be abandoned.

Mobilising capital towards low-emissions investments

Transparency of climate risk is fundamental to grow and redirect the investment needed to enable the transition to a low-emissions economy. Without the correct information, investors may incorrectly value assets or investment opportunities, resulting in misdirected finance or stranded assets. The Government can help to encourage disclosure of climate risk by officially endorsing the recommendations of the Task Force on Climate-related Financial Disclosures. It should work to integrate these recommendations into existing government-mandated reporting requirements.

Other actions for Government include targeted grants and loans (which can play an important catalytic role in reducing market risk for the development and deployment of low-emissions technology), and further elaboration of the details of the proposed Green Investment Fund. Other opportunities are less clear-cut. Feedback is sought on whether the New Zealand Venture Investment Fund should identify low-emissions investments as a sector of interest.

The Government should develop a low-emissions investment strategy for New Zealand. A strategic view across public-sector interventions is important to accelerate progress in a coordinated and non-duplicative manner, as well as providing clarity about the role of government at different phases of the transition.

Pathways to a low-emissions economy

An effective transition to a low-emissions economy will mean that New Zealand will look very different in 2050. During the transition, action to mitigate GHG emissions will require real and significant changes. Those changes will have disruptive impacts on some businesses and households. Yet many pathways to the low-emissions economy are possible, and many factors could affect the rate and scale of change. Whether and when these factors will emerge cannot be predicted with much accuracy. Despite this uncertainty, it is possible to envisage different pathways towards a low-emissions economy. These can be useful for informing policy decisions around priorities, trade-offs and the implications of different rates of economic change.

Modelling can throw light on whether an emissions target is feasible, the measures needed to achieve a target, the existence and character of alternative pathways, and a quantitative picture of what needs to happen by when to reach a target. Yet modelling has well-known limitations and is not prediction. The

transition to a low-emissions economy for any country will be a long journey to a known and desired destination, but through very uncertain terrain.

Modelling commissioned for the inquiry suggests that:

- New Zealand has the opportunity to move to a low-emissions economy (ie, 25 megatonnes of net emissions by 2050) at an emissions price rising to between \$75 a tonne of CO₂e and \$152 a tonne of CO₂e by 2050.
- New Zealand could also reach net-zero GHG emissions by 2050 with emissions prices rising to between \$157 a tonne of CO₂e and \$250 a tonne of CO₂e by 2050 (with the higher figure assuming that technological change is slow). While this is a long way above current levels, these prices are comparable with the emissions prices that it is estimated will be needed in other developed countries to deliver the objectives of the Paris Agreement to limit global temperature rise to under 2°C.
- The pathways modelled rely on three key drivers in achieving emissions-reduction goals: the expansion of forestry; the electrification of New Zealand's transport sector; and changes to the structure and methods of agricultural production.
- Expanding forestry is central to achieving large reductions in emissions up to 2050. Yet, the heavy reliance on forestry will create challenges in the longer term – with continued emissions reductions required after 2050 to maintain net-zero. New Zealand would need to find other ways to reduce emissions. But it has time to consider options and seek technological developments with the potential for further cost-effective mitigation.
- Emissions reductions in agriculture will occur through both technological and structural change; for example, further shifts in land use – mostly away from marginal beef and sheep farming toward forestry, and possibly from pastoral farming to horticulture.

Many benefits from the transition

Significant local co-benefits can be expected from reducing emissions in the New Zealand's economy, including

- Cleaner air, and reduced rates of illness and mortality caused by air pollution. Pollutants from fossil-fuel vehicles (particularly those that run on diesel) are associated with respiratory illnesses such as asthma, impaired lung development and function and heart, brain and general health issues. A shift to a low-emissions vehicle fleet would remove these pollutants.
- Cleaner water, and less harm to biodiversity. As an emissions price is progressively extended to agriculture, and farmers take greater steps to use nitrates effectively, water pollution will reduce. Greater afforestation could also help reduce soil erosion and the resulting siltation of waterways.
- The emergence of new technologies and firms will provide opportunities for employment, exports and productivity gains. A higher emissions price will foster greater demand for emissions-reducing technologies. A reinvigorated and refocused innovation system will put more effort into developing and applying new ideas that offset, reduce or remove GHGs. New Zealand has already proven to be a fertile ground for developing such technologies, and scope exists to considerably expand New Zealand's contribution to global knowledge.

Meeting the challenge

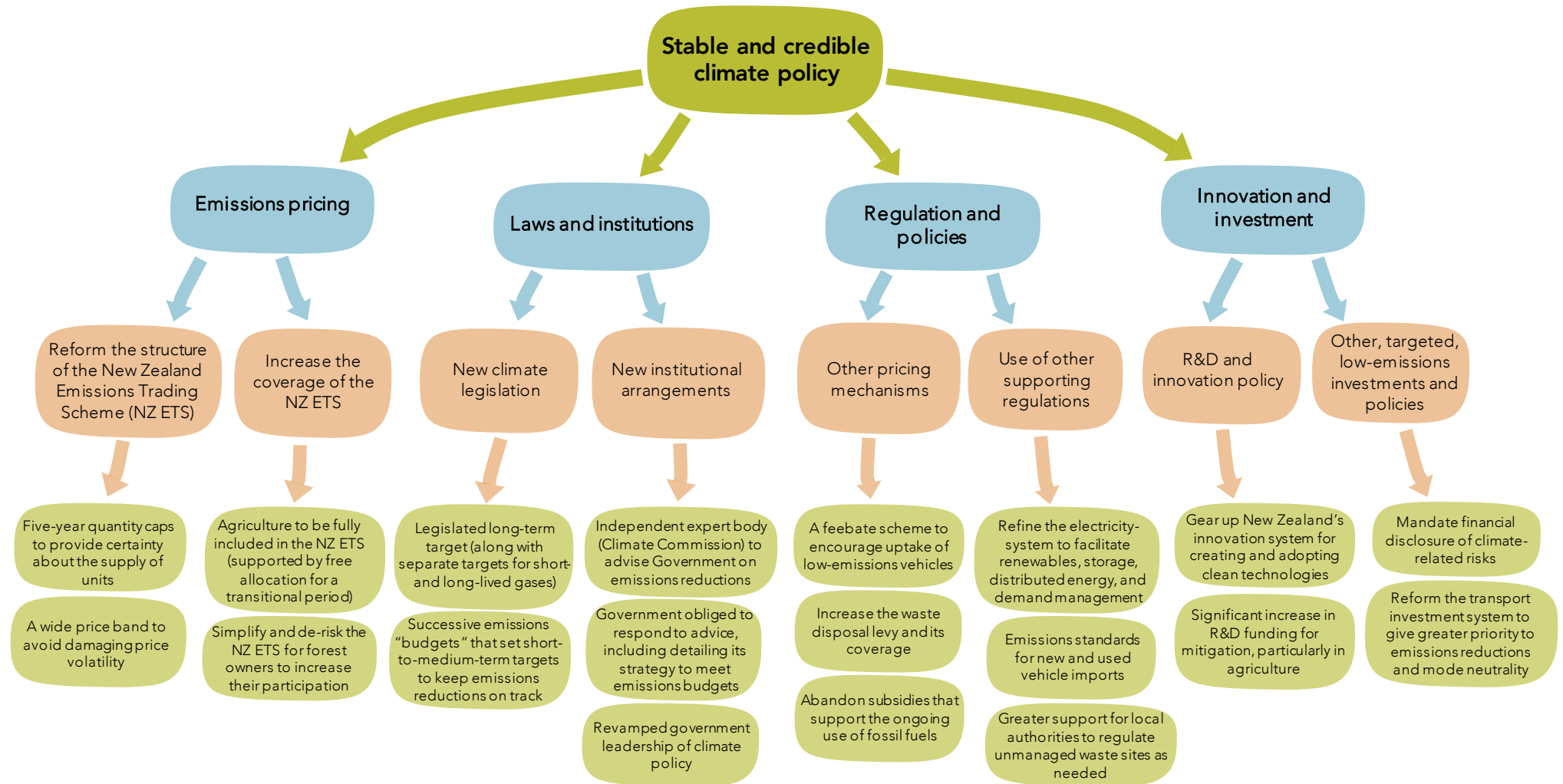
While the challenges of reducing emissions are large, they are not beyond the will or ability of communities to respond. New Zealand has experienced economic and social transformations before, and the scale of change involved in the transition to a low-emissions economy looks comparable to some of those earlier transitions.

This draft report sets out the necessary conditions for New Zealand to transition to a low-emissions economy, while continuing to grow income and wellbeing (Figure 0.7). There is obvious uncertainty about

what lies ahead and how a low-emissions economy will evolve and what this means for New Zealand. An important role for Government is to be clear on its ambition and policy intent for a low-emissions economy, establishing a credible and stable climate policy so that business, households and consumers can plan, invest, make decisions and embrace the opportunities of a low-emissions future.

This is a draft report and is released at this point in our inquiry process in order that the inquiry may benefit from the review and critique of stakeholders with interests in the transition to a low-emissions economy. The Commission welcomes the high engagement to date with stakeholders and looks forward to responses to this draft report as this important work is finalised.

Figure 0.7 Achieving a low-emissions economy for New Zealand



Part One:

Setting the scene

The Government has asked the Productivity Commission to provide advice on how New Zealand should transition to a low-emissions economy.

Part One sets out how the Commission is approaching this task, and provides a guide for reading the rest of this report. It also provides important context for New Zealand's low-emissions transition, including explaining the global challenge of tackling climate change, identifying New Zealand's key emitting sources and trends, and outlining New Zealand's commitments to reducing emissions.

1 About this inquiry

Key points

- New Zealand is committed to be an active participant in the international response to the challenge of climate change and making substantial reductions in its greenhouse gas (GHG) emissions. The Government has asked the Productivity Commission to “identify options for how New Zealand could reduce its domestic greenhouse gas emissions through a transition to a lower emissions future, while at the same time continuing to grow income and wellbeing” (TOR, p. 2).
- Climate change is a classic example of the tragedy of the commons, whereby individuals maximise personal value to the detriment of the whole. The commons in this case is a truly global resource – the shared atmosphere upon which life depends – and its limited ability to absorb GHG emissions without giving rise to climate disruptions potentially enormously damaging to life on the planet.
- Transitioning to a low-emissions future requires effort on two fronts: a fundamental reduction in high-emissions sources and improving the emissions efficiency in production and consumption. This draft report provides insights into how and where emission reductions can be achieved and policies that will be required to drive the transition. It identifies the challenges, opportunities, benefits and costs of alternative transition pathways.
- Future action on climate change is subject to uncertainty; it is both reasonable and appropriate for New Zealand to adapt its policies in response to changed circumstances and a changing evidence base over time, and to take steps to avoid adverse outcomes. Different transition pathways for the economy have been modelled along with different low-emission targets.
- At the heart of a transition to a low-emissions economy is the need for stable and credible climate policy settings. The private sector and civil society must be able to plan and take long-term decisions with confidence. Businesses, households and consumers will be better able to manage the risks of moving to a low-emissions economy and plan for the behavioural and structural changes required in a stable and credible policy environment.
- A stable and credible climate-policy environment requires:
 - A **strong signal** by the Government making a long-term commitment to the transition to a low-emissions economy and being transparent about future policy intentions to achieve this.
 - Getting **emissions pricing** right, to steer investment and change behaviour.
 - Creating **laws and institutions** that support stable policy settings, with clear targets and accountability for action, and that act as a commitment device to help drive the development and implementation of a long-term policy response to climate change.
 - Ensuring other **supportive regulations and policies** are in place, to address non-price barriers, encourage the transition, and manage serious adverse impacts on lower-income households and affected businesses.
 - Harnessing the full potential of **innovation** through significantly more Government resources devoted to supporting research, deployment and adoption of low-emissions innovations.
 - Supporting **investment** in low-emissions technology, infrastructure, and other activities, by greater transparency and mobilising new sources of finance.
- Together, these provide the enabling environment, which will shape the incentives on producers and consumers, to reduce emissions.

1.1 What we have been asked to do?

New Zealand is committed to be an active participant in the international response to the challenge of climate change and making substantial reductions in its greenhouse gas (GHG) emissions. The Government has asked the Productivity Commission to “identify options for how New Zealand can reduce its domestic greenhouse gas emissions through a transition to a lower emissions future, while at the same time continuing to grow income and wellbeing” (TOR, p. 2). This draft report provides insights into how and where emission reductions can be achieved and policies that will be required to drive the transition. It identifies the challenges, opportunities, benefits and costs of alternative transition pathways.

Two broad questions guide this inquiry:

- What opportunities exist for the New Zealand economy to maximise the benefits and minimise the cost of transitioning to a lower net-emissions economy, while continuing to grow incomes and wellbeing?
- How can New Zealand’s regulatory, technological, financial and institutional systems, processes and practices help realise the benefits and minimise the costs and risks of a transition to a lower net-emissions economy?

1.2 The Commission’s approach

An effective transition to a low-emissions economy will mean that New Zealand will look very different in 2050, and even more transformed by 2100. During the transition, action to mitigate GHG emissions will require real and significant changes. Those changes will have disruptive impacts on some businesses and households. A shift from the old economy to a new, low-emissions, economy will be profound and widespread, transforming land use, the energy system, production methods and technology, regulatory frameworks and institutions, and business and political culture.

In the coming years, a range of choices will be made by New Zealand’s government, businesses and society that will influence the structure of the economy and the cost of reducing GHG emissions. The broad purpose of the Commission’s inquiry is to recommend the actions the government might take to reduce New Zealand’s emissions given the range of choices in its control, recognising that some of the factors that will influence the desirability of those choices are beyond its control.

Importantly, the Government has asked the Commission to look at actions that will maximise the benefits and minimise the cost of the transition, while continuing to grow incomes and wellbeing. Wellbeing is a very broad concept that encompasses a range of dimensions, including current quality of life and material conditions as well as sustaining the resources needed for future wellbeing (OECD, 2017b). Thinking on the ambit of wellbeing is still developing. The Treasury, for instance, is building on OECD work to adapt the concept to New Zealand’s circumstances and values (King et al., 2018).

At the core of sustaining future well-being are four types of “capital” – natural, human, economic and social (OECD, 2017). Mitigating climate change is, of course, central to preserving natural capital for future generations. Taking opportunities to maintain and build all these types of capital in the transition will contribute to future quality of life and material wellbeing. Innovation will be central, by finding ways to reduce emissions at low cost, while providing a means to develop new enterprises and ways of living that are consistent with a low-emissions economy. Reskilling will build the human capital needed; actions to reduce emissions will have other environmental benefits (such as improved water and air quality). Developing formal and informal institutions and organisations to set common goals and gain commitment will build social capital. Making sure the costs and benefits of the transition are understood and shared fairly, and that they unfold in a measured way, will also contribute to social capital.

While the Commission does not explicitly address the effects of mitigation efforts on wellbeing in this report, each chapter, in its own way addresses the relevant contributors. The Commission plans to draw these together more systematically for its final report.

Transitioning to a low-emissions future requires effort on two fronts: a fundamental reduction in high-emissions sources and, at the same time, improving the emissions efficiency in production and consumption.

This draft report aims to provide policy decision-makers insights to how and where emission reductions can be achieved, the emissions-pricing and other regulatory policies that will be required to bring about the transition, and the challenges, opportunities, benefits and costs of alternative pathways.

Future action on climate change is subject to uncertainty; it is both reasonable and appropriate for New Zealand to adapt its policies in response to changed circumstances and a changing evidence base over time, and to take steps to avoid adverse outcomes. Different transition pathways for the economy have been modelled along with different low-emission targets. The modelling for this inquiry provides some insight into how different decisions are likely to impact on important outcomes related to wellbeing, such as economic activity, land use and GHG emissions, under uncertain future states of the world.

The climate change problem

Climate change is a problem unlike any other, both because of the scale and because it is mainly about the future. It is a classic example of the tragedy of the commons, whereby individuals have incentives to maximise personal value to the detriment of the whole. The commons in this case is a truly global resource – the shared atmosphere upon which life depends – and its limited ability to absorb GHG emissions without giving rise to climate disruptions potentially enormously damaging to life on the planet.

Climate change policy has several demanding characteristics, including:

- the long-term nature of the climate change problem, spanning many generations;
- the irreversible damage that will arise if present emission trends continue, and the need for both early action and a long-term enduring response;
- deep uncertainty, and the need to accommodate dynamic mitigation pathways where policy choices are deferred or left open until better information is available or policy choices made today are constructed in a way that does not preclude future policy options;
- substantial public good aspects, that are truly global in scope, and provide incentives to free-ride; and
- time inconsistency, where short-term policy decisions are at odds with the optimal policy decisions for the future.

At the heart of a transition to a low-emissions economy is the need for stable and credible climate policy settings. The private sector and civil society must be able to plan and take long-term decisions with confidence. Businesses, households and consumers will be better able to manage the risks of moving to a low-emissions economy and plan for the behavioural and structural changes required in a stable and credible policy environment. As the Parliamentary Commissioner for the Environment puts it,

[u]nderwriting a long-term reorientation of the economy away from fossil fuel dependency requires policy stability decoupled from the short-term ebb and flow of politics ... It requires a broadly shared commitment to steady progress. (PCE, 2018, p. 17)

The need for stable and credible climate policy settings

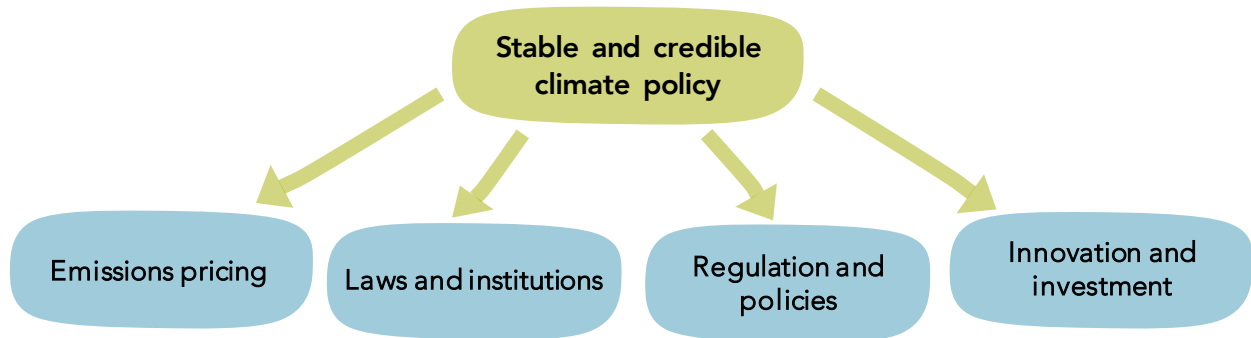
A stable and credible climate-policy environment requires:

- A **strong signal** by the Government making a long-term commitment to the transition to a low-emissions economy and is transparent about future policy intentions to achieve this.
- Getting **emissions pricing** right, to send the right signals for investment and mitigation.
- Creating **laws and institutions** that support stable policy settings, with clear targets and accountability for action, and that act as a commitment device to help drive the development and implementation of a long-term policy response to climate change.
- Ensuring other **supportive regulations and policies** are in place, to address non-price barriers, encourage the transition, and manage serious adverse impacts on lower-income households and affected businesses.

- Harnessing the full potential of **innovation** through significantly more Government resources devoted to supporting research, deployment and adoption of low-emissions innovations.
- Supporting **investment** in low-emissions technology, infrastructure, and other activities, by greater transparency and mobilising new sources of finance.

Together, these provide the enabling environment, which will shape the incentives on producers and consumers, to reduce emissions.

Figure 1.1 Achieving a low-emissions economy



The Commission’s approach to this inquiry is to take the above cross-cutting themes and examine opportunities across the various emitting sources and sectors to transition to a low-emissions economy; specifically, the opportunities regarding land use, transport, electricity, heat and industrial processes, waste and the built environment.

The opportunities to lower emissions need to be considered within the wider policy and institutional framework because:

- each technology or production process has unique characteristics, requiring the right mix of institutions and policies;
- some technologies and processes may offer greater opportunities for cost-effective reductions in emissions than others – so policies need to provide incentives for businesses, households, and consumers to find these opportunities; and
- actions to reduce emissions may also involve a variety of co-benefits or costs.

Action to lower emissions also needs to operate within several complex and interacting systems. These include the domestic and global economies, the physical environment, and social systems shaped by beliefs, social norms and values. Adding to this complexity is uncertainty about future technological change. The choice of options to lower emissions will need to take account of this complexity and uncertainty, using data on emerging developments and analysis to feed back into the ongoing policy design and implementation.

The Commission’s approach to identifying opportunities to transition to a low-emissions economy recognises that GHGs have different atmospheric lifetimes. Some are long-lived and accumulate in the atmosphere, such as carbon dioxide which is the dominant driver of temperature. Others are short-lived such as methane, and only influence temperature in relation to their flows in and out of the atmosphere. The relative proportion of short- to long-lived gases has implications for countries’ trajectories towards low-emissions economies, including the make-up of mitigation targets and policy frameworks. This issue is examined in detail in Chapter 5.

An important policy issue in transitioning to a low-emissions economy is that a disproportionate burden of the transition is likely to fall on lower-income households. Emissions-reducing policies recommended in this report are, in the short term, likely to raise energy, transport and food prices. Like previous economic transformations, the shift to a low-emissions economy will create both opportunities and risks. Some existing firms and jobs will disappear, while new business and occupations will emerge. Risks can be minimised and opportunities maximised if people are able to easily acquire new skills and move between jobs. Policies for

an inclusive transition are important both for initial acceptance of climate policy and for its ongoing implementation.

1.3 The scope of the inquiry

The science of climate change

The inquiry does not focus on the science of anthropogenic climate change (change that is caused by humans). New Zealand's international commitments reflect the acceptance by successive Governments of the need to join international efforts to reduce GHG emissions.

Nor does the inquiry make conclusion on what emissions target should be aimed for.

New Zealand's commitments to emissions reductions

Under the Paris Agreement, New Zealand has committed to reduce its emissions to 30% below 2005 levels by 2030, and under the Climate Change Response Act 2002 it has committed to reduce its emissions by 50% below 1990 levels by 2050 (see Chapter 2). The Paris Agreement commits all countries, including New Zealand, to achieve a net-zero emissions economy in the second half of this century.²

Since receiving the Terms of Reference (TOR) the Government has changed. The new Government has not yet formulated a net emissions target for 2050 and beyond. However, it has publicly signalled its intention to take decisive action on climate change and set a more ambitious target for emissions reduction by 2050. While not yet legislated, the Government has announced intentions of setting a net-zero emissions target by 2050. This intention has been reiterated to the Commission in a letter from the new Minister for Climate Change.³

While the TOR exclude an exploration of the suitability of New Zealand's current or any future emissions reduction target, the Commission has adopted a working assumption that the New Zealand Government is aiming for an emissions target of net-zero by 2050

International trading in carbon credits

For a period, New Zealand was able to acquire specified emissions reduction credits generated in other countries to meet its international commitments. Yet New Zealand closed the New Zealand Emissions Trading Scheme to international emissions units in 2015.

A viable and credible international carbon-trading arrangement might emerge in the future that is suitable for helping New Zealand meet its future international GHG emissions commitments. Yet the TOR requests the Commission to look at options to reduce New Zealand's "domestic" GHG emissions. While the possibility of international trading is relevant to how institutions and policies to reduce emissions are designed in New Zealand, the primary focus of the Commission will be on transitioning to a low-emissions economy through reducing domestic emissions.

Adaptation to climate change

The TOR requires that the Commission "should only consider the implications of a changing climate to inform consideration of different economic pathways along which the New Zealand economy could grow and develop" (TOR, p. 4). As a result, the Commission has not, in general, considered adaptation to climate change during the inquiry. However, it has been important to be aware of climate change effects on the future economy, for example as regards to sources of energy or the suitability of land for different uses.

² Net-zero emissions describes a situation in which the amount of GHG emitted into the atmosphere is equal to the amount sequestered or offset (eg, by forestry).

³ Letter to Chair of Productivity Commission, Murray Sherwin, dated 22 December 2017 (See the front of this report).

1.4 Guide to this report

This draft report is structured as follows:

Chapter	Description
Part 1: Setting the scene	
Chapter 1	<i>The inquiry</i> – outlines the Commission’s approach to the inquiry.
Chapter 2	<i>Climate change, emissions and the New Zealand context</i> – provides important context for New Zealand’s low-emissions transition, including explaining the global challenge of tackling climate change, identifying New Zealand’s key emitting sources and trends, and outlining New Zealand’s commitments to mitigating emissions.
Part 2: Low-emission pathways	
Chapter 3	<i>Mitigation pathways</i> – reports the modelling the Commission has undertaken for the inquiry. The modelling examines pathways for New Zealand to transition from the present to two low-emissions targets in 2050. The modelling throws light on the feasibility of the targets, measures needed to achieve them, and the opportunities and risks of alternative pathways.
Part 3: Policies and institutions	
Chapter 4	<i>Emissions pricing</i> – examines emissions pricing as a crucial policy lever to incentivise businesses and individuals to make decisions that lower their GHG emissions.
Chapter 5	<i>Innovation</i> – examines how and why innovation can play a central role in New Zealand’s transition to a low-emissions economy. It assesses New Zealand’s current support for low-emissions innovation and assesses the need to strengthen and prioritise this support.
Chapter 6	<i>Investment</i> – investigates the capital available for New Zealand’s transition to a low-emissions economy, and explores policies and funding options available to Government.
Chapter 7	<i>Law and institutions</i> – examines the role of laws and institutions in supporting a low-emissions transition and recommends reforms to New Zealand’s legal and institutional architecture.
Chapter 8	<i>Short-lived and long-lived gases</i> – explores the different atmospheric lifetime of GHGs and explains why giving greater relative priority to emissions reductions of long-lived gases is important to limit peak warming to well-below 2°C. It examines options for treating short- and long-lived gases differently in the New Zealand context.
Chapter 9	<i>Policies for an inclusive transition</i> – examines how a transition to a low-emissions economy can be realised while addressing the disproportionate impact of climate-related policies on lower-income households.
Part 4: Emissions sources and opportunities	
Chapter 10	<i>Land use</i> – investigates the changes in land use (particularly large-scale afforestation) and the reductions in agricultural emissions (through better farm management and new technology) needed to reach New Zealand’s emissions reduction targets.
Chapter 11	<i>Transport</i> – explores the significant role that transport can play in achieving large emissions reductions (and valuable co-benefits), in particular through the adoption of low-emission vehicles, reducing the emissions of fossil-fuel vehicles, and shifting to lower-emissions modes of transport.
Chapter 12	<i>Electricity</i> – shows how electricity emissions can be substantially reduced over the next thirty years while electricity supports emissions reductions in other parts of the economy.
Chapter 13	<i>Heat and industrial processes</i> – examines options and opportunities to reduce emissions in process heat and industrial processes (such as the production of aluminium, iron, steel and cement). It also considers the potential of carbon capture and storage (CCS) and the suitability of current legislative frameworks for governing CCS activities.
Chapter 14	<i>Waste</i> – reviews mitigation opportunities for emissions from waste.

Chapter	Description
Chapter 15	<i>The built environment</i> – examines the potential for reducing emissions within the built environment, specifically buildings, urban areas, and infrastructure.
Part 5: Achieving a low-emissions economy	
Chapter 16	<i>Achieving a low-emissions economy</i> – summarises the key themes, insights and recommendations from the report.

2 Climate change, emissions and the New Zealand context

Key points

- The international scientific community firmly concludes that increasing human-induced greenhouse gas (GHG) emissions are causing global temperatures to rise. Temperature rise has widespread impacts on human and natural systems. The most relevant impacts for New Zealand are sea-level rise, a warmer climate, ocean acidification, and more frequent extreme weather events, such as droughts and cyclones.
- Limiting the severity of future impacts is possible through achieving substantial and sustained reductions in global emissions. The 195 signatories to the Paris Agreement, including New Zealand, are committed to achieving net-zero global GHG emissions in the second half of this century. The central aim of the Agreement is to limit temperature rise to well below 2°C, with an aspirational target of 1.5°C.
- New Zealand's absolute contribution to global emissions is very small, but its emissions per person are high. New Zealand is yet to see a decline in its emissions. Gross and net emissions have flattened over the last decade after steadily increasing before the mid-2000s. Population and economic growth are key underlying drivers of growing emissions.
- New Zealand's emissions profile differs markedly from other developed countries. Nearly half of emissions are methane and nitrous oxide from agriculture. Transport is the second biggest emissions source, and its emissions have risen more than other sources. Emissions from electricity generation are relatively small due to New Zealand's abundant sources of renewable energy.
- Forestry offsets cover about a third of New Zealand's gross emissions, a high proportion by international standards. However, due to a decline in planting since the forestry boom in the mid-1990s, carbon offsets from forestry have been falling, and are likely to fall further without a significant increase in planting.
- New Zealand's first commitment under the Paris Agreement is a 30% reduction in net emissions relative to 2005 gross emissions levels by 2030. Meeting this target will require a substantial drop in emissions, especially due to the anticipated fall in forestry offsets. New Zealand can also use purchases of international emissions reductions to help meet its target, although no formal mechanism is currently in place for trading international credits.
- The Government plans to replace New Zealand's current long-term (2050) target of a 50% reduction in emissions (compared to 1990 levels) with a more ambitious target that is set in law. To achieve either the current 2050 target or a more ambitious one, New Zealand will need a substantial and sustained shift in the trajectory of its emissions compared to past trends.
- The Climate Change Response Act 2011 provides the main legal framework for New Zealand's climate change mitigation response. In particular, it provides the statutory basis for the New Zealand Emissions Trading Scheme (NZ ETS), the central policy tool for reducing emissions. It also recognises the rights of Māori to be consulted on ministerial decisions related to climate change, giving effect to the Treaty.
- In addition to the NZ ETS, a range of complementary measures led by central government are in place to encourage emissions reductions. Local government, businesses, iwi and communities also play a key role in not only reducing their own emissions, but also supporting the adoption of mitigation opportunities, and fostering wider support for action.

This chapter provides context for New Zealand’s transition to a low-emissions economy. It:

- explains key concepts around climate change and greenhouse gas (GHG) emissions;
- analyses New Zealand’s contribution to global emissions, how its emissions have changed over recent decades and the key drivers of these changes;
- describes the Paris Agreement – the global climate change treaty which New Zealand is party to;
- outlines New Zealand’s current international emission reduction commitments, including the approach used for accounting for emissions, and New Zealand’s progress towards achieving its mitigation targets;
- discusses New Zealand’s long-term commitments for reducing emissions; and
- provides a brief overview of New Zealand’s climate change mitigation governance arrangements, domestic policy, and collective approaches to reducing its emissions.

2.1 The impact of greenhouse gas emissions on the climate

GHG emissions caused by human activity impact global temperatures (Box 2.1). The Intergovernmental Panel on Climate Change (IPCC) concludes:

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever ... Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century. (IPCC, 2014b, p. 4)

Increases in global temperature are causing, and will continue to cause, widespread impacts on humans and natural systems. Due to the large volume of GHGs already released into the atmosphere, some amount of climate change is now unavoidable. However, allowing global average temperatures to rise much more than 1.5°C (compared to pre-industrial levels) risks more serious and irreversible impacts (IPCC, 2014b; Maslin, 2009). Such global impacts include a large increase in heatwaves and extreme rainfalls, water scarcity, threats to food security, dangerous flooding caused by sea-level rise, and major extinction of species of flora and fauna. The magnitude of changes expected from only a small rise in the global temperature is substantial.

New Zealand is not immune to these impacts. Since the early 1900s, New Zealand’s average temperature has already increased by 1°C. While the detail of future climate change is uncertain and depends on global mitigation efforts, New Zealand can expect sea-level rise, a warmer climate, ocean acidification, and more frequent extreme weather events such as droughts and cyclones (Meduna, 2015; MfE & Stats NZ, 2017b).

These impacts will likely have damaging and pervasive long-term consequences for New Zealand’s people and the natural environment (MfE & Stats NZ, 2017b). For instance, rising sea levels will increase the risk of erosion and inundation on New Zealand’s coastlines. Warmer temperatures favour conditions for the spread of diseases and pests and affect the habitats of many species of New Zealand’s flora and fauna, increasing the risk of their extinction. Ocean acidification also threatens many marine species, while more frequent droughts and cyclones will increase flooding and disruptions for households and economic production.

Box 2.1 Greenhouse gas emissions

GHGs trap heat in the earth’s atmosphere – a process known as the greenhouse effect. The different types of GHGs include, for example, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆). These gases form a blanket above the earth’s surface and prevent the sun’s infrared radiation from escaping into outer space. GHGs play an important role in keeping the temperature of the earth’s surface sufficiently warm to support human life.

However, the rapid increase in the rate of human-induced GHG emissions is strengthening the greenhouse effect. Many different types of human activity result in GHG emissions, such as using fossil

fuels for transport and generating energy, deforestation, and farming. Well over half of global GHG emissions are CO₂ emissions.

While human activity increases the stock of CO₂ in the atmosphere, some natural processes remove CO₂ from the atmosphere. This process is known as carbon sequestration, and the reservoir where CO₂ is stored is called a carbon sink. Trees are excellent carbon sinks. They sequester CO₂ as they grow and store it through the process of photosynthesis. However, once a tree stops growing, it absorbs no more CO₂ than it releases.

The length of time that GHGs spend in the atmosphere and the warming impact of GHGs vary. Short-lived gases, such as CH₄, dissipate relatively soon after being released, but can have a large warming effect while present in the atmosphere. By comparison, long-lived gases, such as CO₂, persist in the atmosphere over much longer timescales. For these gases, what matters most for warming is the stock of cumulative emissions stored in the atmosphere over time (Chapter 8).

To enable adding up of emissions of different GHGs, emissions are measured in units of carbon dioxide equivalent (CO₂e). The standard metric used in international agreements is Global Warming Potential (GWP₁₀₀). This measures the amount of warming that a GHG causes over 100 years from being released compared with CO₂.

Source: Allen (2015); IPCC (2014b); Stips et al. (2016); Vivid Economics (2017a)..

2.2 The global challenge of reducing emissions

Substantial and sustained reductions in global GHG emissions are required to limit rises in global temperatures and the harmful impacts of climate change. To have a likely chance of limiting the rise in global average temperatures to 2°C this century, scenarios modelled by the IPCC indicate that global anthropogenic GHG emissions need to reduce by between 40% and 70% by 2050, and to near zero or below by 2100. Few IPCC scenarios show a likely chance of limiting rise to 1.5°C, although results suggest a global reduction in emissions of between 70% and 95% by 2050 is needed to achieve this end (IPCC, 2014b).

Reducing CO₂ emissions to net zero levels is crucial

Because CO₂ can stay in the atmosphere for hundreds of thousands of years, reducing CO₂ emissions to net zero levels – where removals of CO₂ by carbon sinks offset CO₂ emissions – is a crucial part of stabilising global temperatures (Allen, 2015). As long as the world continues to emit more CO₂ than is absorbed and the stock of CO₂ continues to rise, the climate will keep warming (World Bank, 2015).

Further, the world has a finite amount of CO₂ that it can emit to keep global temperature rise below 2°C (and 1.5°C), widely known as the global carbon budget. This budget is being used up rapidly. The IPCC (2014b) estimates the global carbon budget, as at 2011 for a 2°C threshold, is about 1000 gigatonnes (Gt) of CO₂. If global CO₂ emissions continue to rise at current rates, this budget will be used up by around 2036 (Chapter 8).

The Paris Agreement

Since 2015, 195 parties, including New Zealand, have signed the Paris Agreement, committing to the goal of net-zero emissions globally in the second half of this century (Box 2.2).

Box 2.2 The Paris Agreement

The central aim of the Paris Agreement is to keep global average temperature rise this century well below 2°C above pre-industrial levels, and to pursue efforts to limit temperature increase to 1.5°C. The Agreement entered into force in November 2016.⁴

To achieve these temperature outcomes, the Agreement aims to peak global emissions as soon as possible, and to later undertake rapid reductions to reach net-zero emissions – balancing the amount of GHGs emitted into the atmosphere with the amount of GHGs removed from the atmosphere by sinks (eg, forests) – in the second half of this century.

Under the Agreement, each government must communicate their Nationally Determined Contribution (NDC) every five years. Each NDC outlines a country's chosen ambition for emissions reductions, taking into account its domestic circumstances and capability. These commitments are voluntary. However, failing to comply with these commitments puts a country at risk of being "named and shamed" by the international community, and suffering reputational damage.

Emissions reductions pledged so far in NDCs cover roughly only a third of reductions needed to achieve the 2°C target. Countries are expected to set increasingly ambitious emission reduction targets. Article 4 of the Agreement requires developed countries like New Zealand to take the lead in pursuing economy-wide emissions reductions. The Agreement also encourages countries to prepare a long-term development strategy by 2020, which sets out its policy approach to transitioning to a low-emissions economy.

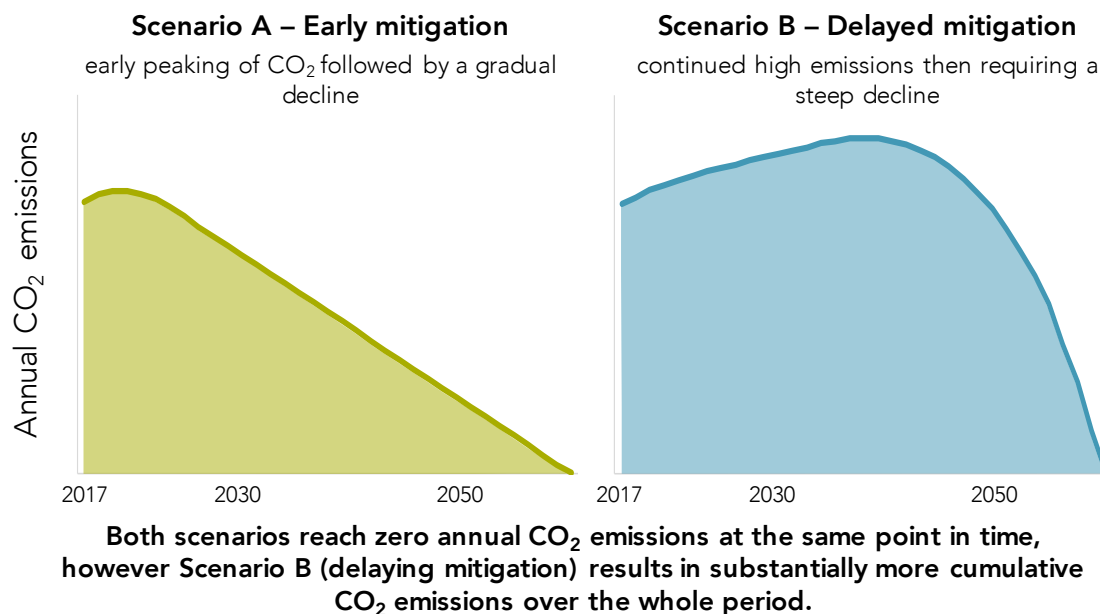
Source: UNFCCC (2018b); UNEP (2017).

Delaying mitigation is costly

The Paris Agreement highlights the urgent need for countries to pursue a low-emissions transition. A low-emissions transition entails the decarbonisation of an economy, including a move away from the use of fossil fuels towards cleaner low-emissions technologies for generating energy. In many countries, significant changes in land use patterns are also needed, to, for instance, remove CO₂ from the atmosphere through greater afforestation, and reduced rates of deforestation (UNEP, 2017).

The pace of this transition matters a great deal. Because most GHGs emitted today will remain in the atmosphere for the rest of the century, delaying action and deferring mitigation to the future comes at the cost of greater long-term warming, even when the future action is substantial (Figure 2.1). It also risks exacerbating the economic and social costs from a low-emissions transition, since future reductions would need to be much more dramatic and abrupt to compensate (OECD, 2017c; RSNZ, 2016; World Bank, 2015).

⁴ Negotiations regarding the implementation of the Agreement are ongoing. Details yet to be resolved include accounting rules and processes for assessing each country's progress towards their NDCs.

Figure 2.1 Simple illustration of CO₂ emissions under early and delayed mitigation strategies

Source: Based on RSNZ (2016).

2.3 New Zealand's emissions profile and recent trends

This section describes New Zealand's contribution to global emissions, its recent emissions trends, and the relative contribution of different sources and gases to New Zealand's overall emissions. The Ministry for the Environment (MfE) reports on New Zealand's emissions each year in the *New Zealand Greenhouse Gas Inventory*. Consistent with the reporting guidelines of the United Nations Framework Convention on Climate Change (UNFCCC), the inventory separates sources of emissions into five broad categories (Table 2.1).

Table 2.1 Categories of emissions sources in New Zealand under UNFCCC reporting

Emissions categories	Dominant examples of emissions sources in New Zealand
Agriculture	<ul style="list-style-type: none"> • Livestock produce CH₄ as they digest their food, through the process of enteric fermentation • A small portion of the nitrogen content in animal urine oxidises into N₂O after interacting with microbes in the soil
Energy	<ul style="list-style-type: none"> • Fossil fuels consumed to power road vehicles emit CO₂ • Process heat generated for manufacturing plants by burning coal or natural gas emits CO₂
Industrial processes and product use	<ul style="list-style-type: none"> • Steel production requires the chemical reduction of iron sand using coal, thereby emitting CO₂ • Refrigeration and air conditioning use HFCs.
Waste	<ul style="list-style-type: none"> • Waste decaying in unmanaged landfills produces CH₄
Land use, land-use change and forestry	<ul style="list-style-type: none"> • As forests grow, they sequester CO₂ from the atmosphere through photosynthesis (an example of emissions removal) • Conversion of forests to pastoral agriculture reduces the stock of carbon held in the land and results in CO₂ being released into the atmosphere.

Source: MfE (2017i).

The inventory also reports on two different measures of New Zealand’s total emissions:

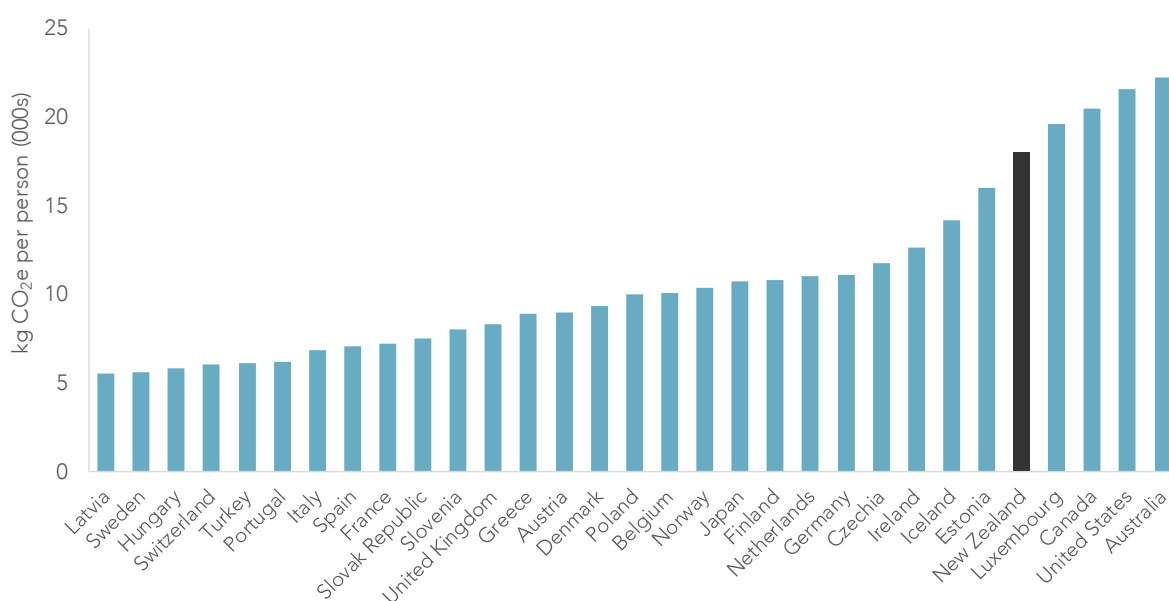
- gross emissions includes all sources of emissions except forestry and other land uses (these come under the category “land use, land-use change and forestry” (LULUCF)); and
- net emissions includes all sources (and removals) of emissions.

The difference between New Zealand’s gross and net emissions is the emissions from forestry and other land uses. This amount can be positive or negative. It is roughly the difference between the amount of CO₂ emitted after forests are harvested or deforested and the amount of CO₂ that growing forests sequester.⁵

New Zealand’s emissions per person are relatively high

New Zealand is a small country and its emissions make up only about 0.2% of the world’s total GHG emissions. However, New Zealand’s emissions per person are high. Its gross emissions per capita are the fifth highest among developed countries (Figure 2.2).

Figure 2.2 Gross GHG emissions per capita for OECD countries, 2014



Source: OECD (2018a).

F2.1

As a small country, New Zealand’s absolute contribution to global emissions is small. However New Zealand’s per person emissions are one of the highest among developed countries.

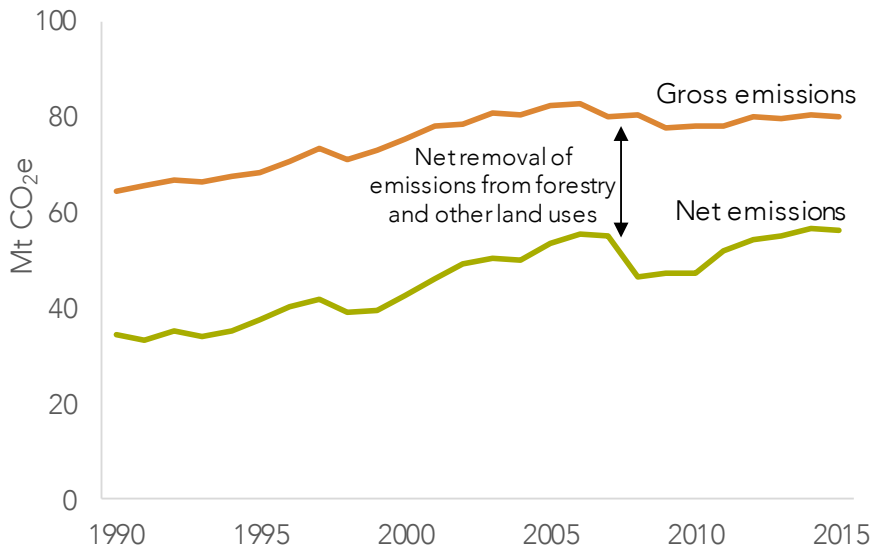
New Zealand is yet to see a sustained decline in its emissions

New Zealand’s gross and net emissions have flattened over the last decade after steadily rising before the mid-2000s (Figure 2.1). Between 1990 and 2015, gross emissions rose by about 15 megatonnes (Mt) of CO₂e, or in percentage terms by about 24%. Net emissions increased by about 22 Mt CO₂e or 63%, reflecting the rise in gross emissions as well as a fall in the net amount of CO₂ removed by New Zealand’s forests. Factors causing emissions to fluctuate include the Global Financial Crisis, lower livestock numbers during droughts, tree harvesting cycles, cold winters, and dry years (PCE, 2017).

New Zealand’s gross emissions are currently greater than its net emissions. This is because New Zealand’s forests are a net carbon sink – they absorb more CO₂ than they release each year. Currently, forestry offsets just under one third of New Zealand’s gross emissions (Figure 2.3).

⁵ Emissions for LULUCF can also come from non-forestry sources such as the change in the stock of carbon held in cropland. However, nearly all New Zealand’s LULUCF emissions are due to carbon sequestration by forests and harvested wood products, forest harvesting and deforestation.

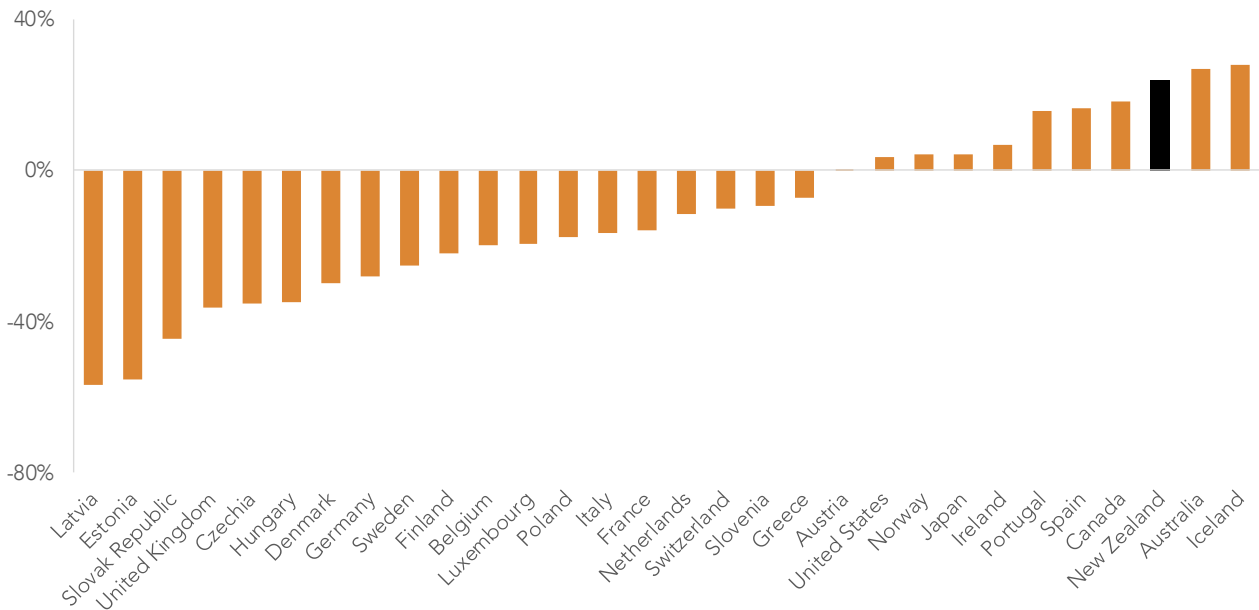
Figure 2.3 New Zealand's gross and net emissions, 1990–2015



Source: MfE (2017i).

Over the last 25 years, New Zealand’s emissions have increased faster than most other developed countries. Further, more than half of developed countries reduced their emissions between 1990 and 2015 (Figure 2.4). These trends not only reflect the relative stringency of each country’s mitigation efforts (including decarbonising their energy supply), but also a multitude of other country-specific factors such as economic and population growth, and the composition of each country’s emissions. For example, strong population growth was a factor that contributed to New Zealand’s rising emissions (see discussion later in this section).

Figure 2.4 Percentage change in gross emissions across OECD countries, 1990–2015



Source: OECD (2018a).

Notes:

1. Turkey is excluded from Figure 2.4, as its rate of emissions growth is a significant outlier.

F2.2

New Zealand is yet to see a sustained decline in its emissions. Gross and net emissions have flattened over the last decade after steadily increasing before the mid-2000s. In contrast, most other developed countries have lowered their emissions.

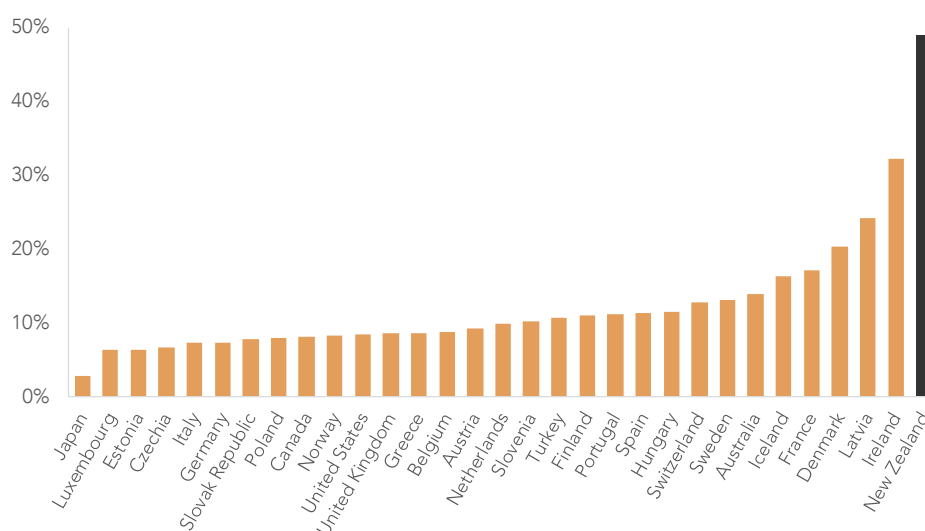
New Zealand's emissions profile is distinctive

The challenge New Zealand faces in mitigating its emissions differs from most other developed countries, because of its distinctive emissions profile. New Zealand's emissions profile largely reflects its prominent agricultural and forestry sectors, and its abundant sources of low-emission renewable energy.

Agriculture and transport make up a large share of New Zealand's emissions

Nearly half of New Zealand's emissions come from agriculture (Figure 2.6) – considerably more than any other developed country (Figure 2.5). Sheep and cattle are responsible for nearly all New Zealand's agricultural emissions. Over a third of New Zealand's total emissions are CH₄ produced by livestock, from digesting their feed. About 10% of emissions are N₂O that arise from the oxidisation of the nitrogen in animal urine and dung and in chemical fertilisers.

Figure 2.5 Agricultural emissions as a percentage of gross emissions across OECD countries, 2014



Source: OECD (2018a).

After agriculture, the largest source of emissions is transport – particularly road transport. Together, transport and agriculture account for roughly two-thirds of emissions. Generating energy for manufacturing is also a significant emissions source, accounting for about 8% of emissions. This includes emissions from industrial heat for drying milk and producing chemicals.

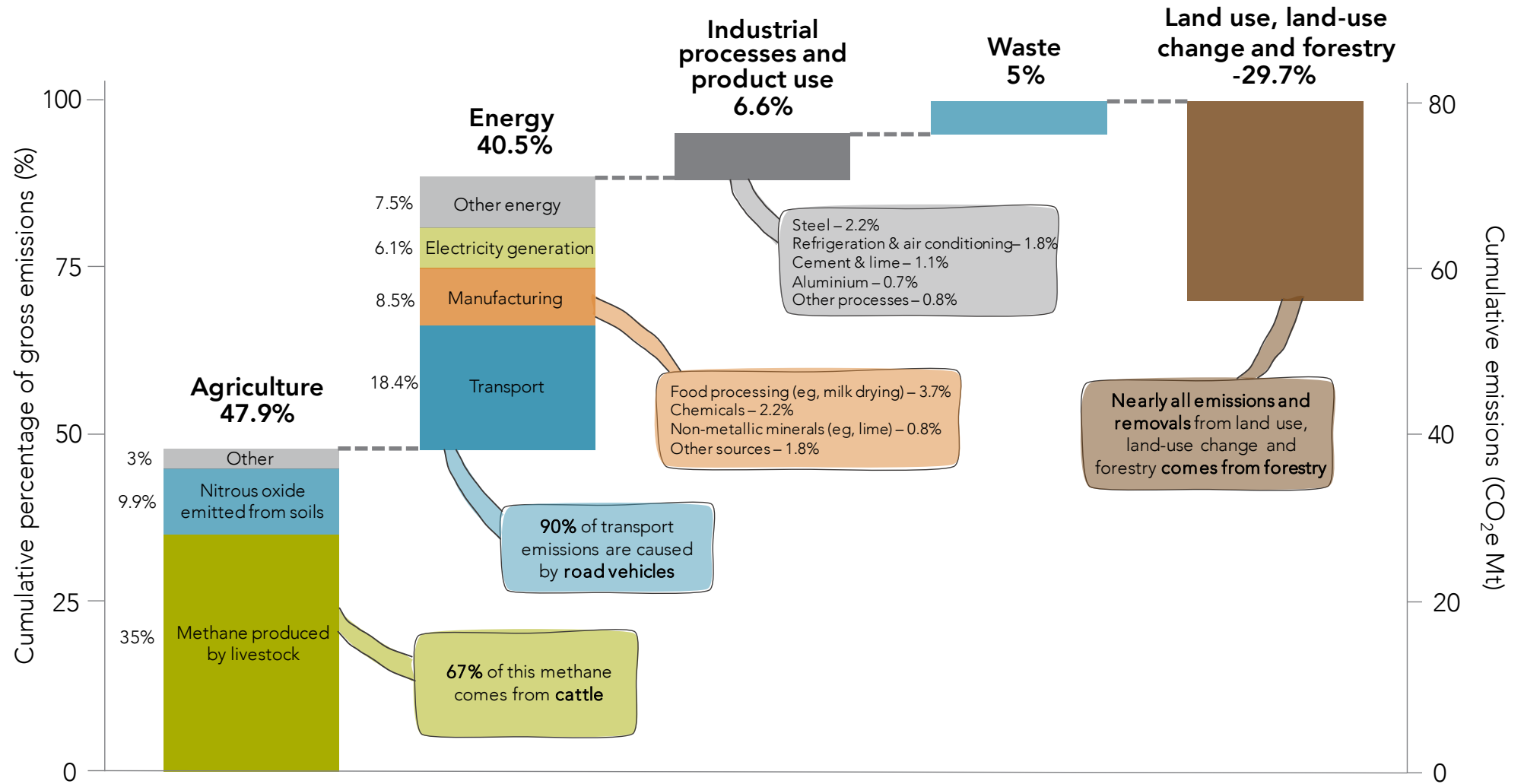
Electricity generation accounts for about 6% of emissions. The percentage is low by international standards, due to New Zealand's abundant sources of low-emissions renewable energy. Around 85% of New Zealand's electricity is generated using renewable sources, particularly hydropower and geothermal power. This compares to 17% in Australia, 25% in the United Kingdom, and 65% in Canada (Clean Energy Council, 2016; Natural Resources Canada, 2018; UK Government, 2017a). Overall, roughly 40% of New Zealand's energy (including for transport, electricity and industrial heat) is generated using renewable sources.

Industrial processes such as those used to manufacture steel, cement and aluminium contribute about 5% of emissions, with a large proportion of these produced by a relatively small number of large emitters. Emissions from the waste sector also make up about 5% of emissions. The use of fossil fuels for space heating of commercial and residential buildings, and the use of refrigeration and air conditioning systems, both account for just under 2% of emissions.

F2.3

Agriculture makes up nearly half of New Zealand's emissions – more than any other developed country. Transport is the next largest source, contributing about a fifth of emissions. Electricity emissions are relatively low in New Zealand due to the country's abundant sources of low-carbon, renewable energy.

Figure 2.6 New Zealand’s GHG emissions and removals by source, 2015



Source: MfE (2017i, 2017j).

Notes:

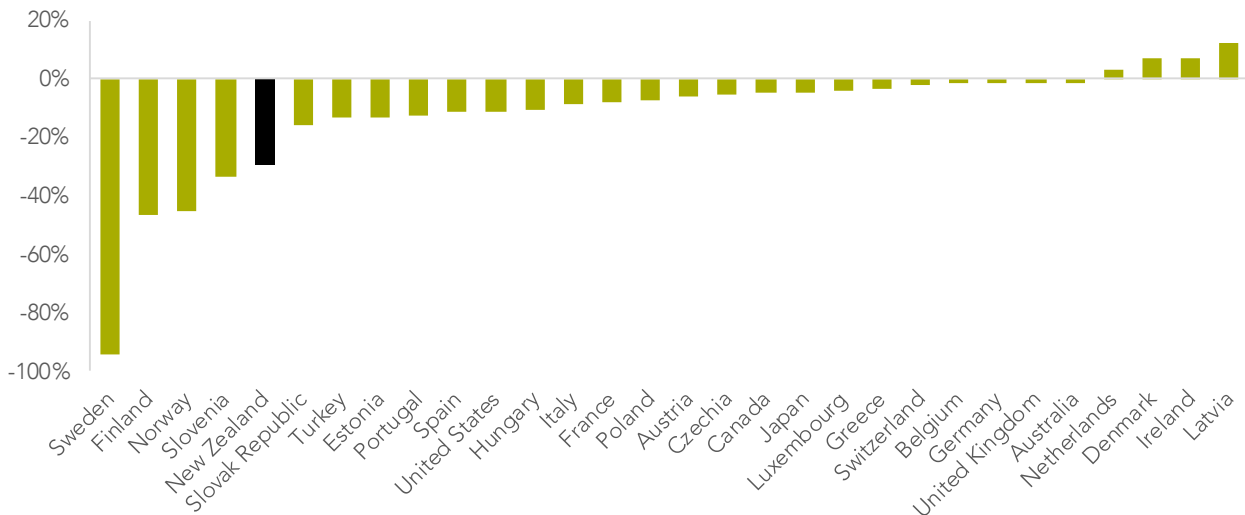
1. Emissions from industrial processes exclude emissions from the generation of energy to power those processes.
2. Emissions from electricity generation include fugitive emissions from producing geothermal energy.

Forestry plays a significant role in offsetting New Zealand's gross emissions

Sequestering carbon in forests at present offers the only viable way of meaningfully removing CO₂ already emitted into the atmosphere (Evison, 2016). On the other hand, harvesting forests and changing land uses, for example from forestry to pastoral farming, emits CO₂.

New Zealand's forests offset just under one-third of gross emissions each year – a significant proportion by international standards (Figure 2.6 and Figure 2.7). Plantation forests cover about 1.7 million hectares of New Zealand's land. Those forests and strong historic planting (especially in the mid-1990s) have benefited New Zealand by lowering the country's net emissions.

Figure 2.7 Forestry and other land-use emissions as a percentage of gross emissions across OECD countries, 2015



Source: OECD (2018a).

Notes:

1. Israel, Chile, Mexico and Korea are excluded due to absence of up-to-date data. Iceland is also excluded as it is an extreme outlier – above 200%.

Yet the yearly amount of CO₂ sequestered by New Zealand's forests fell by about 20% between 1990 and 2015 (MfE, 2017i). Since the planting boom in the mid-1990s, planting rates have fallen dramatically to the point where the total area of forest deforested each year is now greater than the area of new plantings (see Chapter 10).

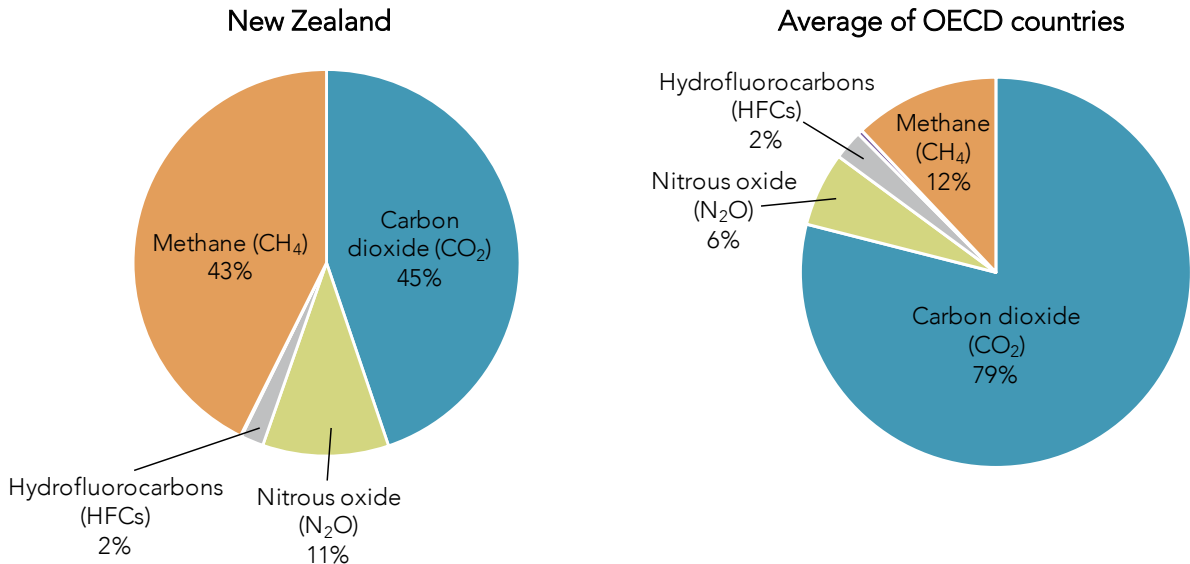
In addition, forest CO₂ sequestration is likely to fall further without a significant increase in planting, as many of those forests planted in the 1990s are due for harvest between now and 2030 (MfE, 2017d).

F2.4

Forestry offsets just under one-third of New Zealand's gross emissions. Yet, because planting rates have dropped sharply since the planting boom in the 1990s, and many of these forests are shortly due for harvest, carbon offsets from forestry are likely to decline without a significant increase in planting.

Carbon dioxide, methane and nitrous oxide emissions are all important for New Zealand

For other developed countries, limiting the impacts of climate change primarily means focusing on mitigating CO₂ emissions. Yet, because such a large proportion of New Zealand's emissions comes from agriculture (and such a small proportion comes from generating electricity), over half of its emissions are made up of non-CO₂ gases – CH₄ and N₂O (Figure 2.8).

Figure 2.8 GHG gross emissions by gas, for New Zealand and OECD countries, 2015

Source: OECD (2018a).

Notes:

1. Perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆) together accounted for approximately 0.1% of New Zealand's emissions and 0.4% of the average OECD country's emissions.
2. OECD countries exclude Israel, Korea, Chile for which no data was available.

The large contribution of CH₄ to New Zealand's emissions is important because CH₄ is a short-lived gas – it lasts on average about 12 years in the atmosphere. While reducing CH₄ emissions slows warming and limits temperature rise, eliminating CH₄ emissions is not needed to stabilise global temperatures (Chapter 8).

This is not to say that CO₂ is not important in the New Zealand context. CO₂ is still the most prominent GHG in New Zealand, making up around 45% of emissions. Further, New Zealand's CO₂ emissions have increased much more than other gases over the last 25 years (see next subsection). Transport contributes roughly 40% of New Zealand's CO₂ emissions, while generating energy for manufacturing contributes just under 20%.

F2.5

New Zealand's emissions profile differs markedly to other developed countries, because of its high agricultural emissions and low electricity emissions. While carbon dioxide is New Zealand's most prominent greenhouse gas, over half of emissions are methane and nitrous oxide.

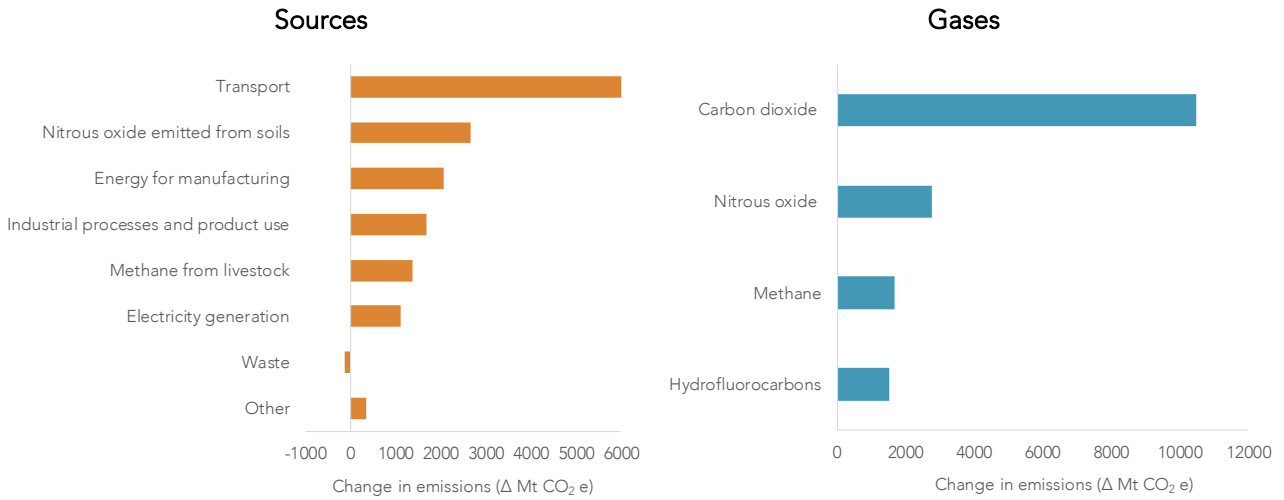
Transport has dominated the increase in New Zealand's emissions

Transport has been by far the biggest contributor to the rise in New Zealand's gross emissions since 1990. As a result, CO₂ emissions have risen much more than other gases (Figure 2.9). Between 1990 and 2015, transport emissions increased by about 70%. Over this period, New Zealand's vehicle fleet increased in size by 1.5 million vehicles. New Zealand's vehicle fleet is among the oldest and lowest in terms of fuel efficiency in the developed world, therefore exacerbating the emissions impact of having additional vehicles on the road (Chapter 11).

Growth in agricultural emissions accounted for only a quarter of the increase in gross emissions, since the large growth in emissions from dairy farming was partially offset by a fall in emissions from sheep and beef farming. Between 1990 and 2015, New Zealand's sheep numbers halved and beef cattle numbers fell by nearly a quarter, while its dairy herd nearly doubled. The intensification of the dairy industry, and greater use of synthetic nitrogen fertilisers led to more than a 50% rise in agricultural N₂O emissions (Chapter 10).

The rise in industrial emissions mostly came from HFCs used to replace ozone-depleting substances in refrigeration and air conditioning. Waste emissions decreased, mainly due to better landfill management practices, such as CH₄ recovery.

Figure 2.9 Absolute change in gross emissions across sources and gases, 1990–2015



Source: MfE (2017).

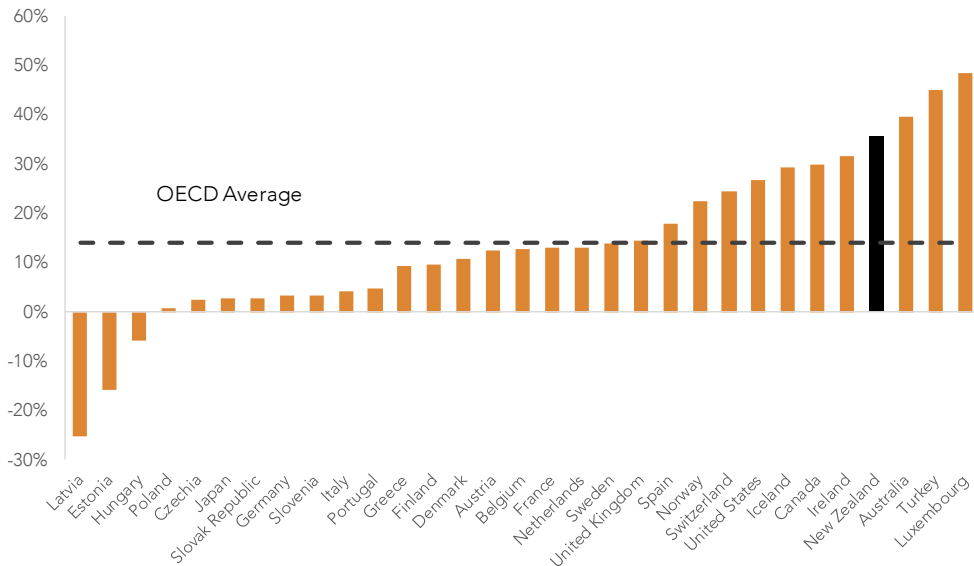
F2.6

Transport has been by far New Zealand’s fastest growing emitting source, in absolute terms, followed by nitrous oxide emitted from soils. Strong growth in emissions from dairy farming was partially offset by a fall in emissions from sheep and beef farming. Because of the large growth in transport emissions, carbon dioxide emissions have risen much more than methane and nitrous oxide.

Population and economic growth have been underlying drivers of emissions

Strong population growth and economic growth have been key underlying drivers of New Zealand’s rising emissions since 1990. Between 1990 and 2015, New Zealand’s real GDP nearly doubled. During the same period, population growth was higher than most other developed countries (Figure 2.10). More people means greater consumption of goods and services that contain emissions (eg, more vehicle use, and greater demand for electricity). Economic growth (and, indirectly, population growth) means more emissions-intensive goods and services are produced, leading to higher emissions.

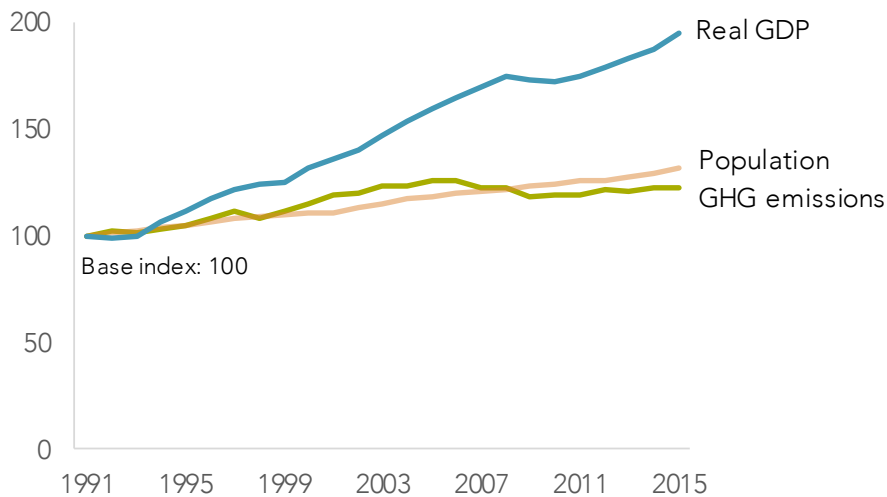
Figure 2.10 Population growth across OECD countries, 1990–2015



Source: UN DESA (2018).

Yet, emissions have been growing slower than economic and population growth (Figure 2.11). The average New Zealander was responsible for 8% fewer emissions in 2015 than in 1990, while New Zealand emitted about 37% fewer emissions per unit of goods and services produced (also known as emissions intensity) over the same period. Technological advancements in areas such as energy and fuel efficiency, and agriculture, and greater use of low-emissions sources of electricity help to explain these trends. Globally, declining emissions intensity has been a recent trend (RSNZ, 2016).

Figure 2.11 Relative growth in New Zealand’s gross emissions, population and real GDP, 1991–2015



Source: MfE (2017i); Stats NZ (2018c, 2018d).

New Zealand’s population is projected to hit 6 million by 2050, and the economy is projected to grow. Future population and economic growth could therefore provide a challenge for New Zealand, at least in the short term, to reduce its total emissions. That said, the impact of future population and economic growth on emissions could diminish with advances in technologies. For instance, currently, population growth is strongly linked to higher transport emissions, but the adoption of low-emission vehicles (eg, electric vehicles) could significantly reduce the emissions that an additional person produces.

F2.7

Economic and population growth have been important underlying factors in New Zealand’s rising emissions. Over the last 25 years, New Zealand’s emissions per person and emissions per unit of output have decreased, but the increase in population and output has caused overall emissions to increase.

2.4 New Zealand’s international mitigation commitments

As a party to the Paris Agreement, New Zealand has committed to reducing GHG emissions to limit global temperature rise to well below 2°C, and to pursue efforts to limit temperature rise to 1.5 °C. New Zealand recently submitted its first NDC under the Paris Agreement. This has a target of reducing emissions to 30% below 2005 levels by 2030. New Zealand is required to submit a new or updated NDC by 2020 and every five years after that. Commitments must become increasingly ambitious.

In addition, New Zealand has a 2020 target, set through the UNFCCC, to reduce emissions to 5% below 1990 levels.

Both New Zealand’s 2020 and 2030 targets are examples of international responsibility targets. This means that New Zealand can meet these commitments through a combination of reducing its domestic net emissions, and purchasing credits for emissions reductions in other countries (Box 2.3).

Box 2.3 The contribution of international credits to emission reduction targets

New Zealand can make progress towards meeting its international commitments by purchasing emissions reductions from other countries. The Paris Agreement explicitly allows for “cooperative approaches that involve the use of internationally transferred mitigation outcomes towards nationally determined contributions” (UNFCCC, 2015b, p. 6). For New Zealand’s first NDC, the previous Government expressed its intention to use these reductions to meet its 2030 target.

The use of international offsets played an integral part for New Zealand in meeting its first emissions reduction commitment between 2008 and 2012 under the Kyoto Protocol. At the time, New Zealand’s Emissions Trading Scheme (NZ ETS, see section 2.6) was linked to the global carbon trading market set out in the Kyoto Protocol, which allowed emitters to purchase overseas credits to “pay” for their emissions. New Zealand accumulated a large surplus of overseas credits, after a huge oversupply on that market led to a dramatic drop in the global price of emissions credits. It is widely accepted that a significant number of credits traded in the global market did not constitute credible emissions reductions (E. Mason, 2013; OECD, 2017e). New Zealand was the top buyer of units from this market, as a proportion of its domestic emissions (Young & Simmons, 2016).

At present, no formal mechanism is in place for trading international emissions reductions, since the NZ ETS is no longer linked to global markets. The Government is currently working with other countries on developing new arrangements for trading credits under the Paris Agreement (MfE, 2015a). Possible arrangements could include purchasing reductions from individual governments, co-operative approaches, and linking New Zealand’s emissions market bilaterally with other markets. The development of such arrangements is in its early stages. Ensuring that any future purchases of emissions reductions are of a high environmental integrity will be essential for maintaining the credibility of New Zealand’s mitigation efforts.

Accounting for international commitments to reduce emissions

Accounting for New Zealand’s emission reduction targets is not as simple as comparing New Zealand’s net emissions (as reported in the national inventory) in the specified target year with its net emissions in a baseline year. The three reasons for this are:

- New Zealand uses a gross/net accounting approach for its targets;
- only certain types of forests can contribute towards New Zealand targets; and
- progress toward New Zealand’s targets is based on emissions across a multi-year period.

A gross/net accounting approach means that New Zealand’s targets are expressed as reductions in net emissions compared to a historic gross emissions baseline. For example, New Zealand’s 2030 target of reducing emissions to 30% below 2005 levels translates to a 30% reduction in net emissions compared to 2005 gross emissions levels. The implication is that past forestry emissions do not affect the setting of emissions targets but can contribute towards achieving them.

However, net emissions reported in the GHG inventory are **not** the same as net emissions for the purposes of New Zealand’s targets. This is because special accounting rules determine the types of forestry and other land-use emissions that can count towards targets. Box 2.4 explains these rules.

Further, New Zealand manages its progress towards its targets using a multi-year budget approach. Rather than just looking at emissions in the single target year, New Zealand looks at emissions in each year across a target period. New Zealand’s commitments require it to keep emissions over this target period within an allocated budget so that the country stays on track to achieve its specific emissions target. For instance, New Zealand’s 2030 NDC target has a target period from 2021 to 2030. Over this period, New Zealand must keep its total net emissions (minus any international credits) below roughly 600 Mt CO₂e (or 60Mt a year).

Box 2.4 Accounting for forestry emissions: inventory versus emissions-reduction targets

The amount of forestry and land-use emissions reported in New Zealand's inventory is not the amount that counts towards its targets. This is an important yet often misunderstood fact. The inventory includes emissions for all land across New Zealand. Yet, special accounting rules determine the subset of these emissions that can contribute towards targets. These rules are intended partly to ensure that countries are only rewarded for newly planted forests.

One of the most consequential rules concerns the treatment of forests established before 1990. Essentially, the removal of CO₂ by these pre-1990 forests does not count towards New Zealand's targets, but it is included in estimating net emissions for the inventory. This distinction may seem minor, but it is important. Of the 24 Mt of CO₂ sequestered in 2015, only about 12 Mt counts towards New Zealand's 2020 target.

Accounting rules can also differ between specific targets. For the Paris Agreement, countries have greater flexibility in choosing their own accounting rules, compared to under the Kyoto Protocol. In its first NDC, the Government has indicated that it will modify the Kyoto Protocol rules to adopt an averaging approach,⁶ though the full details of the rule changes are not yet confirmed.

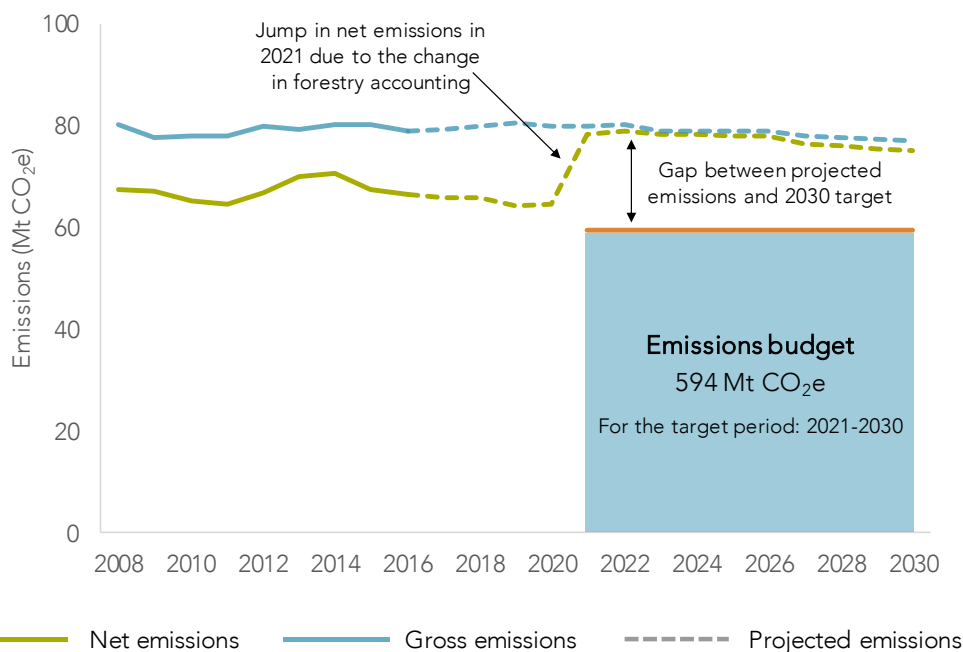
Source: MfE (2017b, 2017i); New Zealand Government (2017b).

Progress towards New Zealand's current international commitments

New Zealand is on track to meet its upcoming 2020 target. The target period for this commitment is between 2013 and 2020. MfE projections indicate that emissions over this period will end up comfortably within the allocated emissions budget, only after recognising New Zealand's surplus credits from its first commitment under the Kyoto Protocol.

However, New Zealand's first NDC under the Paris Agreement will be far more challenging to meet (Figure 2.12). The gap of roughly 20 Mt CO₂e a year between New Zealand's projected emissions path (based on current policies) and its emissions budget is significant. This gap is equivalent to New Zealand's yearly emissions from dairy farming. Net emissions (calculated using target accounting rules) are expected to jump up substantially in 2021, due to the upcoming change in accounting rules for forestry emissions (Box 2.4). However, if the rules did not change (and assuming no additional policies), New Zealand's net emissions would likely increase by even more, because of the significant harvesting expected in the 2020s (Young & Simmons, 2016; see footnote 6 below).

⁶ New Zealand communicated in its NDC that it will adopt an averaging approach for accounting for forest sequestration. Under this approach, New Zealand will receive credit for sequestering CO₂ in a forest up to the long-term average stock of carbon stored in the forest. After this point, a forest is assumed to be carbon neutral. So, New Zealand's emissions, with respect to targets, are not affected when a forest is harvested, as long as the forest is replanted.

Figure 2.12 New Zealand's projected emissions compared with its 2030 target

Source: MfE (2017).

Notes:

1. Net emissions are based on target accounting rules for forestry. Rules are specific to each target period.
2. Emissions projections are based on current mitigation policies.
3. For projections of net emissions after 2020, the Commission took the average of MfE's high and low projections.

F2.8

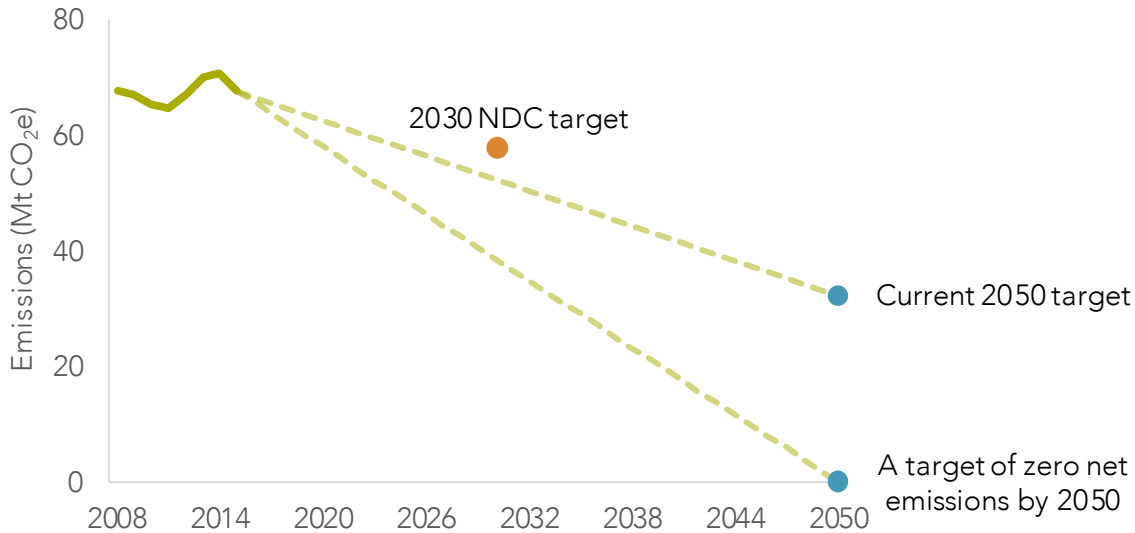
New Zealand is on track to meet its 2020 emission-reduction target. However, its first target under the Paris Agreement for 2030 will be far more challenging to achieve. New Zealand's net emissions are projected to rise in the early 2020s, due to a decrease in forestry offsets.

2.5 A long-term emissions reduction target for New Zealand

Currently, New Zealand has an emissions reduction target for 2050 to reduce net emissions to 50% below 1990 gross emissions levels. The Government set the target in 2011, and gazetted it under section 224 of the Climate Change Response Act 2002. The rules for accounting for forestry and other land use emissions for the target are based on the Kyoto Protocol rules (MfE, 2016b).

The current Government has announced plans to replace this target with a more ambitious long-term target that would be set in legislation. In the Cabinet's 100 Day Plan for Climate Change, the Minister for Climate Change Issues expressed the Government's intention to set a "net-zero" emissions target for 2050, although the Government will undertake a consultation process to consider options for a long-term target (Office of the Minister for Climate Change, 2017, p. 3). The Government has not yet confirmed the role that international offsets will be able to play in meeting a long-term target, although it has agreed in principle that mitigation efforts should not unduly rely on international emissions reductions.

Achieving a 50% reduction in emissions (compared to 1990) or reducing net emissions to zero by 2050 would require a substantial and sustained shift in the trajectory of emissions compared to past trends (Figure 2.13). However, simply meeting New Zealand's current 2030 target would subsequently necessitate an even steeper reduction in emissions post-2030 to reach either target. Introducing a more ambitious long-term target may therefore necessitate a revision of New Zealand's first NDC. New Zealand can adjust its NDCs under the Paris Agreement at any time.

Figure 2.13 New Zealand's net emissions, compared to current and more ambitious 2050 targets

Source: MfE (2017e).

Notes:

1. Net emissions are based on target accounting rules for forestry. Rules are specific to each target period.

F2.9

Achieving either New Zealand's current 2050 emissions-reduction target or a more ambitious emissions-reduction target requires a substantial and sustained shift in the trajectory of its emissions compared to past trends. If the Government adopts a more ambitious long-term target, there is a good case for revising New Zealand's current 2030 target under the Paris Agreement.

2.6 Governance arrangements, policy and collective initiatives

This section provides a brief overview of New Zealand's governance arrangements, policy and collective action approaches to reducing its emissions. It covers New Zealand's Climate Change Response Act and how the Treaty is reflected in current governance arrangements. It also describes New Zealand's main tool for reducing domestic emissions – the New Zealand Emissions Trading Scheme. It concludes by outlining local government, iwi and business initiatives to mitigate emissions.

Governance arrangements

The Climate Change Response Act 2002 (CCRA) is New Zealand's principal statute for mitigating climate change. The Act has two central purposes:

- providing a legal framework for New Zealand to meet its commitments under the Kyoto Protocol and the UNFCCC; and
- implementing, operating and administering the NZ ETS to reduce emissions beyond business as usual (see discussion of the Scheme below).

The CCRA was established in the context of New Zealand's participation in the Kyoto Protocol. After 2020, the Paris Agreement will supersede the Protocol as the global framework for mitigating emissions.

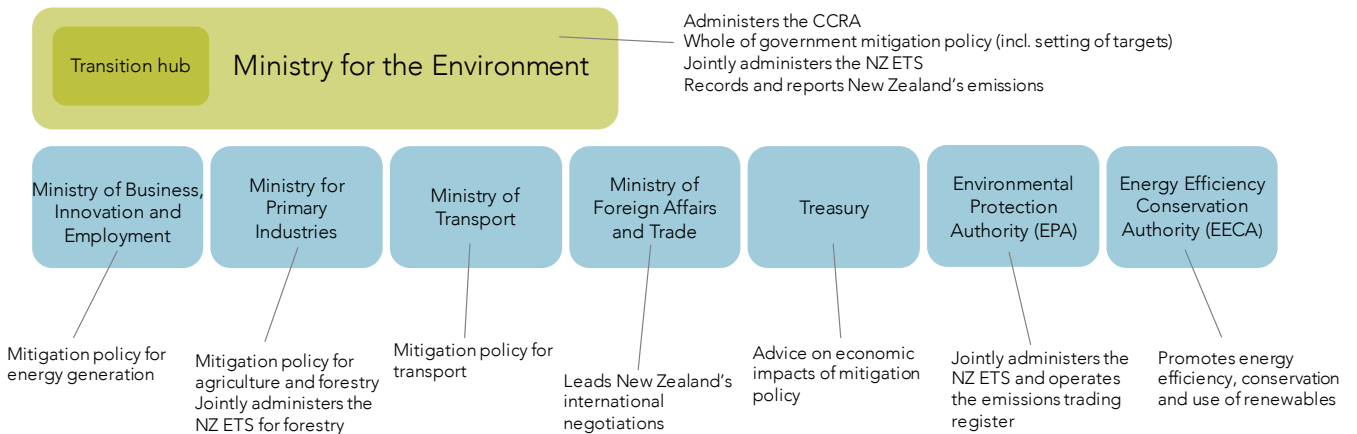
The CCRA requires the Minister or the Chief Executive of the administering agency to consult with Māori before making specified decisions under the Act (Chapter 7). This is intended to recognise the Crown's responsibilities to give effect to the principles of the Treaty of Waitangi, which include the principle of partnership. The specified decisions particularly (but not only) recognise that actions to mitigate climate change may affect or involve Māori interests in the natural environment and their ancestral relationship with

the land (Chapter 10). The Paris Agreement specifically recognises the rights of indigenous peoples in the context of climate change mitigation (CCILG, 2016).

Currently, MfE is the lead department on climate change mitigation, being the administrator of the CCRA. In early 2017, the Government created a Transition Hub to provide advice on New Zealand’s transition to a low-emissions economy. The Hub sits within MfE. The advice it delivers in late 2018 will inform the Government’s strategy for meeting New Zealand’s 2030 target. In late 2017, Cabinet also agreed to establish an interim climate change committee in 2018 to provide further advice on key policy issues (Chapter 7).

Yet, climate change mitigation is far-reaching and several departments across government play a role in providing advice on mitigation, administering mitigation policy and supporting New Zealand in climate change negotiations (Figure 2.14). The Ministry for Primary Industries, for example, not only provides advice on mitigation policy for agriculture and forestry; it also helps to administer the NZ ETS for forestry.

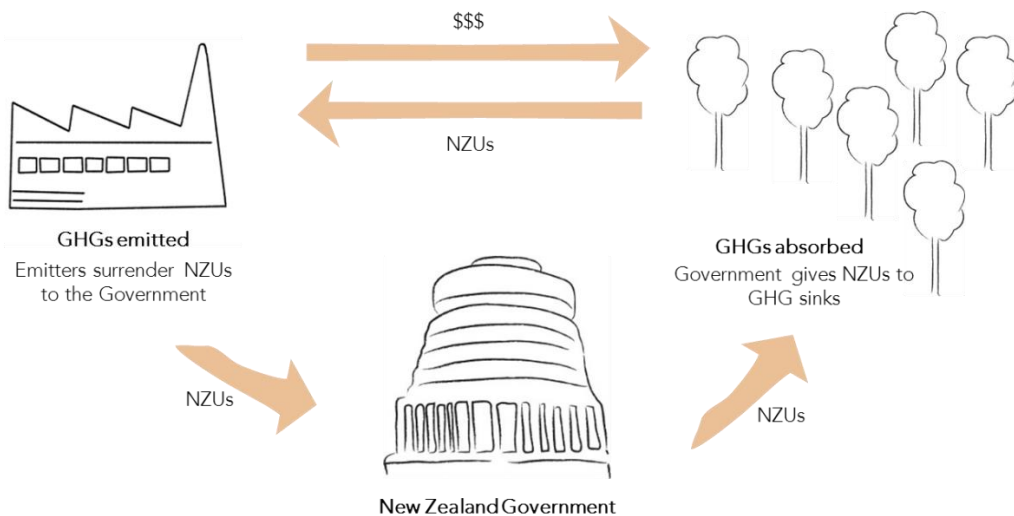
Figure 2.14 Government’s current roles in mitigating New Zealand's emissions



The New Zealand Emissions Trading Scheme

The NZ ETS is the Government’s principal response to climate change. Established under the framework of the CCRA, the NZ ETS commenced in 2008. The NZ ETS currently requires the energy, fishing, forestry, industrial processes, liquid fossil fuels (ie, transport fuels), synthetic gases,⁷ and waste sectors to report on, purchase and surrender emissions units to the Government so as to emit GHGs. Agriculture is the only sector exempted from having to surrender units for their emissions.

Figure 2.15 The basic structure of the NZ ETS



Source: MfE (2015c).

⁷ Synthetic gases emitted in New Zealand include HFCs, PFCs, and SF₆.

Under the NZ ETS, New Zealand Units (NZUs) each represent one tonne of CO₂e. The scheme covers CO₂, CH₄, N₂O, SF₆, PFCs, and HFCs. Participants must surrender one NZU for a certain amount of CO₂e emitted (eg, one NZU for each tonne of CO₂e emitted). The Government provides credits in the form of NZUs to eligible forestry activities that sequester CO₂. Participants can purchase these credits (Figure 2.15). Currently, they can also purchase NZUs from the Government at \$25 a unit.

Allocations of NZUs differ depending on activities of each participant firm and are determined under the Climate Change Response (Moderated Emissions Trading) Amendment Act 2009. Emissions-intensive, trade-exposed (EITE) industries receive free allocations of either 60% or 90% of their requirements as determined by the Climate Change (Eligible Industrial Activities) Regulations 2010. Requirements are determined by multiplying the output of each EITE firm by the average emissions intensity of its industry based on data collected between 2006 and 2009. This system is designed to maintain the international competitiveness of New Zealand production and to prevent emissions leakage.⁸

The point of obligation – the point at which the scheme participant is required to monitor and surrender NZUs – differs for each participant sector but, in general, is upstream (eg, fossil fuel producers or importers) rather than downstream (eg, consumer-level).⁹ For example, in the industrial processes sector the point of obligation is the point of production of the good in question (eg, aluminium), and in the waste sector it sits with landfill operators.

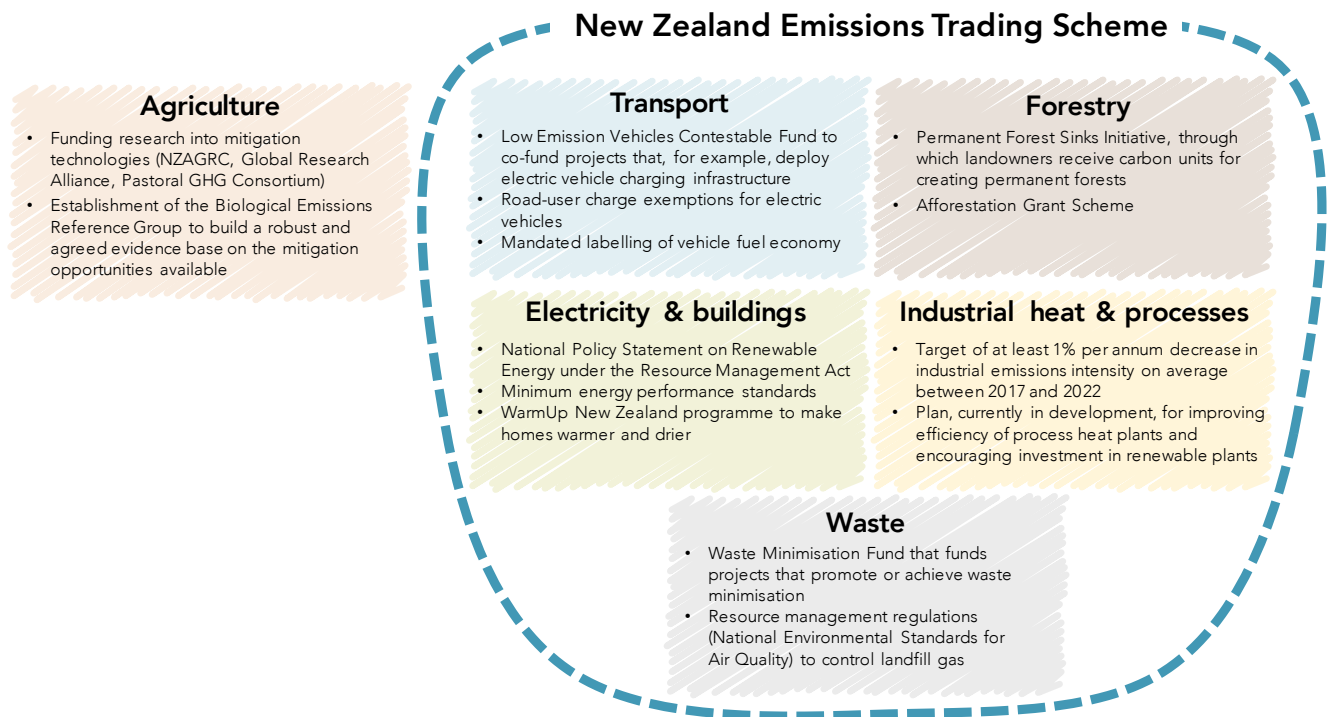
Complementary policies for achieving domestic emissions reductions

Outside the NZ ETS, a range of policies affect New Zealand's domestic emissions, although only a handful was implemented purely for addressing climate change. This demonstrates that emissions reduction policies can have a range of benefits. For example, the Afforestation Grant Scheme was put in place to help reduce soil erosion, improve land-use productivity, boost regional development, improve water quality and store CO₂. Other policies, such as the Warm Up New Zealand: Healthy Homes Programme, were implemented primarily for reasons unrelated to climate change. The Programme subsidises insulation for homeowners to make homes warmer, drier and healthier. Yet improved insulation has the indirect benefit of reducing the need to heat homes, which in turn helps to reduce emissions.

Figure 2.16 provides examples of New Zealand's mitigation policies currently in place. New Zealand's unique emissions profile has also provided impetus for investment into researching low-cost ways of reducing on-farm emissions, such as through the New Zealand Greenhouse Gas Agricultural Research Centre (see Chapter 10).

⁸ Emissions leakage refers to the situation whereby reducing emissions in location A through a reduction in output leads to an increase in output in location B and an increase in its emissions. Where location B is a higher-emitting producer than location A, total emissions may rise.

⁹ See Section 4.4 of MfE and The Treasury (2007) for a more detailed discussion of potential points of obligation in the NZ ETS.

Figure 2.16 Examples of New Zealand's current mitigation policies

Community, industry, iwi and local government initiatives

Concerns about the effects of climate change and a desire to mitigate those effects as part of global action are widespread in New Zealand. Awareness that a consensus supporting more stringent action is growing has motivated others to consider effective responses in their industries or communities. Voluntary action to mitigate climate change (for instance through consumption choices, planting trees, choosing low-emissions production methods) complements Government regulation such as an emissions price.

Examples (among a great many) of voluntary initiatives to mitigate climate change include:

- The Dairy Action for Climate Change Plan led by DairyNZ in association with Fonterra (DairyNZ, 2017);
- Air New Zealand providing customers with an option to offset the emissions from their air travel, by contributing to forestry initiatives;
- The Climate Change Iwi Leaders Group (CCILG), for at least a decade, leading work to develop Māori responses on climate change adaptation and mitigation, and providing advice to Government in support of effective action (CCILG, 2016) and
- Local Government initiatives, for example, providing charging infrastructure for electric vehicles (LGNZ, sub. 36).

Coalitions to take action to mitigate climate change can take different forms. For instance, in 2017, local Government leaders made a climate change declaration in which they together committed to a range of local actions to reduce GHG emissions, guided by a set of agreed principles (LGNZ, sub. 36). Te Rūnanga o Ngāi Tahu has been working with its constituent marae, local government and businesses to develop climate change mitigation and adaptation responses (sub. 83). Te Rūnanga notes that, as a post-settlement iwi, “[w]e are well equipped to partner with central and local government, as natural agents of change and intergenerational investors within the Ngāi Tahu takiwā and nationally” (sub. 83, p. 5).

Both Te Rūnanga o Ngāi Tahu and LGNZ emphasised the importance of climate change mitigation and adaptation together (subs. 36 and 83). This reflects the reality that many marae and local communities face immediate threats from climate change, and actions taken to adapt can also mitigate emissions.

2.7 Conclusion

Globally, countries face the serious challenge of dramatically reducing their GHG emissions to net-zero levels this century to limit temperature rise and the potentially damaging impacts of climate change. The Paris Agreement, the first global climate change treaty, sets out a global goal of limiting rise to well below 2°C with an ambitious goal of 1.5°C.

New Zealand is yet to see a sustained decline in its emissions. Nearly half of New Zealand's total emissions come from agriculture, most of which are methane. This makes New Zealand's emissions-reduction challenge distinctive compared to many other developed countries. Transport is another significant source, and its emissions have been growing rapidly. On the other hand, New Zealand benefits greatly from its large forestry sector as an emissions offset, and the low-emissions footprint of its electricity grid, due to its abundant sources of renewable energy such as hydropower and wind.

For its first commitment under the Paris Agreement, New Zealand has committed to reducing its emissions to 30% below 2005 levels by 2030. This represents a mitigation task of roughly 20 Mt a year between 2021 and 2030, compared to what is projected. To put into perspective, this amount is broadly equivalent to New Zealand's yearly emissions from dairy farming.

The Government also plans to increase the ambition of New Zealand's present long-term emissions-reduction target from a 50% reduction (compared to 1990 levels). To achieve either the current target or a more ambitious one, a substantial and sustained shift in the trajectory of New Zealand's emissions is needed.

A range of government policies are in place to reduce emissions, the main one being an Emissions Trading Scheme, as well as a climate change law. Recent emissions trends clearly show that additional policies and reform of existing policies are necessary. That said, the Government is merely one player; the scale of the climate change problem demands broader action across local governments, iwi, businesses and households.

Part Two:

Low-emission pathways

Part One looked back at New Zealand's historic emissions over the last 30 years. Part Two now looks into the future at possible pathways for New Zealand's transition to a low-emissions economy.

Specifically, Part Two presents the results of modelling undertaken for the inquiry. Crucial to fulfilling the inquiry Terms of Reference, the modelling can throw light on important questions such as:

- Is an ambitious low-emissions target feasible for New Zealand?
- What are likely to be the key opportunities, as well as the biggest risks and uncertainties for New Zealand in reducing its emissions?
- What measures are likely to be needed to achieve a low-emissions economy? What role will an emissions price play?

Examining possible pathways to a low-emissions future lays the ground for later chapters of this report. Part Three examines policies and institutions, such as emissions pricing and setting targets in law, that will be important for keeping New Zealand's emissions headed in the right direction at the right pace. Part Four then digs into specific emitting sources that contain the key opportunities and challenges to reduce emissions

3 Mitigation pathways

Key points

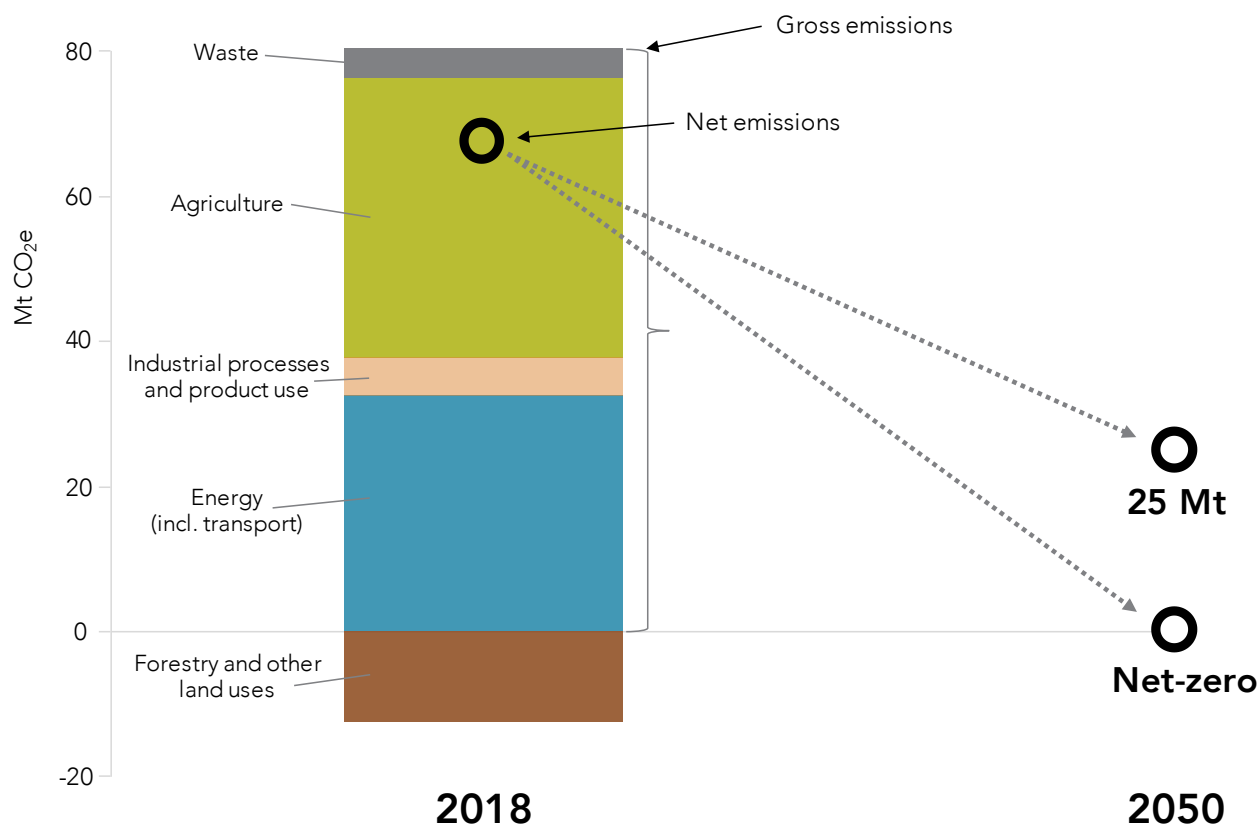
- The Commission has undertaken modelling to examine pathways that lower New Zealand's emissions of greenhouse gases (GHG) from current levels to two alternative long-term targets of 25 megatonnes (Mt) of carbon dioxide equivalent (CO₂e) by 2050 (around a 60% reduction from 1990 levels) and a more ambitious target of net-zero emissions by 2050.
- Modelling can throw light on important aspects of the transition to low emissions including whether a target is feasible, the measures needed to achieve a target, the existence and character of alternative pathways, and a quantitative picture of what needs to happen by when to reach a target.
- Yet modelling has well-known limitations and is not prediction. The transition to low emissions for any country will be a long journey to a known and desired destination, but through very uncertain terrain. The modelling captures some important aspects of the uncertainty by examining three scenarios about how future technology could evolve.
- The scenarios vary in the extent and type of technology changes that reduce emissions, and the impact of those changes on the structure of the economy. In the first, termed 'Policy Driven', technologies are slow to develop so that reductions in emissions must rely on strong policy settings such as high emissions prices. In the second, termed 'Disruptive Decarbonisation', technological change is fast and it disrupts existing industries. In the third, termed 'Stabilising Decarbonisation', technological change is also fast but it reduces emissions in existing industries.
- The modelling simulates six different pathways to low emissions. These arise from the two long-term, emissions-reduction targets and the three scenarios about the type and extent of future technological change. The pathways offer some rich and important insights for New Zealand's transition to low emissions.
- The modelling indicates that reducing New Zealand's emissions at least cost will require three key drivers: the expansion of forestry, the electrification of transport, and changes to the structure and methods of agricultural production. The combination of the three could see New Zealand reduce its emissions to 25 Mt of CO₂e in 2050 at emissions prices rising strongly from current levels to between \$75 a tonne (t) of CO₂e and \$152/t of CO₂e by 2050.
- Further, the results suggest that New Zealand could reach net-zero GHG emissions by 2050, with emissions prices rising more strongly to between \$157/t of CO₂e and \$250/t of CO₂e by 2050. These prices are within the range of emissions prices that will likely be needed in other developed countries to deliver the objectives of the Paris Agreement. Key to enabling New Zealand to reach net-zero GHG emissions by 2050 are its low-emissions electricity system and the availability of a large land area (relative to population) that is suitable for forest expansion.
- Yet, the heavy reliance on forestry could create challenges in the longer term – with continued emissions reductions required after 2050 to maintain net-zero emissions. New Zealand would need to find other ways to reduce emissions or continually plant more and more land in forests. Yet New Zealand has time to consider its options, and develop or deploy technologies that offer new, cost-effective ways to mitigate GHGs.
- Examining possible pathways to low emissions lays the ground for later chapters. Part 3 chapters examine policies and institutions (such as emissions pricing and setting targets in law) that will be important to keep New Zealand headed in the right direction at the right pace. Part 4 chapters dig into sectors such as agriculture, forestry, transport and electricity that contain the key opportunities and challenges to reduce emissions – as highlighted by modelling the pathways.

This chapter presents the results of modelling undertaken for the inquiry. This modelling is crucial to fulfilling the inquiry Terms of Reference which call upon the Commission “to consider the different pathways along which the New Zealand economy could grow and develop so as to achieve New Zealand’s emissions targets”. Without judging their merits of the targets, the Commission has examined pathways from current greenhouse gas (GHG) emission levels to two alternative low-emissions targets:

- net emissions in 2050 of 25 MtCO₂e of GHGs (which is around 60% below 1990 levels¹⁰ and, with further progress, is consistent with achieving net-zero GHG emissions in the second half of the century); and
- a more ambitious target of net-zero emissions of GHGs by 2050 (Figure 3.1).

This first target would achieve a 10 percentage-point greater reduction in emissions than New Zealand’s current long-term target of a 50% reduction on 1990 levels. It would put the country on track to achieve net-zero emissions in the second half of this century. Yet, as noted in Chapter 2, the current Government plans to replace this with a more ambitious target. The Minister of Climate Change re-stated this in a letter to the Chair of the Commission, noting that this “may include setting a zero net emissions target for 2050”. This motivates the choice of the second target used in the modelling.

Figure 3.1 The two emissions targets for the modelled pathways



Modelling pathways to these low-emission targets provides insights to how and where New Zealand can achieve reductions in its GHG emissions to fulfil its international commitments. In particular, modelling can throw light on:

- whether achieving a target reduction in emissions by domestic decarbonisation is feasible;
- the measures needed to achieve a target such as emissions pricing and other regulatory policies;
- the role and importance of different sorts of technological change;

¹⁰ New Zealand’s gross and net emissions in 1990, as measured under its emissions accounting rules, were essentially the same. Sequestration from pre-1990 forests does not generally count as offsetting gross emissions (Chapter 2).

- the alternative pathways that exist and the challenges, opportunities, benefits and costs of each pathway; and
- what likely has to happen by when in quantitative terms – the hard numbers that can reveal where the tough choices and risks lie, as well as the opportunities.

Modelling has limitations and it does not constitute a prediction about the future. Models are a simplified representation of reality focussed on the essential elements and relationships to make complex problems more tractable. By necessity, there is always going to be a level of detail and complexity omitted from modelling. However, models can help build a stronger evidence base to inform decision making. They can be used to shed light on the potential consequences of alternative courses of action, and help identify opportunities and risks.

New Zealand's journey to a low-emissions economy, while to a known destination, is subject to deep uncertainties. It would be foolhardy to try to pin down the best route for this 32-year journey to 2050 in advance. Rather, the situation calls for careful preparation and a capability for adaptation that equips the country to deal well with whatever terrain emerges, and enables a wise choice of route for the first stage of the journey.

The chapter is structured as follows:

- an overview of key modelling results and insights;
- the modelling approach – structure, assumptions and workings;
- results for three modelled pathways that achieve the 25 megatonnes (Mt) target under different scenarios about technology and structural change in the economy, and another three that apply the same scenarios but achieve the more ambitious net-zero target;
- comparisons with other modelling of New Zealand's transition to a low-emissions economy;
- further modelling that will be undertaken for the Commission's final report; and
- conclusions on modelling insights, and how they relate to the rest of the report.

3.1 Overview of key modelling results and insights

In the coming years, New Zealand's government, businesses and society will make choices that will influence the structure of the economy and the cost of reducing GHG emissions. The broad purpose of the Commission's inquiry is to recommend the actions the government might take to reduce New Zealand's emissions given the range of choices within the government's control, yet recognising that some factors that will influence the desirability of those choices are outside its control. The modelling seeks to throw light on the impacts of this decision making by considering how different decisions and outside factors impact outcomes of interest, such as economic activity and GHG emissions across sectors.

The modelling investigates three scenarios about possible technological developments that reduce GHG emissions. Each scenario is associated with matching policy and investment strategies adopted by the government and private actors as New Zealand reduces its emissions. These policies and strategies will also vary according to which target is chosen. Combining each scenario with each target creates six pathways that the modelling investigates. Along each pathway there will be major long-term impacts on investment in capital assets in the energy and industrial sectors, on land use, and on jobs and employment. Sections 3.3 and 3.4 describe and assess these impacts.

The central policy lever for the government is its influence over the emissions price. As detailed in Chapter 4, in New Zealand, this influence comes through setting the total allowable number of emission permits in the New Zealand Emissions Trading Scheme (NZ ETS).

The modelling results, while preliminary, suggest that New Zealand could move onto a pathway consistent with a 60% reduction in net emissions by 2050 at moderate emissions prices by international standards. This

pathway to decarbonisation would rely on three key drivers: the expansion of forestry, electrification of transport, and changes to the structure and methods of agricultural production. By combining the three drivers, the results suggest New Zealand could move to a pathway consistent with 25 Mt of carbon dioxide equivalent (CO₂e) in 2050 at emissions prices that rise to between \$75/t of CO₂e and \$150/t of CO₂e by 2050 (where prices are in 2017 New Zealand dollars).

Further, the results suggest that New Zealand could reach net-zero emissions by 2050 with emissions prices of between \$150/t of CO₂e to \$250/t of CO₂e. These are within the estimated range of the emissions prices likely to be required in other developed countries to deliver on the objectives of the Paris Agreement.

Along the modelled pathways, the expansion of forestry is central to the achievement of large reductions in net emissions. This is particularly the case to achieve net-zero emissions by 2050. Yet this reliance on forestry could create challenges in the longer term – with continued emissions reductions required after 2050 to maintain emissions at around net zero. New Zealand would need to find other ways to reduce emissions, or continue to sequester emissions by further expansion of permanent forestry or forestry for harvest. But New Zealand has time to consider these options and pursue technological developments with the potential for further cost-effective mitigation.

The modelling shows that the electrification of transport has the potential to play a large role in supporting New Zealand's emissions-reduction objectives. With the country's current comparatively emissions-intensive vehicle fleet and its low-emissions electricity system, a move to electric vehicles (EVs) could deliver significant and rapid reductions in emissions. Yet the tendency of New Zealanders to keep their vehicles on the road for up to 20 years or more works against this if no additional measures are put in place.

Emissions reductions in the agricultural sector can be delivered through a mix of technological and structural change. With improvements in emissions intensity, it appears that the dairy industry may be able to expand, although this may be limited by water-quality concerns. Sheep and beef farming is likely to contract, in a continuation of recent trends. The scale of this shift will be driven by demand for land from an expanding forest sector, which increases the opportunity costs of retaining livestock on this land.

The results indicate that greater technological change and early action to raise emissions prices may help to constrain long-term costs. Given technological change is uncertain, this suggests that early action provides future options, which would allow New Zealand to benefit from low costs should technological breakthroughs occur. And New Zealand can continue to meet its commitments with lower risk of high emissions prices in the future, should technological progress be slower than hoped.

Choices made now will have long-term consequences. For instance, assets, such as cars and industrial process heat boilers, may remain in operation for several decades. Likewise, a landowner's decision to convert land may have implications for land use over an extended period. Given these dynamics, it is important to influence these decisions sooner rather than later, to avoid locking-in higher emissions for decades. Yet taking action sooner would need to be balanced against a concern that moving more quickly than international partners could, without protective measures, lead to problems such as some economic activities moving offshore and even increasing global emissions.

Decision makers can and should update their strategies over time as uncertainties resolve and evidence accumulates. In other words, it is both reasonable and appropriate for New Zealand to adapt its policies in response to changed circumstances and a changing evidence base over time, and take steps to anticipate and avoid adverse outcomes. New Zealand's recent history as a flexible economy shows that it can grasp opportunities created by the inevitable shifts in the domestic and international business environment. Further modelling for the final report will test strategies that the government and businesses might adopt in the face of a wide range of potential developments over the coming decades.

3.2 Modelling approach: structure, assumptions and workings

Early in its inquiry, the Commission and the Ministry for the Environment contracted a consortium of organisations with experience in modelling and the economics of climate mitigation to undertake modelling New Zealand’s transition to a low-emissions future. The three organisations and their specialisms are noted below.

- **Vivid Economics** is a London-based consultancy whose practice areas include carbon pricing, energy and industry, growth and development, and natural resources. Vivid Economics produced the report “Net zero in New Zealand” for Globe-NZ, a cross-party group of 35 members in the last Parliament (Vivid Economics, 2017a).
- **Concept Consulting Group** is a specialist energy and economics consultancy based in Wellington. It has done recent work for the Parliamentary Commissioner for the Environment, and several electricity distribution companies (Concept Consulting, 2016, 2017a, 2018).
- **Motu Economic and Public Policy Research (Motu)** is a leading economic and public-policy research institute with an extensive distinguished record of work focused on the environment and agriculture. Recent work on climate mitigation policy includes Motu (2017), Kerr (2016a); Kerr et al. (2017).

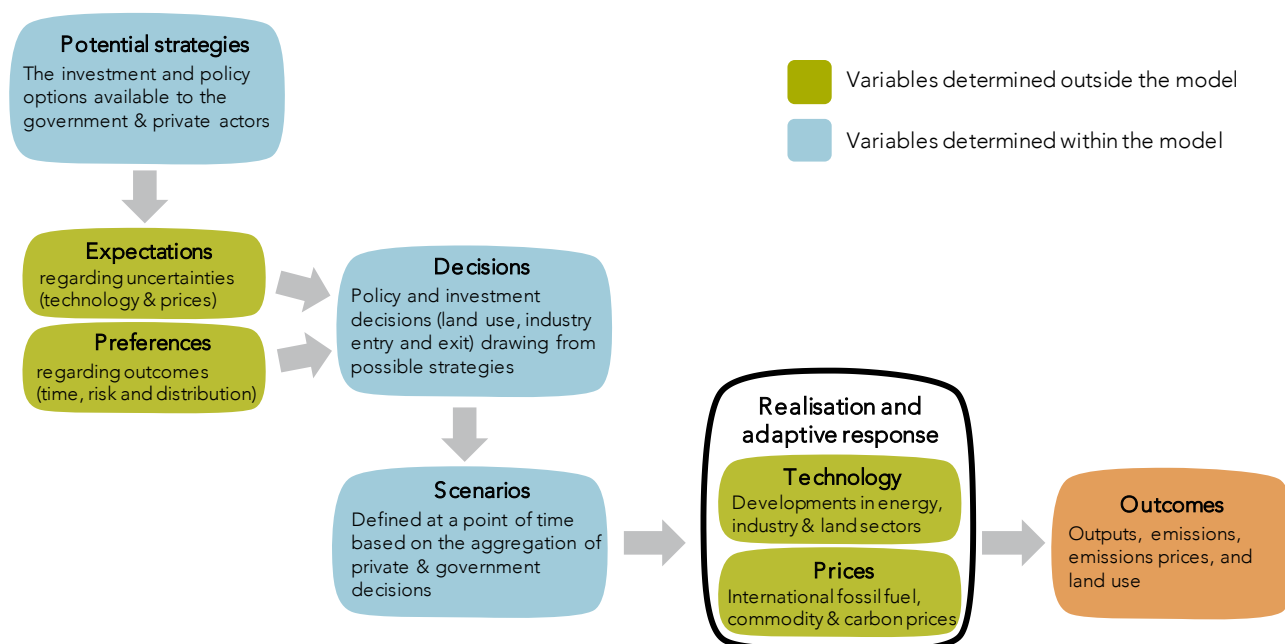
Vivid Economics headed the consortium and led the interpretation and reporting of modelling results. Motu used its Land Use in Rural New Zealand (LURNZ) model to simulate the effects of the emissions price and other factors on owners’ land-use decisions between forestry, dairy, sheep/beef, scrub and horticulture. Concept Consulting used its Energy and Industry (ENZ) model to simulate the effects of the emissions price and other factors on decisions in the transport, energy, process heat and industrial processes parts of the economy, as well as on household decisions such as to buy an EV or install heat pumps for home heating. Concept also integrated the LURNZ and ENZ models into what became, in effect, a model of the whole New Zealand economy as it transitions to progressively lower emissions. Concept Consulting et al. (2018a) contains a full description of the modelling and results.

Modelling reduces complex reality to its essential elements and relationships. These elements include the main economic activities across New Zealand, the rates at which these activities change and emit GHGs, how labour (of varying types) and different capital assets are deployed across these activities, and New Zealand’s trend population growth. Relationships of interest include how economic actors – firms and households – react to government policies such as the ETS, environmental regulations, laws and other institutions. These policies constitute levers of influence over businesses and households as they decide how far to shift their behaviour and investments towards lower emissions.

In addition to the modelling for this inquiry, the Ministry for the Environment has commissioned other modelling to inform its climate-policy advice. This other modelling uses a different “computable general equilibrium” approach to examine New Zealand’s transition to net-zero emissions by 2050. The results, when available, are likely to be a useful complement to the Concept-Motu-Vivid modelling.

The structure of the model

The Concept Consulting, Motu, Vivid Economics (CMV) model is illustrated in Figure 3.2. The starting point is a set of actors comprising the government on the one hand and private actors on the other (businesses and households). Each actor has a set of potential strategies from which to choose. They each decide their best strategy based on their preferences and their expectations about how the future will evolve (in terms of features such as technology and prices). The government is concerned to achieve an emissions target for the whole country at least economic cost. Businesses want to be commercially successful, and households want a high standard of living (including good environmental quality).

Figure 3.2 Conceptual structure of the CMV model

Source: Concept, Motu, Vivid Economics

Scenarios

When the government decides a strategy, and acts on it by setting a clear, long-term emissions target and by implementing policies that reward some behaviours and discourage others, businesses and households respond to these signals and incentives. The government actions and the private-sector responses add up to a pattern of decisions across society. The pattern reflects the preferences and expectations of the actors. This pattern of decisions is called a **scenario**.

The government has a target for emissions reductions and many policy levers and institutional arrangements that it can use to deliver on the target. Among them, emissions pricing is central as it provides economy-wide incentives that encourage business and individuals to consider the costs of emissions when making investment and consumption decisions. The government may also adopt other policies alongside or instead of emissions pricing. The government's policy stance and mix will reflect:

- the ambition of its emissions reduction target;
- its expectations about future technology developments and shifts in demand;
- the preferences and the trade-offs it will have to make to achieve emissions reductions *and* other goals that are important. For example different emissions reduction policies will have different impacts on the various groups and sectors that make up New Zealand's economy and society. The government will have preferences about how the impact should be distributed across these groups (Chapter 9); and
- intertemporal trade-offs – because GHGs vary in their impact on the climate over time. This could lead to the government choosing to take different approaches to short- and long-lived GHGs (Chapter 8), for example.

Taking some examples of business decisions, the choice by a landowner about whether to convert a harvested forest to dairy production will be a function of not only current policies and prices (eg, commodity prices and the emissions price) but also expectations regarding how such policies and prices will evolve over the future. Similarly, investors choosing the composition of new electricity-generation assets, or about the future of emissions-intensive manufacturing, will factor in their expectations about future demand, prices (commodity and emissions), and technological developments.

Scenarios of technology development

Expectations about future technological developments that have the potential to reduce emissions at lower cost are a fundamental part of scenarios. While reality is bound to be complex, the modelling assumes that technology will develop in one of three distinct ways. These ways differ in two dimensions – the extent and the type of technology development. In turn, the three technology scenarios have impacts on demand, production patterns, jobs and prices across the New Zealand economy. The three technology scenarios are noted below.

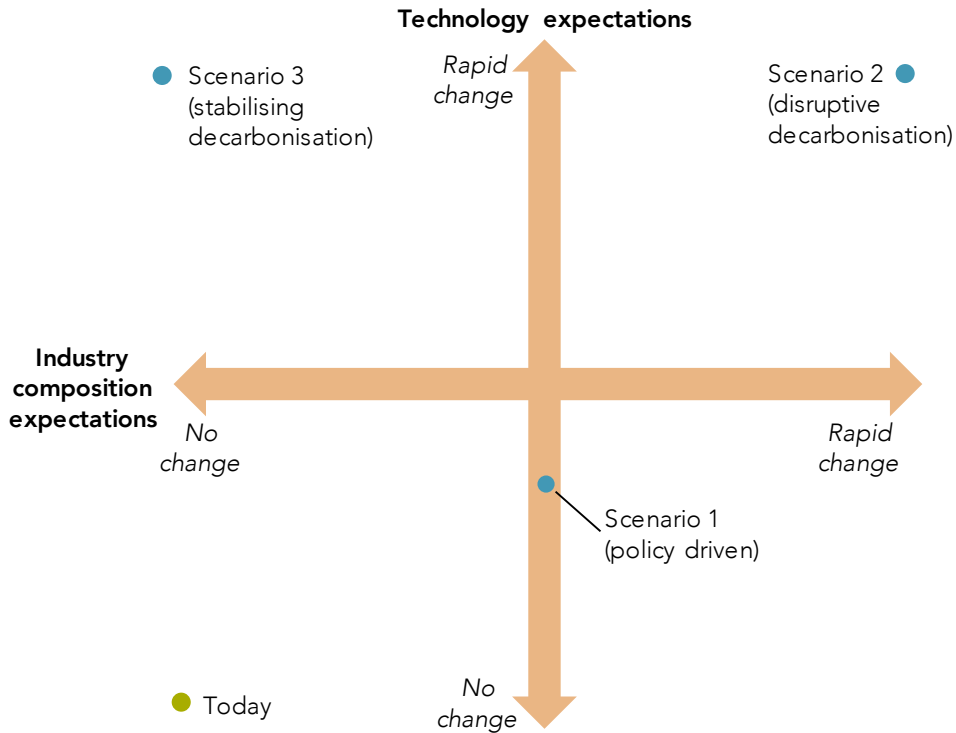
1. **Policy Driven Decarbonisation** – this scenario features slow, sector-neutral, technological change. This means that efforts to reduce emissions can expect only modest help from new technologies. Rather they will need to rely on strong policy action, specifically a rapid rise in emissions prices, to achieve the low-emissions targets. As seen in the modelling results, the high emissions prices stimulate a rapid expansion of the forestry sector (including policy to support native afforestation) and contraction of emissions-intensive animal agriculture. In the transport sector, the government provides further incentives to support public and active transport, and EVs enter the fleet at only a moderate pace since EV prices fall only slowly.
2. **Disruptive Decarbonisation** – this scenario features rapid technological change that disrupts current economic structures, with new technologies and products creating new markets, destroying demand in traditional industries and accelerating turnover in capital assets. A shift in global demand patterns supports the expansion of horticulture and reductions in dairy. EVs spread rapidly due to low costs, supportive policies and consumer preferences. The reduction in the cost of renewable generation is reflected in the closure of coal-generation capacity, and a reduction in baseload gas-generation capacity. It is assumed that aluminium and steel plants choose to close in response to expectations that global technological developments and market shifts will reduce demand for these products.¹¹
3. **Stabilising Decarbonisation**¹² – this scenario features rapid technological change that stabilises existing industry structures through the emergence of new mitigation options (such as methane vaccines and nitrogen inhibitors) that reduce the need for large shifts in economic activity. Recent trends to convert land for dairy farming continue at a modest rate. In transport, technological advances and minimum regulatory requirements for the use of biofuels prolong the life of the existing transport capital stock. This is reflected in the much slower uptake of EVs.

These three technology scenarios are illustrated in Figure 3.3 by locating them against the two dimensions of expectations that drive decision making: the pace of technological change, and the extent that industry composition changes.

¹¹ Making aluminium and steel is an emissions-intensive manufacturing process. New substitute materials may emerge that use a manufacturing process that is less emissions-intensive.

¹² In Concept Consulting et al (2018), the Stabilising Decarbonisation scenario is called “Techno-optimist”.

Figure 3.3 Illustrative mapping of technology scenarios against expectations that drive decision making



Source: Concept, Motu, Vivid Economics

Techno-policy pathways

The modelling work for this draft report examines pathways from the present to the two emission-reduction goals. These are called “techno-policy pathways” because each is a combination of one of the three technology scenarios and a set of government, business and household decisions that align with that technology scenario. In other words, the modelling assumes that the decisions government and private actors make are based on expectations about how technology (and associated prices) will develop, and these expectations turn out to be correct.

The number of pathways modelled is six because each of the three technology scenarios is linked with each of the two emissions targets as shown in Table 3.1. The right column shows the abbreviations used for each pathway.

Table 3.1 The six modelled pathways

Scenario	Net emissions target in 2050	Pathway name
1. Policy Driven	25 MtCO _{2e}	PD-25
2. Policy Driven	Net zero	PD-0
3. Disruptive Decarbonisation	25 MtCO _{2e}	DD-25
4. Disruptive Decarbonisation	Net zero	DD-0
5. Stabilising Decarbonisation	25 MtCO _{2e}	SD-25
6. Stabilising Decarbonisation	Net zero	SD-0

The three sets of pathways also represent differences between demand-side and supply-side mitigation. The Policy Driven pathways are characterised by policy that pushes up the price of emissions-intensive products and processes and causes the demand for them by households and businesses to drop and switch to lower-emissions alternatives. By contrast, the Disruptive and Stabilising Decarbonisation pathways are defined by

supply-side response to new technology opportunities: the Disruptive Decarbonisation pathway is associated with new products and services and rapid industrial change; while the Stabilising Decarbonisation pathway is based on the emergence of new technologies that reduce emissions intensity of existing industries and enables them to continue.

In short, the “techno-policy” pathways that the modelling simulates represent, in a stylised manner, three possible ways that low-emissions technologies could develop. The differences between these pathways are profound and fundamental to New Zealand’s future as it seeks to transition to a low-emissions economy. For instance, as a major exporter of agricultural products, New Zealand’s pastoral agriculture faces a significant risk that hi-tech firms could develop synthetic meat and dairy products to the point they become extremely cost competitive with traditional products, with a fraction of the environmental footprint of traditional products.¹³

F3.1

The modelling depicts, in a stylised manner, three possible ways that low-emissions technologies could develop. First, they could fail to develop or develop only slowly. Second, they could develop faster in ways that disrupt existing industries. Third, they could also develop faster but lower the emissions intensity of existing industries. The differences between these scenarios are profound and fundamental to New Zealand’s future as it seeks to transition to a low-emissions economy.

Outcomes of interest will emerge as uncertainties resolve themselves

The modelled pathways are based on the actors having expectations about the future that turn out to be correct. Yet, the outcomes of interest that flow from embarking on a pathway are uncertain at the time the decisions that underpin it are made (and the expectations that influence those decisions are formed).¹⁴ How a pathway turns out will depend on the resolution of the uncertainties about technology and other factors that will take place as New Zealand pursues its low-emissions strategy. If the expectations turn out to be correct, then the expected outcomes will eventuate. These outcomes relate to matters of daily economic life such as prices, products, jobs, business outcomes and economic costs.

The key future uncertainties facing New Zealand’s low-emissions transition are:

- technological change;
- fossil fuel and commodity prices; and
- international carbon prices.

In general, rapid emissions-reducing technological change will decrease global mitigation costs. However, the specific nature of this change can result in different impacts across industries. As noted, in the agricultural sector, advancements in the development of plant-based meat substitutes and cellular agriculture would result in accelerated movement away from animal-based agriculture and growth in the production of crops or horticulture. By contrast, assuming that agricultural emissions are priced, development of vaccines to reduce the production of methane by livestock would increase the competitiveness of pastoral agriculture relative to alternative land uses. In the transport sector, increased internal combustion engine (ICE) fuel efficiency could prolong the use of ICE vehicles, while rapid improvements in EVs and reductions in their cost could accelerate the transition away from fossil-fuelled ICE vehicles.

Fossil fuel and commodity prices are a key uncertainty that will determine changes in the level of production especially in trade exposed industries, such as agriculture, forestry and manufacturing. New Zealand acts as a price taker in most tradeable goods markets, making its economic performance closely linked to

¹³ The low environmental footprint is likely to manifest in outcomes such as better water quality and low GHG emissions. Factoring in emissions prices for farm-produced meat and dairy products would make the synthetic versions even more cost competitive.

¹⁴ A decision can also be to do nothing except wait for the uncertainty to be resolved, and then decide. Yet, a strategy of wait and decide can be risky if, by failing to act now, an adverse and irreversible change in the environment occurs down the track that could have been prevented by acting sooner.

commodity prices. Fossil-fuel prices also play an important role in helping to determine the competitiveness of different electricity-generation assets and transport technologies.

International carbon prices are a key determinant of the relative costs of emissions between jurisdictions. Differences in carbon prices across countries can be a driver of carbon leakage where some production activity transfers from a jurisdiction with a higher carbon price to one with a lower carbon price, even though the latter may have a higher emissions intensity. The modelling includes simulation of the international competitiveness of trade-exposed industries in New Zealand.

Revising strategies as new information becomes available

At what future point will uncertainties resolve themselves and decision makers revise their strategies as a consequence? The answer to this question is uncertain. In reality, new information about such matters as technological advances and commodity prices arrives in a fairly continuous stream. But this information comes with further questions, such as is the new information a blip or is it a trend, and how much will the new technology cost? Another consideration is that it would be undesirable to adjust policy settings with every new piece of information. That would make for great policy uncertainty. Rather, businesses and households require clear direction and policy stability if they are to be confident about making investments that reduce emissions.

Later chapters describe policy frameworks that seek to strike a balance between responsiveness to new information and policy stability. Chapter 4 recommends five-year intervals for setting ETS emissions caps (and guidance for 10 years beyond) while Chapter 7 has recommendations for the timing of climate policies and carbon budgets.

The Commission is undertaking further analysis that will examine the extent to which uncertainty will affect the decisions of government and different types of economic actors (eg, landowners, major industrial companies and households). It will report the insights in its final report. This analysis will take 2030 as the point at which the government re-sets its climate strategy after considering the new information. The key point is that anticipating that expectations may turn out to be incorrect, and that adjustments to policy settings will be needed down the track, should be built into the initial choice of strategy.

F3.2

New Zealand's transition to a low-emissions economy will be a long journey to a known and desired destination but through very uncertain terrain. It would be foolhardy to try to pin down the best route for this 32-year journey to 2050 in advance. Rather, the situation calls for careful preparation, a capability for adaptation, and a balance between responsiveness to new information and policy stability. This approach will best equip the country to deal well with whatever terrain emerges.

How does the modelling work?

As noted, the modelling draws on two models: Concept Consulting's ENZ model, and Motu's LURNZ model. These two models together cover almost all New Zealand's GHG emissions and provide a robust base for testing the implications of policy and investment strategies across the economy.

The models are "structural" models in that they break down the New Zealand economy into individual sectors, and then explicitly model the effects of key drivers of outcomes in those sectors. Box 3.1 and Figure 3.4 provide short descriptions of the models. The technical appendix of Concept Consulting et al. (2018a) provides much fuller descriptions.

Box 3.1 Short descriptions of the models used

Concept Consulting's ENZ model

ENZ is a series of inter-dependent modules or sub-models. The sub-models seek to identify the least-cost means of meeting demand for a service (for instance transport, process heat or electricity) given

the underlying market drivers (such as population growth, emissions prices, fossil fuel prices and technology costs) and exogenous policy actions (such as support for shifting travel mode to public transport/cycling, or the forced closure of a fossil power station). Some sub-models are highly dynamic and model the key drivers of outcomes in detail. For example: the electricity-sector modelling considers the intermittency in renewable generation (particularly in hydro and wind generation) and the transport-sector modelling considers differences between light- and heavy-fleet road transport. Conversely, some sub-models are relatively simple, reflecting their relatively small share of emissions, the existence of significant uncertainty, or both.

The basic premise is that the business actors in the scenarios are driven by profit motives and will choose the lowest-cost investments to meet demand. Costs include the carbon prices for GHG emissions. Effectively, supply-side investment decisions are targeted at meeting demand in the future at least cost. Households decisions focus on fuel and energy choices, including household investments in the expensive, long-lived assets associated with these (eg, vehicles and home heating). The model also simulates some of the non-price drivers of consumer decisions.

Motu's LURNZ model

LURNZ is a dynamic and spatially explicit, partial-equilibrium model of rural land use. It can simulate changes in dairy, sheep-beef, forestry and scrub in response to changes in economic incentives. In addition, it can spatially allocate exogenously determined changes in horticulture according to land suitability. LURNZ also simulates land-use intensity and emissions (or sequestration) associated with these land uses.

At the core of LURNZ are two econometrically estimated models that establish the relationship between observed drivers of land use and land-use outcomes:

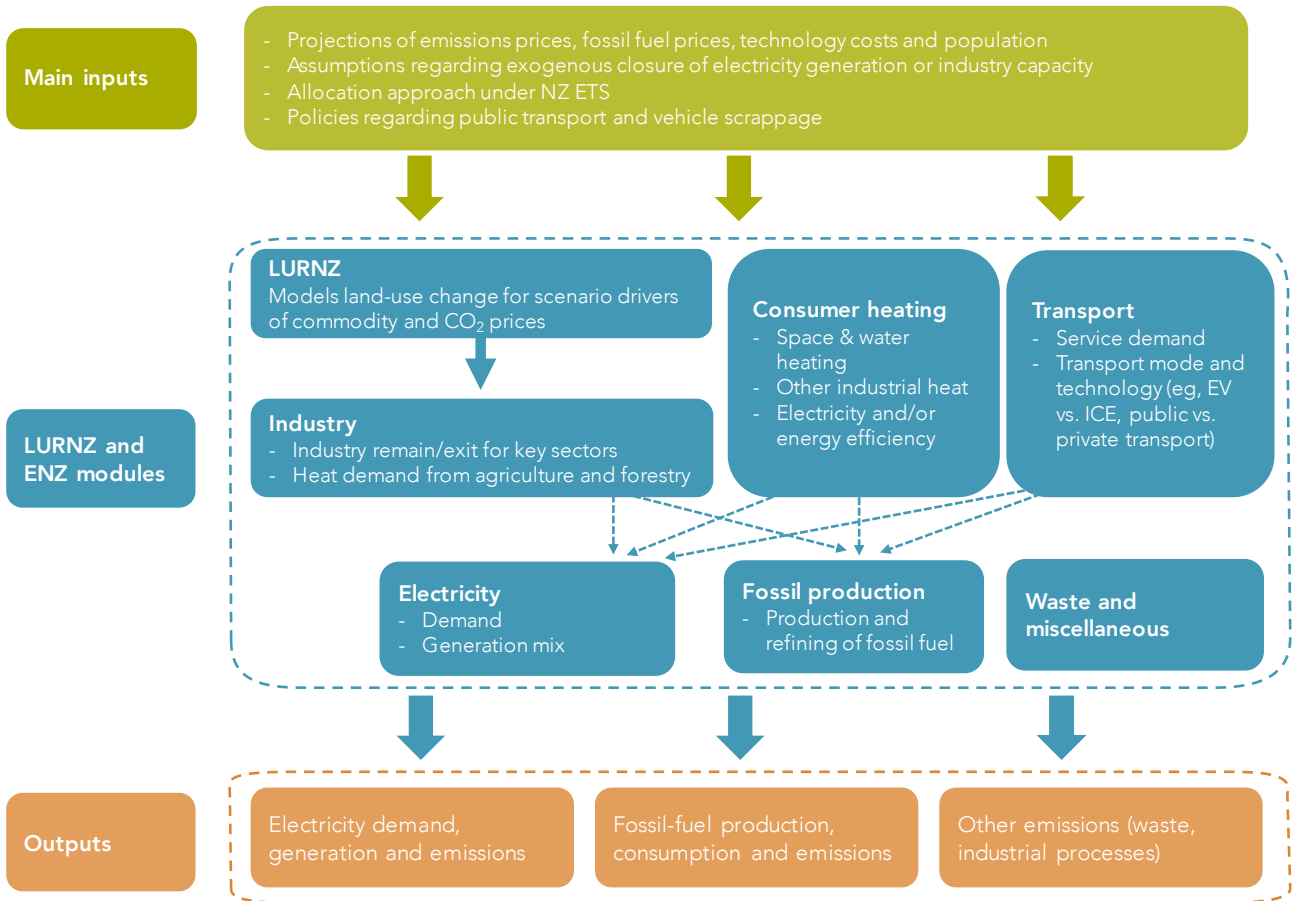
- a system of regression equations that estimate dynamic land-use responses to changes in economic drivers, such as commodity prices, at the national level; and
- a spatial model that relates land-use choices to various geophysical characteristics of the land, and to proxies for the cost of market access, land tenure and yields.

LURNZ has a strong empirical basis. It requires relatively few assumptions about farmers' objectives and decision processes: results are largely driven by how land use has responded to its main drivers in the past. The model's underlying datasets and processes have been validated, and its results are consistent with data and trends at the national scale, including New Zealand's Greenhouse Gas Inventory.

Combining the models

Links between sectors are made through the outputs from one sector feeding into the inputs of another sector, both within and between models. For example, the outputs of LURNZ, in terms of meat and dairy production, feed into the ENZ module of industrial process heat which, in turn, feeds into the ENZ modules for electricity generation and gas production. Figure 3.4 illustrates how the models, sectors and modules are linked.

Figure 3.4 How the models and sectors are linked



Source: Concept, Motu, Vivid Economics

The assumptions of the modelling

In common with other modelling, the CMV modelling makes a large number of assumptions about parameter values and how variables change over time. In particular, different assumptions about rates and types of technological change (and prices that result from them) characterise the Policy Driven, Disruptive Decarbonisation and Stabilising Decarbonisation technology scenarios.

Table 3.2 lists some of the more important of assumptions – those common across the technology scenarios and those that differ. Concept Consulting et al. (2018a) contains a full description of the assumptions.

Table 3.2 Key technology scenario assumptions

Variable	Policy Driven	Disruptive Decarbonisation	Stabilising Decarbonisation
Common across technology scenarios			
ETS coverage	All sectors are covered, including agriculture	Same as for policy driven	Same as for policy driven
Population growth (average to 2050) ¹⁵	1% a year	1% a year	1% a year
Different across technology scenarios			

¹⁵ Population growth in the earlier years is significantly greater than in the later years, as noted in Statistics NZ central forecasts.

Variable	Policy Driven	Disruptive Decarbonisation	Stabilising Decarbonisation
ETS free allocation	From 2015 to 2020, the allocation is in line with the NZ ETS, with agriculture receiving a 90% allocation. From 2020, fast withdrawal of assistance, withdrawn at 3 percentage points from 2020 to 2030 and 5 percentage points a year from then on	Same as for policy driven	From 2015 to 2020, the allocation is in line with the NZ ETS, with agriculture receiving a 90% allocation. From 2020, slow withdrawal of assistance, withdrawn at 1 percentage point a year from 2020 to 2030 and 3 percentage points a year from then on
Industry			
Iron and Steel	Future operation endogenously modelled based on New Zealand and international emissions prices	Exogenously specified closure in 2025	Future operation endogenously modelled based on New Zealand and international emissions prices
Aluminium	Future operation endogenously modelled based on New Zealand and international emissions prices	Exogenously specified closure in 2025	Future operation endogenously modelled based on New Zealand and international emissions prices
Transport			
Rate of cost reduction in EV batteries (a major influence on EV prices and uptake)	Medium: 6% pa	High: 8% pa	Low: 4% pa
Rate of improvement in the fuel-efficiency of the Internal Combustion Engine	Medium	Medium	High
Extent of mode-shifting to public transport, walking and cycling, and car-sharing ¹⁶	50% increase over 30 years in the proportion of trips by public transport, walking, cycling and a 20% increase in the proportion of car-sharing.	75% increase over 30 years in the proportion of trips by public transport, walking, cycling and a 30% increase in the proportion of car-sharing.	25% increase over 30 years in the proportion of trips by public transport, walking, cycling and a 10% increase in the proportion of car-sharing.
Vehicle scrappage rates ¹⁷	Scrappage rates continue at historic scrappage rates.	Scrappage rates 25% higher than historic rates.	Scrappage rates 25% higher than historic rates.
Electricity			
Rate of renewable technology (wind, solar, geothermal) cost reduction ¹⁸	Cost reductions for wind, solar and geothermal of 1.25% pa, 2.5% pa and 0.25% pa respectively.	Cost reductions of 1.5 times the rates for policy driven	Cost reductions of 0.5 times the rates for policy driven

¹⁶ The Medium scenario assumes a 50% increase over 30 years in the proportion of trips by public transport, walking, cycling, and a 20% increase in the proportion of car-sharing. The High and Low scenarios assume increased rates of 75% and 25% respectively (except for car-sharing which are 30% and 10%, respectively).

¹⁷ Scrappage indicates the proportion of vehicles scrapped each year. A high scrappage rate results in more vehicles being brought into New Zealand to meet the demand for transport, and results in a lower average life of a vehicle before it is scrapped.

¹⁸ The Medium rate of yearly cost improvement for wind, solar and geothermal is 1.25%, 2.5% and 0.25%, respectively. The High and Low scenarios assume rates that are 1.5 times and 0.5 times above the Medium rates.

Variable	Policy Driven	Disruptive Decarbonisation	Stabilising Decarbonisation
Agriculture			
Emissions intensity	Continuous improvement (year on year) in the efficiency of GHG emissions per unit of product produced, with dairy and sheep/beef intensity based on the “minimum efficiency” baseline scenario in Reisinger et al. (2016).	Same as for policy driven	Same as for policy driven, except that a methane vaccine becomes available after 2030: reducing dairy livestock emissions by 30%, and sheep/beef emissions by 20%. 100% adoption rate assumed
Horticulture area	Linear increase to 500 000 hectares by 2050	Linear increase to 1 000 000 hectares by 2050	Constant

Source: Concept, Motu, Vivid Economics

How does the modelling compare with Vivid Economics’ “Net Zero in New Zealand” modelling for Globe NZ, 2017?

Globe NZ, a cross-party group of 35 members of the previous New Zealand Parliament, commissioned Vivid Economics in 2016 to apply scenario analysis to illuminate long-term future states of the New Zealand economy that would have varying levels of lower GHG emissions (Vivid Economics, 2017a). The approach was similar to the Commission’s modelling in timescale (looking out to 2050) and in the extent of emissions reductions considered (the most ambitious scenario coming close to achieving net-zero emissions by 2050). It was also similar in its focus on domestic reductions of emissions and relating these reductions to the emissions intensities of different economic activities and technologies.

The main differences between the two modelling exercises are:

- The scenario analysis in Vivid Economics (2017a) focused on end states (ie, what would New Zealand have to look like in 2050); in contrast, CMV tracks the pathways from the present to the end state.
- Vivid Economics’ 2050 scenarios were based on sets of assumed outcomes across emitting sectors (eg, level of EV uptake) that were considered realistic under ambitious global and domestic climate policy, with national emissions outcomes calculated from these assumptions. CMV sets 2050 emissions targets and models the changes that will occur throughout the economy to meet these targets (under assumptions about drivers such as technology changes, population growth and commodity prices).
- CMV estimates the track of emissions prices that achieve the target reductions in emissions. The model has the economics of specific processes and mitigation options built into it (eg, uptake of EVs, electrification of process heat, and land-use change to forestry). The model computes the changes that will occur in response to the emissions price.
- The second phase of CMV modelling will undertake a more ambitious treatment of uncertainty not captured in the Vivid modelling.

3.3 Modelling results

The modelling results paint a picture of a New Zealand in 2050 that has changed significantly from today. The picture suggests a gradual evolution of New Zealand’s economic structure enabling it to achieve its decarbonisation objective under a variety of potential futures. It suggests the movement away from some traditional industries, and the creation of new ones (for instance, electrified transport), and points to the important role that new technologies could play in enabling a low-emissions economy.

This section describes the results of the six techno-policy pathways (Policy Driven, Disruptive Decarbonisation and Stabilising Decarbonisation under the two targets for net emissions in 2050: 25 Mt CO₂e and zero). In line with the abbreviations in Table 3.1, the six pathways are: PD–25, PD–0, DD–25, DD–0, SD–25 and SD–0.

The modelling found emissions-price trajectories and associated pathways that succeeded in reducing emissions to the targets or, in the case of two pathways, to close to the targets. In doing this, the modelling also estimated the outcomes along each pathway for key attributes of interest including:

- cumulative net and gross emissions along each pathway;
- the change in structure of the energy, transport and industry sectors; and
- the change in size and structure of the agriculture and forestry sectors.

Emissions

The first notable result is that all pathways are feasible. That is, according to the modelling, New Zealand can achieve both the 25 MtCO₂e emissions target and the more ambitious net-zero target by 2050 under each of the three technology scenarios¹⁹ (Figure 3.5).

However, the six pathways take different trajectories resulting in different cumulative emissions over the period.²⁰ The Disruptive Decarbonisation scenario has the lowest cumulative emissions driven by relatively rapid decarbonisation (compared to other scenarios) in the 2020s. Under DD–25, emissions over the period 2016 to 2050 reach only 1.6 Gt of CO₂e – notably lower than the SD–25 or PD–25 pathways which each reach 1.8 Gt of CO₂e.

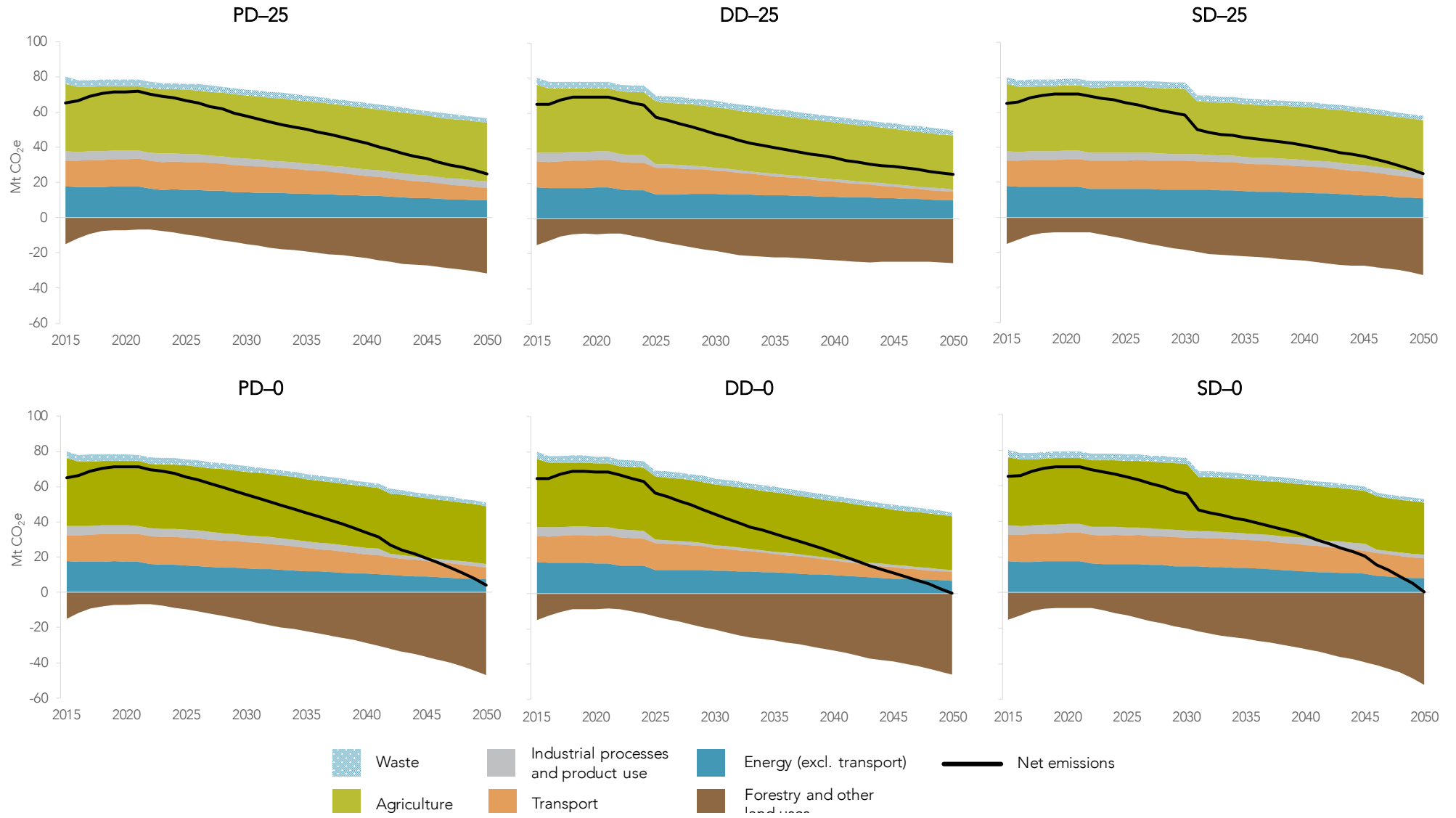
Under the more ambitious net-zero target, cumulative emissions in DD–0 reach 1.3 Gt of CO₂e, compared to just over 1.5 Gt of CO₂e in the SD–0 pathway and 1.6 Gt of CO₂e in the PD–0 pathways. Comparing the SD and PD pathways, although they achieve similar cumulative emissions over the period (2016–2050), in the period to 2030 the PD pathways achieve greater emissions reductions than the SD pathways. However, the introduction of a methane vaccine in 2030 sees emissions in the SD pathways drop rapidly and remain below those of the PD pathways for most of the period to 2050.

The different shapes of the emissions trajectories in part reflect differing reliance on converting more land to forestry to meet the 2050 target. While all pathways see an increase in sequestration from forestry compared to current levels, the PD and SD pathways rely more heavily on the expansion of forestry to deliver lower net emissions. This means that gross emissions in 2050 are highest in the SD pathways, reaching 58.0 Mt of CO₂e in the SD–25 pathway and 523.4 Mt of CO₂e in the SD–0 pathway. The PD pathways rely nearly as heavily on forestry, with gross emissions reaching 56.7 Mt of CO₂e in the PD–25 pathway and 51.0 Mt of CO₂e in the PD–0 pathway. In comparison, the DD pathways use less forestry mitigation, with gross emissions falling to 50.6 Mt of CO₂e in the DD–25 pathway and 46.8 Mt of CO₂e in the DD–0 pathway. This outcome has important implications for mitigation after 2050. It means that, to achieve or maintain net-zero GHG emissions, the SD and PD pathways will either need to continue to rely on greater amounts of forestry sequestration, or make up the mitigation gap with other, potentially more expensive, options.

¹⁹ Due to modelling constraints, the Policy Driven and Stabilising Decarbonisation pathways reach close to, but do not reach 0 Mt of CO₂e in these results, with PD–0 reaching emissions of 3.9 Mt of CO₂e in 2050 and SD–0 reaching emissions of 0.4 Mt of CO₂e in 2050.

²⁰ In Figure 3.5, cumulative emissions are represented in each graph by the area under the black net-emissions line and the horizontal (zero) axis.

Figure 3.5 All pathways deliver large reductions in net emissions



Source: Concept, Motu, Vivid Economics

Emissions prices

Notably, the modelling assumes that the government sets emissions prices up to 2030 according to its expectations under the different technology scenarios.²¹ It is only beyond 2030 and up to 2050 that emissions prices are generated by the model to achieve the 2050 emissions targets. Table 3.3 sets out the assumed prices at 2030 and the model-generated prices in 2050, and Figure 3.6 shows the full emissions-price trajectories.

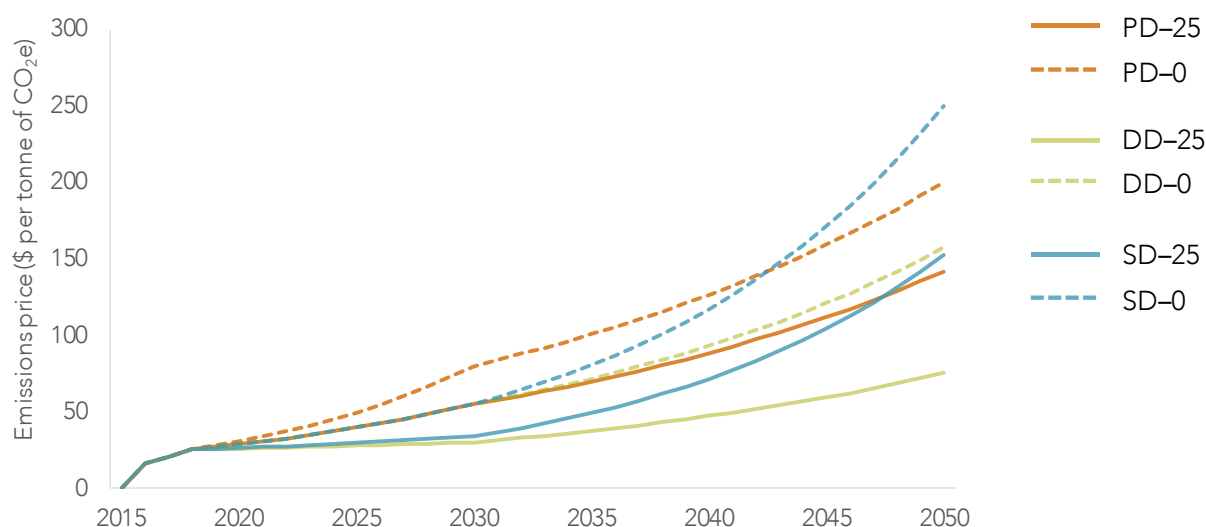
Table 3.3 Emissions prices vary by pathway at 2030 and 2050

2050 net emissions target	Technology scenario	Assumed emissions price set for 2030	Reason for 2030 emissions price	Model-generated emissions price in 2050
25 MtCO _{2e}	Policy driven	\$55	Reflects strong early policy action given expectation of slow technological change	\$142
25 MtCO _{2e}	Disruptive decarbonisation	\$30	Lower price relying on technological breakthroughs	\$75
25 MtCO _{2e}	Stabilising decarbonisation	\$30	Lower price relying on technological breakthroughs	\$152
Zero	Policy driven	\$80	Higher price needed sooner to achieve more ambitious 2050 target	\$200
Zero	Disruptive decarbonisation	\$55	Higher price needed sooner to achieve more ambitious 2050 target, but not as high as PD0 because of anticipated help from technology	\$157
Zero	Stabilising decarbonisation	\$55	Higher price needed sooner to achieve more ambitious 2050 target, but not as high as PD0 because of anticipated help from technology	\$250

The modelling indicates that emissions prices will need to rise strongly from their current levels of around \$21 a tonne to achieve the 2050 targets. The estimated range of prices in 2050 is \$75 to \$250 a tonne.

The analysis reveals significant differences in the emissions prices both between pathways and targets. First, the more ambitious zero-emissions target calls for much higher prices than the 25 Mt target. Comparing pathways, the DD pathways have lower emissions prices than both the PD and SD pathways, with a price of only \$75 in 2050 required for DD25. The PD-0 pathway sees an emissions price of \$200/t of CO_{2e} in 2050 to reach emissions of 3.9 Mt of CO_{2e}, while even with a price of \$250/t of CO_{2e} in 2050, the SD-0 pathway sees net emissions remain marginally above zero at 0.4 Mt of CO_{2e}.

²¹ Under New Zealand's Emissions Trading System, the government does not set emissions prices directly. Rather, the government influences them through its control of the supply of emission permits or units. The government can set yearly emission caps. For a full description and discussion, see Chapter 4.

Figure 3.6 Emissions price trajectories, 2015–2050

Source: Concept, Motu, Vivid Economics

Electricity, transport and industry

Electricity

New Zealand's electricity system already has very low GHG emissions by global standards, and, as such, it does not feature heavily as a source of mitigation. Yet the modelling does reveal a major shift in New Zealand's energy system, as it expands its electricity system to handle increased rates of electrification, predominantly in transport but also in industry and the residential sector. In all pathways, electricity demand grows by more than 45% from 2015 levels. It grows least in the SD pathways, with lower rates of EV penetration. The DD pathways see slightly higher demand growth, with high levels of vehicle electrification somewhat offset by a large drop in demand because of an assumption that the Tiwai aluminium smelter will choose to close from 2025. The largest growth is in the PD pathways, with moderate rates of electrification and higher industrial demand seeing total generation increase by 58% in PD-25 and by over 63% in PD-0.

The modelling projects that New Zealand's electricity system will move to higher proportions of renewable energy, but with some fossil generation remaining to provide infrequent "firming" generation²². Most of the growth in electricity demand is met by the building of new renewable generation. Further, the remaining combined-cycle gas turbine (CCGT) generators are projected to be displaced from baseload operation by new renewable generation as emissions prices rise. A need remains for some peaking fossil generation to manage periods of particularly high demand, low renewable output, or both – for instance, dry years where hydroelectricity generation is low. Further, some industrial gas-fired cogeneration is projected to remain operational at projected emissions prices.

Wind generation is expected to grow to service most of the growth in electricity demand, alongside new geothermal and solar generation. The extent to which these different technologies meet the growth in demand and displace existing fossil generation is sensitive to rates of technological change and the relative costs of technology, future emissions prices and the extent to which storage and demand-side responses can provide low-cost balancing of variable wind or solar generation.

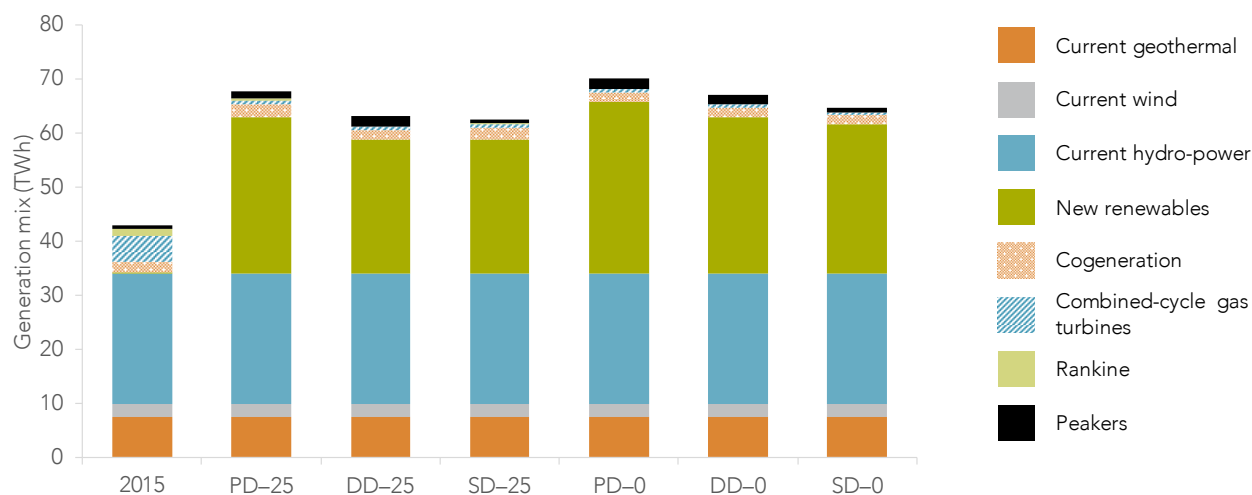
Different plausible futures for these different drivers can materially affect how much growth in renewable generation comes from wind, geothermal and solar. Although the composition of the generation mix (both the type of new renewables, and the composition of remaining peaking fossil generation) is inherently uncertain, it is highly likely to be economic to build additional renewables to displace existing fossil generation from baseload duties at projected emissions prices. This will provide the largest gain in terms of reducing emissions from the power generation sector. With the retirement of the baseload CCGT generators and a reduction in Rankine generation, emissions from geothermal generators are anticipated to be larger than the emissions from the remaining Rankine and Peaker generators (whose role is principally

²² Generation that adds to (or "firms up") the supply of electricity when hydro or other renewable generation falls owing to weather events.

dry-year generation and winter generation). Figure 3.7 shows these compositional changes and Chapter 12 covers the electricity sector in greater depth.

Despite these large changes, the costs of both the energy-system network and generation remain at current levels or slightly increase. Total wholesale energy and network costs are estimated to increase slightly in the Policy Driven and Stabilising Decarbonisation pathways and remain broadly stable along the Disruptive Decarbonisation pathways.

Figure 3.7 All pathways involve substantial growth in electricity demand, provided mainly by renewables



Source: Concept, Motu, Vivid Economics

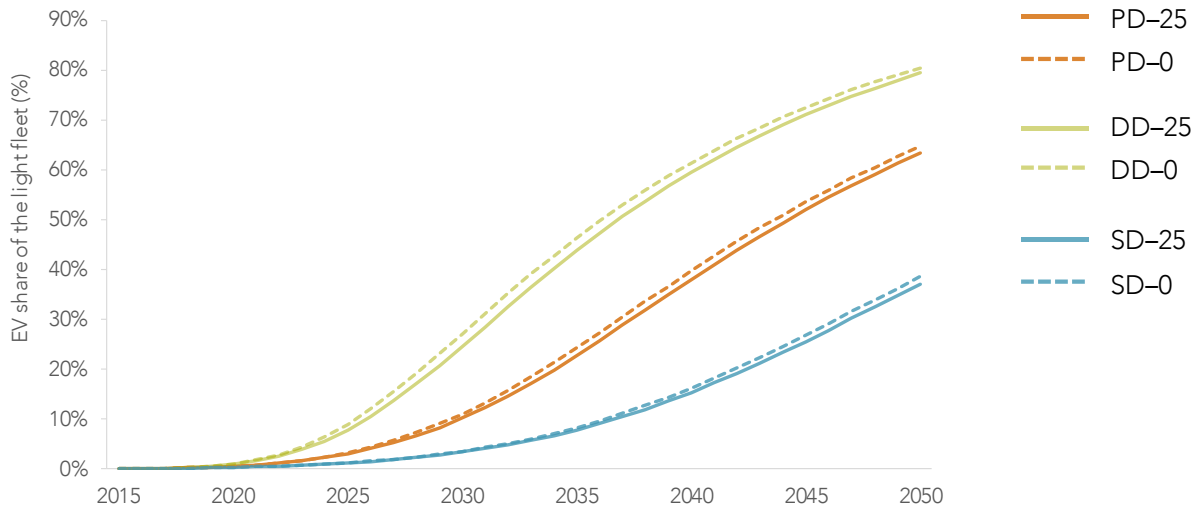
Transport

The largest driver of emissions reductions in the use of energy (across both transport and industry) is the rapid expansion of the EV fleet. Battery technologies have developed rapidly over the last five years, reflected in reduced battery and EV costs that have allowed them to start to compete on cost with conventional vehicles. This has been influenced by, and in turn spurred on, new investment and policy changes, with many countries envisioning phasing out the ICE in all light vehicles over the next decade or two.

As a small economy, New Zealand will be an adopter, rather than a driver, of these new technologies. Even so, EVs are likely to play a major role in decarbonising the New Zealand economy. Under all scenarios, uptake of light EVs occurs rapidly, reaching almost 80% of the light vehicle fleet by 2050 under the DD pathways and almost 65% in the PD pathways. Uptake is slower under the SD scenario, as slower reductions in battery costs and advances in the efficiency of vehicles with ICE slow the uptake of EVs. Yet, even on this pathway, EVs reach almost 40% of the light vehicle fleet by 2050 (Figure 3.8). Additional policies and actions in areas such as consumer electricity pricing and price incentives are likely to be needed to tilt purchasing decisions towards low-emissions vehicles (Chapters 11 and 12).

Upgrading the light vehicle fleet increases vehicle purchase costs (the model estimates these will rise by 10% to 25% by 2050 compared to 2015). These cost increases reflect the degree of electrification of transport. They are smallest in the SD pathways and highest in the DD pathways. Yet, fuel costs will also differ by pathway, with the shift to greater electrification likely reducing fuel costs relative to those of petrol or diesel vehicles, and potentially offsetting higher purchase and maintenance costs.

A broad consideration of the costs associated with the transport system should also include externalities, for instance the costs imposed on society through congestion or health impacts. Here the PD pathways have better outcomes than the DD and SD pathways because increased public and active transport reduce congestion, demand for land, and road construction costs, and improve health outcomes. Chapter 11 analyses transport policies and pathways in the transition to low emissions in greater depth.

Figure 3.8 Light electric vehicles form a substantial part of the fleet along all pathways

Source: Concept, Motu, Vivid Economics

Industry

Emissions outcomes differ substantially by industry across the pathways, as shown in Figure 3.9. Under the 25 Mt target pathways, the largest variance in outcomes is for iron, steel and aluminium, reflecting the assumption that these operations close in the DD pathways. Under the net-zero target pathways, higher emissions prices drive large reductions in emissions from the food processing and pulp and paper sectors, driven by several technical and process factors, including electrification, biomass uptake and energy efficiency. Interestingly, under the higher emissions prices needed to achieve net-zero emissions by 2050, production of iron and steel also ceases in the PD and SD pathways (which does not happen along these pathways with the 25 Mt target).

The cessation of such production is driven by:

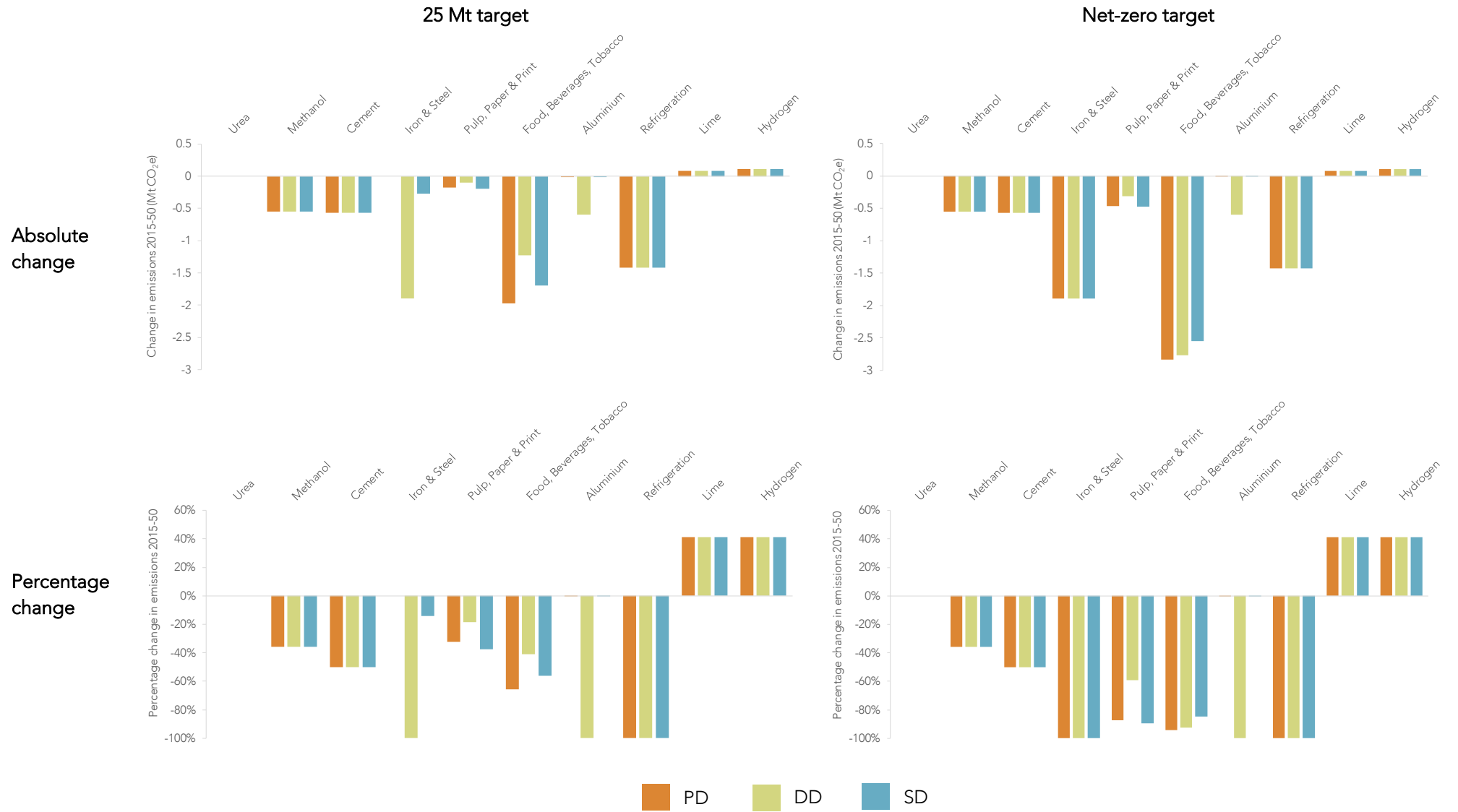
- the assumption that a world with such high carbon prices will see a shift away from steel (the steel-making process being very emissions intensive); and
- New Zealand steel production being neither very low cost, nor very low emissions, relative to overseas producers.

Yet considerable uncertainty exists around such assessments.

“Fugitive” emissions²³ from mining coal and producing gas decline significantly as electricity generation using these fuel sources declines, while emissions from geothermal are broadly stable reflecting its ongoing importance in New Zealand’s energy mix. This means that, across all pathways, fugitive emissions from geothermal generation become the largest source of emissions from the electricity-generation sector. Emissions in waste also decline, driven by a reduction in the generation of waste across the economy and an increase in methane capture and combustion.

²³ Fugitive GHG emissions are emissions that escape as by-products of another process such as coal mining or oil and gas production. Fugitive GHG emissions are distinct from the GHG emissions caused when these fossil fuels are combusted. The use of geothermal energy also produces fugitive emissions.

Figure 3.9 Changes in emissions in industrial sectors across pathways, 2015–2050



Source: Concept, Motu, Vivid Economics

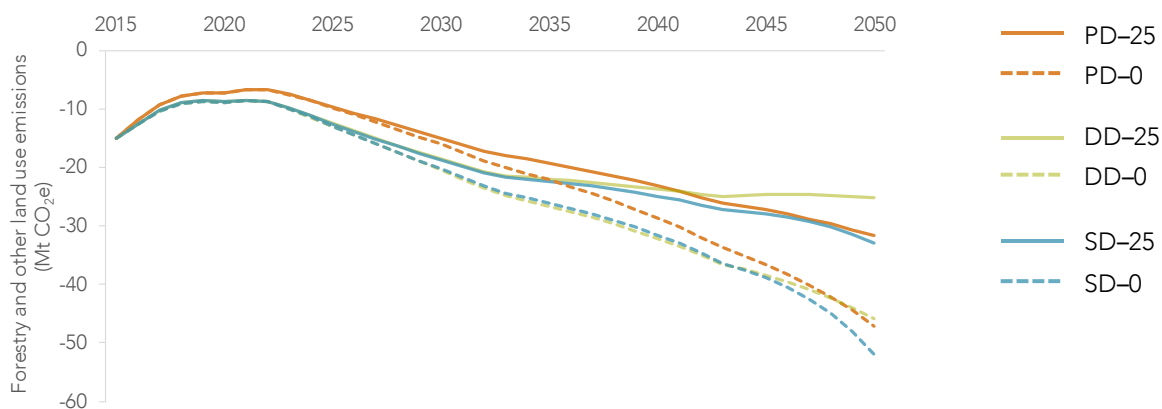
Agriculture and forestry

The largest driver of net emissions reductions to 2050 are the agriculture and forestry sectors. New Zealand's unusual emissions profile means that today the land sector is much more important to New Zealand's emissions profile than in comparable countries. This importance makes achieving emissions reductions in these sectors central to the challenge of reducing New Zealand's emissions.

Under all scenarios, forestry sequestration increases. In the 25 Mt of CO₂e target pathways, sequestration from forestry increases from about 15 Mt of CO₂e in 2015 to about 25 Mt of CO₂e by 2050 in DD-25, rising further to 32 Mt of CO₂e in PD-25 and 34 Mt of CO₂e in SD-25. Yet these levels of sequestration are dwarfed by the large expansion of forestry sequestration in the net-zero target pathways as shown in Figure 3.10. Along these pathways, forest sequestration increases to reach over 45 Mt of CO₂e in both DD-0 and PD-0 and more than 50 Mt of CO₂e in SD-0.

These large relative increases in forestry sequestration for both targets and across all pathways imply that further expanding forestry is a relatively low-cost mitigation option under the model specifications. This reflects the current knowledge of opportunities to reduce emissions. In the future, it is possible that cost-effective reductions in emissions could come from technologies that do not yet exist, particularly if incentivised by higher emissions prices.

Figure 3.10 Forestry sequestration increases from current levels



Source: Concept, Motu, Vivid Economics

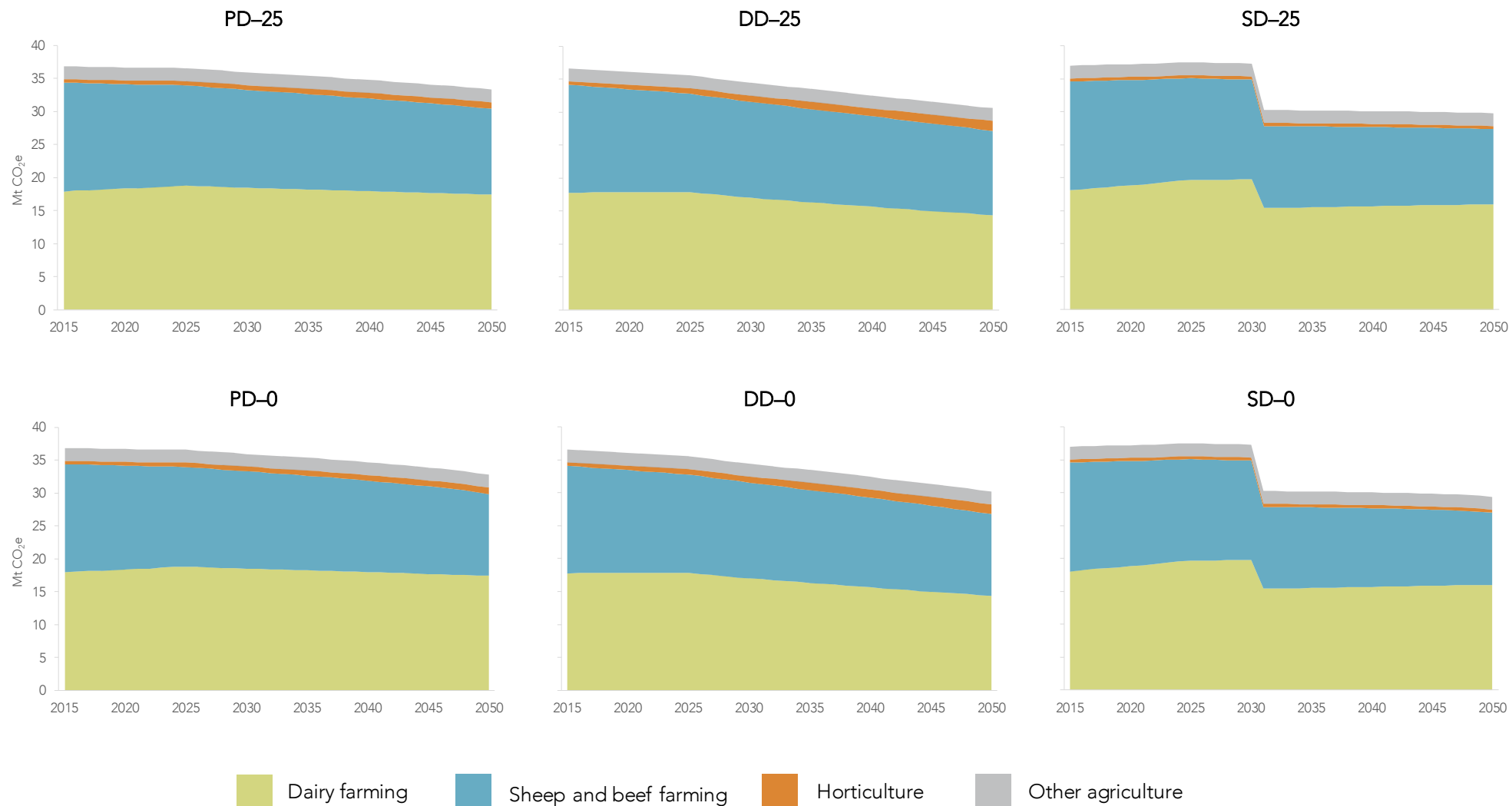
Emissions from agriculture decline under all pathways. The smallest relative fall is under the PD pathways, with emissions falling by 13% from 2015 to 2050 in PD-25 and 15% in PD-0. Agricultural emissions along the other pathways fall by over 20%, with slightly larger reductions under the SD pathways (22% in SD-25 and 23% in SD-0) than the DD pathways (20% in DD-25 and 21% in DD-0), as shown in Figure 3.11. However, the declines in the DD pathways occur gradually over the period, while the SD pathways see abrupt change driven by the assumed introduction of a methane vaccine for pastoral agriculture in 2030–2031. Differences in agricultural emissions between the 25 Mt of CO₂e and net-zero targets are minor, with the tighter target driving only small changes in overall agricultural activity.

These emissions outcomes imply different patterns of land-use change in rural New Zealand (Figure 3.12). Under all scenarios forestry sees a renewed expansion. The smallest increases occur under the DD pathways, with an additional 1.3 million hectares under plantation in DD-25 and 2.1 million hectares under DD-0. The largest land-use change occurs under the PD pathways, with:

- 2.0 million hectares of additional forestry under PD-25 (1.4 million hectares of new plantation forest and 0.7 million hectares of native forest);
- 2.8 million hectares under PD-0 (1.9 million hectares of new plantation forest and 0.9 million hectares of new native forest).

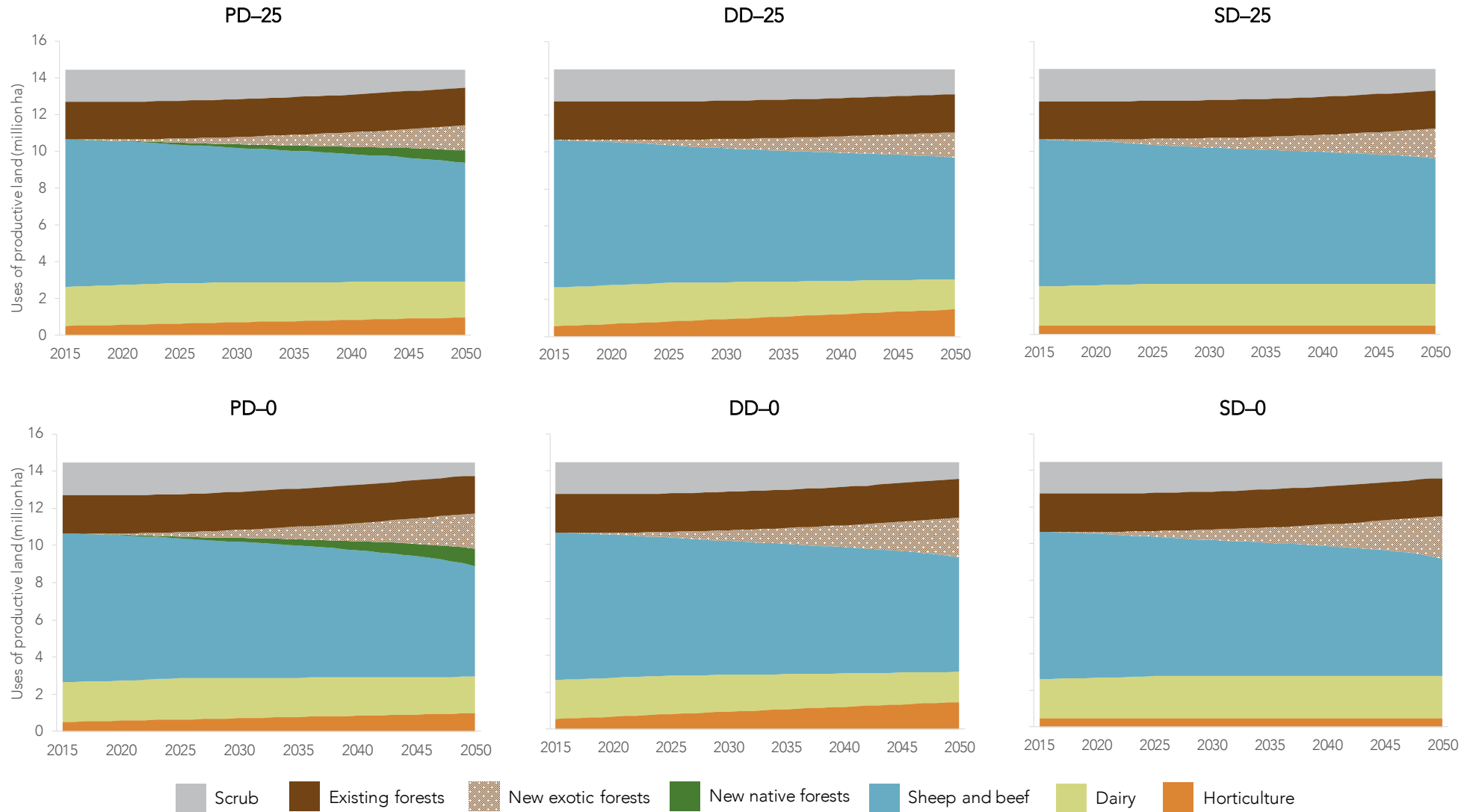
The SD pathways also see forestry increasing by between 1.6 million hectares (SD-25) and 2.3 million hectares (SD-0).

Figure 3.11 Agricultural emissions by pathway



Source: Concept, Motu, Vivid Economics

Figure 3.12 Land use by pathway



Source: Concept, Motu, Vivid Economics

Land used for sheep and beef farming declines under all scenarios. It falls from about 8 million hectares in 2015, to 6.8 million hectares in SD–25, 6.6 million hectares in DD–25 and 6.4 million hectares in PD–25. Reductions in land use for sheep and beef farming are more pronounced under the net-zero target pathways, with land use declining to 6.4 million hectares in SD–0, 6.2 million hectares in DD–0 and 5.9 million hectares in PD–0. As a corollary, production of sheep and beef (proxied by stock units) declines in all pathways, by between 7% and 16%.²⁴

Land used for dairy farming increases under some pathways and falls in others. For instance, the SD pathways see dairy land use increase from 2.1 million hectares in 2015 to 2.3 million hectares in 2025 and then remain constant.²⁵ However, dairy land declines under the other pathways to 2.0 million hectares in the PD pathways and 1.6 million hectares in the DD pathways. Changes in the production of dairy products also vary. Dairy production increases by 25% in the SD pathways and 7% in the PD pathways. Yet it falls by 11% in the DD pathways.

Some of these land changes are spurred by the expansion of horticulture. That expansion is stable at 0.5 million hectares under the SD pathways, but is assumed to double to 1.0 million hectares under the PD pathways and triple to 1.5 million hectares under the DD pathways. The model does not break down the increase in horticultural land use, given the variety of horticultural products and uncertainty about their future growth.

Better water quality because of reduced nitrate leaching into waterways will be a co-benefit of reduced emissions of nitrous oxide from agricultural soils. Water quality is likely to improve along all pathways with the potential exception of the SD pathways. These emissions decline by almost 10% under the PD pathways, and by almost 20% in the DD pathways. However, in the SD pathway nitrous oxide emissions increase marginally.

F3.3

Modelling indicates that New Zealand can achieve low GHG emissions by 2050. A pathway relying on a combination of three key drivers – the expansion of forestry, the electrification of transport, and changes to the structure and methods of agricultural production – could see New Zealand reduce its emissions to 25 Mt of CO₂e at an emissions price rising to between \$75 a tonne (t) of CO₂e and \$152/t of CO₂e by 2050. New Zealand could reach net-zero emissions by 2050, with emissions prices rising to between \$157/t of CO₂e to \$250/t of CO₂e by 2050.

F3.4

Land-use change varies across the six modelled pathways. Forestry land expands greatly across the six pathways while land for sheep and beef farming declines. Land for dairy farming increases under those pathways that see the development of a methane vaccine and falls in the other pathways. Without the methane vaccine and with disruptive advances in plant-based meat and dairy substitutes, land for horticulture (and cropping) is likely to expand.

3.4 Modelling insights: conclusions and links to the rest of the report

The results outlined above reveal a noticeably different New Zealand economy and a very different emissions profile in 2050 compared to today. Given the scope and scale of potential changes within and between the pathways, this section considers in more detail some of the key findings and potential implications from these first-stage modelling results.

²⁴ The production of stock units does not necessarily result in the same reduction in total production, with, for instance, the increased weight of livestock having the potential to offset part of the reduction in stock units.

²⁵ The modelling assumes a cap on land being used for dairy farming from 2025, as a proxy for regulation to address concerns about water quality.

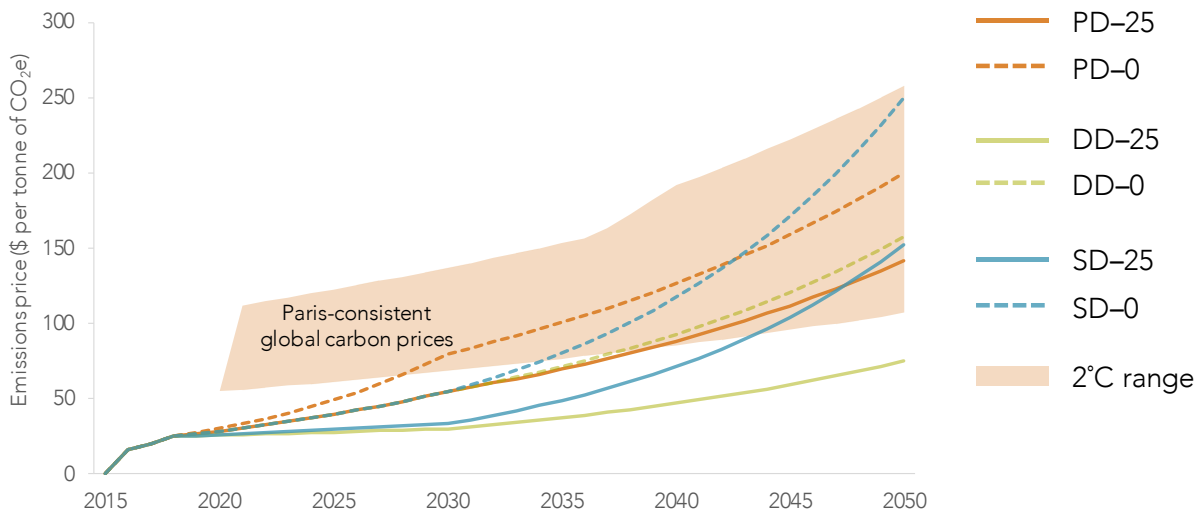
New Zealand can substantially decarbonise its economy with higher emissions prices

The modelling results suggest that New Zealand can substantially decarbonise its economy with higher emissions prices. These prices, although much higher than New Zealand's current emissions price, would be comparable to what are likely to be necessary in the rest of the developed world to limit global warming to under 2° C, consistent with the Paris Agreement. Under a 25 Mt target in 2050, the domestic emissions prices required are below Paris-consistent global carbon prices until well after 2035, and below or towards the lower bounds of the Paris-consistent global carbon prices in 2050 (Figure 3.13).²⁶ This reflects a confluence of factors, most notably the potential for significant increases in afforestation and New Zealand's low-emissions electricity system facilitating the cost-effective uptake of EVs.

This is particularly evident under the Disruptive Decarbonisation pathway, which achieves both the lowest emissions prices and the lowest cumulative emissions over the 2016–2050 period. In this case, technological developments and structural change early in the modelling period enable emissions to be constrained in the 2020s and 2030s, lessening the required emissions reductions after this period. The emissions prices needed are particularly low in the DD–25 scenario, where they remain far below the anticipated envelope of emissions prices consistent with the Paris Agreement throughout the period.²⁷

When moving to the more ambitious target of net-zero emissions in 2050, the prices are toward the middle of the envelope of Paris-consistent carbon prices for PD–0 and DD–0, and toward the upper bound of these anticipated prices for SD–0. Along the pathway with the highest emissions price under this target (the Stabilising Decarbonisation pathway), emissions prices reach around \$250/t of CO₂e in 2050.

Figure 3.13 Emissions prices to achieve net-zero-consistent emissions reductions, NZ\$



Source: Concept, Motu, Vivid Economics

Notes:

- Global carbon prices that are consistent with the Paris Agreement are based on the range of estimates developed by the Carbon Pricing Leadership Coalition and under the International Energy Agency's Sustainable Development Scenario to meet the Paris Agreement commitment to limit global warming to below 2°C. Some of these estimates extend only to 2030 and some to 2040, not to 2050. Vivid Economics has extended the price series at the lower of their implied real growth rate or 3% a year, to approximate the real rate of interest. Prices are translated to New Zealand dollars using an exchange rate of 0.74 USD/NZD.

Notably, the emissions-price trajectories for the SD pathways are below the PD pathways for much of the total period (mainly caused the government taking early action to raise emissions prices in the PD scenario). But then the SD price trajectories each rise above the corresponding PD trajectories ending at higher

²⁶ See Note1 under Figure 3.13 for an explanation of global carbon prices that are consistent with the Paris Agreement. These prices are used here as a benchmark against which to compare the emissions prices that the modelling has indicated are needed to achieve domestic emissions reductions in New Zealand consistent with a net-zero target either by 2050 or in the second half of the 21st century.

²⁷ A natural question is what would be the effect of raising New Zealand's emission prices to the lower boundary of the Paris-consistent envelope over 2020 to 2030 (ie, the prices that are set exogenously in the modelling)? The modelling did not investigate this question.

emissions prices (from around 2043 in the case of the net-zero pathways). These high emissions prices for the SD pathways later in the period are indicative of the value of taking early action to avoid more extreme action later (to achieve a given emissions target).

F3.5

Modelling indicates that New Zealand has the potential to decarbonise towards net-zero GHG emissions at emissions prices which, although much higher than the \$21 a tonne of CO₂e prevailing in early 2018, would be comparable to the prices expected to be needed in other developed countries to reduce emissions to levels consistent with the Paris Agreement ambition of keeping global temperature rise to below 2°C.

New Zealand's potential to achieve this goal stems from a confluence of factors, most notably the potential for significant increases in afforestation and its low-emissions electricity system facilitating the cost-effective uptake of electric vehicles.

Several features are common to all pathways

A clear majority of net emissions reductions along all six pathways are sourced from agriculture, forestry, and transport: this implies that any New Zealand decarbonisation strategy should focus on these opportunities.

A concerted expansion of the forestry sector is likely required to put New Zealand on a path consistent with net-zero emissions by the middle of the 21st century. Forest sequestration provides 25% to 45% of the net emissions reductions required to meet the 25 Mt of CO₂e target and provides 47% to 57% of net emissions reductions required to meet the net-zero target.

Agriculture is also a significant source of mitigation. All pathways see a continued reduction in pastoral agriculture, with sheep and beef farming in particular being outcompeted by alternate uses. Along the Stabilising Decarbonisation pathways, the successful development of a methane vaccine reduces emissions intensity and limits, but does not fully offset the need for land-use change. In the 25 Mt target pathways, reductions in emissions from agriculture are responsible for between 13% and 22% of total net-emissions reductions, and between 9% and 18% of emissions reductions in the net-zero target pathways.

Transport is the major driver of emissions reductions in the energy sector. The pace of technological development and uptake of low-emissions vehicles is of primary importance for the transport sector (Figure 3.8). Along the 25 Mt of CO₂e target pathways, reductions in emissions from transport, primarily electrification of the transport fleet, are responsible for between 8% and 24% of total net-emissions reductions, and between 6% and 16% of emissions reductions along the net-zero target pathways.

In turn, the expansion of EVs increases demand for further electricity generation, which the modelling suggests will be most cost effectively met through additional renewable generation. The difference in the outcomes for the transport sector between the 25Mt of CO₂e and net-zero targets is relatively minimal, with the increased carbon price in the net-zero target pathways driving only a small increase in mitigation.

Other sources deliver between 20% and 30% of net-emissions reductions. This is mainly achieved by:

- reducing emissions from direct energy use in agriculture and process heat for food processing;
- reducing emissions from refrigeration; and
- closing (as assumed) iron and steel production, particularly along the net-zero target pathways.

F3.6

All the modelled pathways show that the reductions in net GHG emissions come mainly from the forestry, agriculture and transport sectors. New Zealand's decarbonisation strategy should therefore focus on these opportunities. The dependence on forestry sequestration is particularly strong in the case of the target of net-zero GHG emissions by 2050.

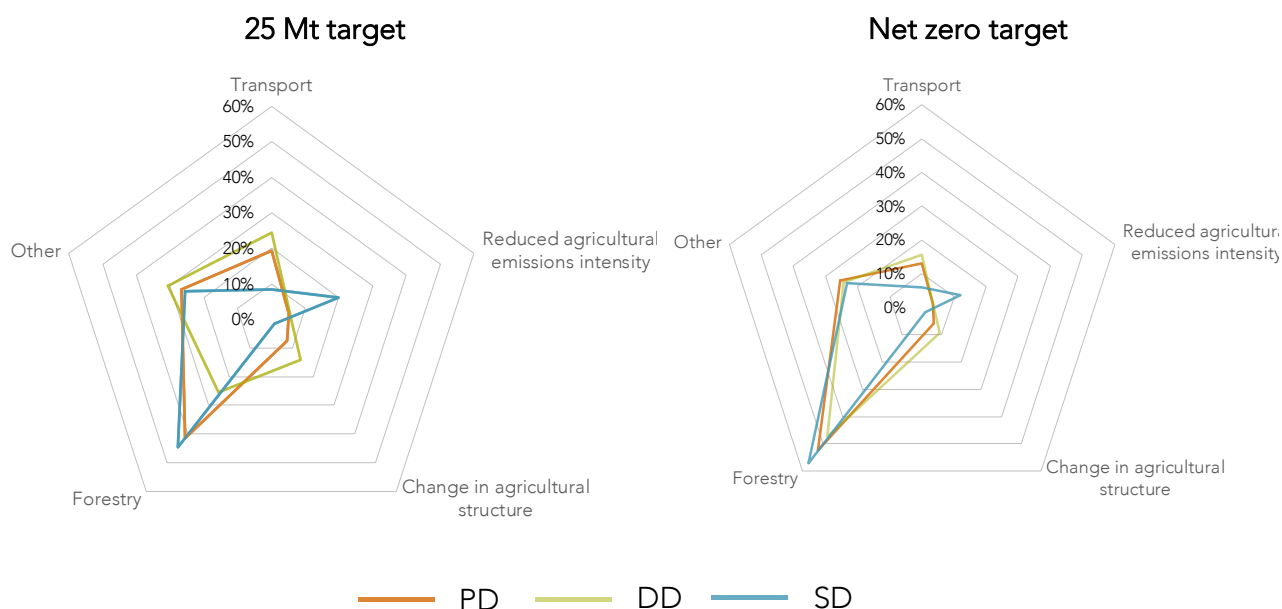
But differences between strategies merit further consideration

While the different pathways have much in common, their differences reveal important choices that New Zealand can take on the relative contribution made by different sectors and options for reducing the country's emissions. Figure 3.14 shows how New Zealand's emissions reductions are distributed across five main areas, and the relative weight that the different pathways place on each area.

The areas with potential for emissions reductions are:

- EV uptake, reducing emissions in the transport sector;
- reductions in the emissions intensity of agriculture, driven primarily by the potential introduction of a methane vaccine, inhibitor, or both, in pastoral agricultural systems.
- structural change in agriculture, moving from highly emissions-intensive farming to forestry, or to less emissions-intensive agricultural options, such as crops or horticulture;
- forest sector sequestration, with plantation or permanent forestry increasing in area; and
- other options, such as reducing industrial emissions intensities.

Figure 3.14 Proportions of total mitigation achieved that come from key areas



Source: Concept, Motu, Vivid Economics

Under the 25 Mt targets, the PD and SD pathways rely most heavily on forestry, which means that less mitigation is required from each of the other four areas. In contrast, the DD pathway relies more on the expansion of EVs (including in heavy vehicles) and structural change in other sectors of the economy. The SD pathway draws much more of its emissions reductions from reductions in agriculture emissions intensity, and much less from changes in agriculture structure.

However, under all net-zero pathways, sequestration from forestry dominates. In these cases, it provides about half of the required reduction in net emissions. In other words, in moving from a 25 Mt of CO₂e target to a net-zero emissions target, the modelling suggests that the expansion of the forestry sector would do much of the "heavy lifting".

Social and political preferences will influence the attractiveness of drawing on these different areas of mitigation opportunity. In addition, the next phase of modelling work will help identify how robust the pathways (and therefore their implied distribution of emission-reduction costs) are to uncertain, external events.

Transitioning from forest sequestration may prove challenging

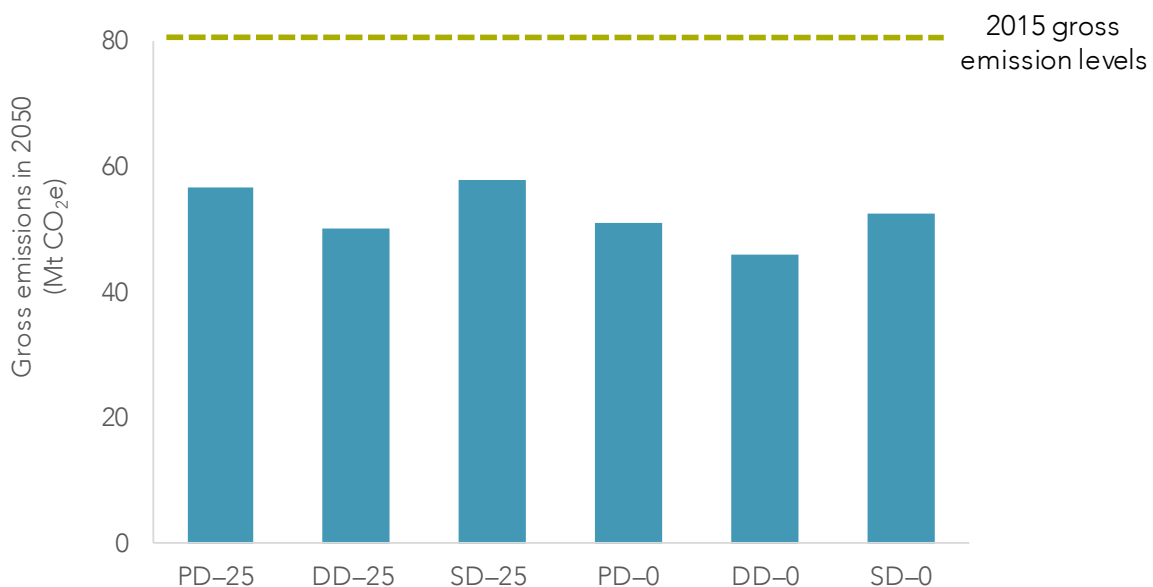
While afforestation provides plenty of scope for reducing emissions in the short term and medium term, challenges still exist in the longer term. Figure 3.15 shows the gross emissions (ie, before the effect of forestry sequestration) along each of the six pathways. In each case, gross emissions in 2050 are only 28% to 43% lower than in 2015.

To continue to reduce emissions beyond 2050 (or to stay at net-zero emissions beyond this date), New Zealand would either need to find ways of reducing these emissions, or to continue to sequester emissions from forestry. Such sequestering could be achieved by:

- some combination of further transition to forestry in land use patterns – which could be achieved if technological breakthroughs (such as synthetic meats) are realised and in use; or
- a transition from plantation forestry to permanent forestry.

At the emissions prices indicated by the modelling, significant movement from harvested forestry to permanent carbon forestry is likely. The modelling does not capture this dynamic.

Figure 3.15 Along all pathways New Zealand's gross emissions fall by less than 50%



Source: Concept, Motu, Vivid Economics

F3.7

While afforestation provides plenty of scope for reducing emissions cost-effectively in the short term and medium term, it is unlikely to continue to do so in the longer term since achieving such reductions would entail planting more and more land in trees. New Zealand will need to make additional cuts in gross emissions in the longer term. Such cuts will be costly in the absence of technological breakthroughs.

Each pathway has distinctive features

Each pathway has distinctive features. These must be considered carefully in terms of their implications for managing economic and social change and taking account of future uncertainties.

Distinctive features across the three pairs of pathways are noted below.

- The **Policy Driven** pathways require higher emissions prices in the short term to constrain emissions, but then see these prices grow at a slower rate to 2050 than those of the **Stabilising Decarbonisation** pathways. However, Policy Driven pathways still generate the highest cumulative emissions. They see a large expansion in forestry production and moderate increases in dairy production, but large reductions in output from sheep and beef. At the same time, policy to expand native forestry may bring biodiversity

and other environmental benefits and provide sequestration at a slower pace but over longer time periods. Support for public transport reduces negative externalities, but this support must be balanced against the potential for increased government costs.

- The **Disruptive Decarbonisation** pathways have the lowest cumulative emissions, lowest gross emissions, and lowest emissions prices. However, under these pathways, economic activity will be lost within New Zealand from the closure of iron and steel and aluminium production in 2025. The pathways have the lowest 2050 electricity costs and highest EV penetration rate. The DD pathways are alone in seeing lower dairy production, but this occurs alongside a trebling in land dedicated to horticulture and a large expansion in forestry.
- The **Stabilising Decarbonisation** pathways result in the highest emissions prices by 2050, but they avoid a degree of economic disruption in the process. They see the largest increases in dairy production, and smallest falls in sheep and beef production of all the pathways. But this means they are also likely to deliver the worst outcomes of the pathways for water quality. The pathways retain iron, steel and aluminium production longer than the other pathways, even though iron and steel manufacturing eventually closes under the net-zero emissions target. The rate of expansion in EVs is slower. This could mean lower capital costs for vehicles but higher fuel costs.

In addition to the differences across pathways, the choice of a less or more ambitious target brings its own trade-offs. As expected, a more ambitious target results in higher emissions prices and the potential for greater structural change. However, the analysis of targets does not simply relate to the costs of mitigation, but also to the costs incurred from climate change, and an assessment of New Zealand's appropriate contribution as part of a global response. Further, the economic dynamics modelled do not account for potential economic advantages stemming from early action on New Zealand's part; for instance, innovation in the development of new technologies and processes (Chapter 5). Nor, on the other side, do they consider the potential for some early actions taken by New Zealand to have a negative impact in the form of carbon leakage (Chapter 4).

Links between modelling insights and the rest of the report

This chapter on modelling New Zealand's transition to a low-emissions economy has set the scene for many of the later chapters in this draft report. These chapters dig much more deeply into topics that this chapter has only lightly touched on or ignored.

The modelling has suggested that two of the most important influences on New Zealand's path to low or net-zero GHG emissions are emissions pricing and new technology. Emissions pricing is examined in depth in Chapter 4. Technology is a strong focus in Chapter 5, which examines the role of innovation for low emissions. Technology also features prominently in the chapters on land use, transport, electricity, and heat and industrial processes (Chapters 10, 11, 12 and 13 respectively).

The modelling indicates that the biggest opportunities for reducing net emissions lie in three areas: forestry, agriculture and EVs. These areas are examined in depth with Commission recommendations for policy changes in the chapters on land use (which covers both forestry and agriculture), transport and electricity (the latter because of its importance in supporting increased electrification in transport and other areas).

Different pathways have very different impacts on different sectors and the people who work in them. Some government policies that support pathways are not included in the modelling. They include the social policies, for example, that help people who face disruption to make changes in their lives. Chapter 9 examines the topic of a transition that is inclusive.

Chapter 8 examines the important issue of whether to treat differently those GHG gases that are relatively short-lived in the atmosphere (such as methane) when compared to CO₂ (which is very long-lived). This is an important issue for New Zealand because over 40% of the country's gross emissions consist of methane from agriculture. Chapter 8 recommends that New Zealand should set separate targets for long-lived GHGs and short-lived GHGs. The aim would be to reduce emissions of long-lived GHGs to net zero, and reduce short-lived GHGs to a lower, yet positive, level. The modelling reported in this chapter can distinguish short-lived

GHGs and long-lived GHGs. Notably, pathways that achieve the 25 Mt of CO₂e target by 2050 achieve close to net zero emissions of long-lived GHGs.

Finally, Chapter 7 is about the laws and institutions to support a transition to a zero-emissions destination. The modelling shows it will be a long journey that requires steady progress towards the objective stretching over many years. Without suitable laws and institutions this journey is unlikely to happen in a democracy with 3-year parliamentary terms and subject to strong pressures to award political priority to short-term, immediate problems. The laws and institutions must provide clarity and steadfastness of purpose, transparency about progress, and the ability to take stock and, if necessary, change direction in the light of new information along the way.

Further modelling for the final report

As noted above, the current modelling is work in progress. Reported here are the results of modelling techno-policy pathways determined by expectations about technology and commodity prices that turn out to be correct.

The three pairs of pathways are:

- Policy Driven, requiring an early lift in the emissions price because technological progress is expected to be slow;
- Disruptive Decarbonisation, where technology that can sharply lower emissions is expected to disrupt existing industries; and
- Stabilising Decarbonisation, where technology is expected to lower the emissions of existing industries and enable them to continue.

The Commission is undertaking further analysis for the inquiry that aims to reveal insights about the effects of uncertainty about the medium- to long-term future. Decision makers know that the world may not turn out as expected, but that they will have future opportunities to revise their strategies once they observe how the future is evolving. To capture this important reality, the next phase of modelling will explore the implications of future external factors (eg, technology change and international emissions prices) turning out differently than expected. It will consider the ability of decision makers to “re-optimize” as key uncertainties are resolved.

This second phase of modelling to explore uncertainty, and how decision makers can best take it into account, is under way and will be reported in the Commission’s final report. Through this modelling, the Commission hopes to achieve insights about which starting strategies for achieving low emissions will not only be sensible in the short run, but also resilient to future information “shocks”. Resilient strategies take uncertainty into account by preserving rather than closing off future options. Resilient strategies also enable adjustments to be made as needed long the way that do not involve excessive costs, or regrets about earlier decisions.

Part Three:

Policies and institutions

In transitioning to a low-emissions economy, getting the right mix of policies and institutions in place is critical, not just for achieving sufficient emissions reductions, but also for maximising the benefits of the transition.

Part Three focuses on cross-cutting policies and institutions for New Zealand's transition that are pervasive across the wider economy. These establish a foundation of stable and credible climate policy that can enable the private sector and civil society to plan and take long-term decisions with confidence.

Key elements of this supporting architecture include:

- Effective emissions pricing
- Harnessing the full potential of innovation
- Supporting investment in low-emissions activities and technologies
- Laws and institutions to act as a commitment device
- Targeting short- and long-lived gases differently
- Policies for an inclusive transition

4 Emissions pricing

Key points

- An emissions price is the price emitters pay for each unit of greenhouse gas (GHG) they release to the atmosphere. The price should reflect the costs of emissions arising from their causal link to global warming.
- Emissions pricing can and should be used as the central policy lever to incentivise businesses and individuals to make decisions that lower their GHG emissions.
- Emissions pricing can take several forms: taxes and charges, subsidies, and tradeable emission permit schemes (sometimes called “cap and trade” or “emissions trading” schemes).
- A single emissions price has important benefits: it provides a strong incentive to reduce emissions at least cost; and it decentralises decisions to invest, innovate and consume across the economy to people who have the best information about opportunities to lower emissions given their circumstances.
- The two main forms of emission pricing – a carbon tax and an emissions trading scheme – have much in common. Yet they also have important differences such as whether it is better to have certainty in the price or the quantity of emissions, the ease of trading internationally, and the scope for participants to handle risk.
- A good emissions pricing scheme needs to handle several challenging issues including carbon leakage and free allocation for emissions-intensive and trade exposed firms, policy stability over time, the strategic use of government revenue from the scheme, points of obligation, and rewarding sequestration of carbon through forestry.
- The New Zealand Emissions Trading Scheme (NZ ETS) began in 2008 aspiring to be an all-gases, all-sectors scheme linked to international carbon markets. But biological emissions (mainly methane) remain excluded. The link to international markets led to a sharp and undesirable fall in the effective carbon price, which undermined incentives to reduce net domestic emissions.
- The Government severed the international link and the NZ ETS became a domestic scheme from 2015. This is desirable for now, and the price has risen to around NZ\$21 a tonne of carbon dioxide equivalent (CO₂e). Despite reforms announced in mid-2017, the NZ ETS needs a combination of greater control over permit supply (a robust domestic cap), greater price stability, and cross-party agreement on policy stability, to make it work well.
- New Zealand should not replace the NZ ETS with a carbon tax. Doing so would incur large transition and learning costs for no offsetting gain. Further, an ETS is better for revealing information, setting quantity caps on emissions, managing risk, and international trading.
- Modelling and other available evidence suggests that New Zealand’s emissions price will need to rise to at least NZ\$75 a tonne of CO₂e and possibly over NZ\$200 a tonne over the next few decades for reductions in domestic emissions to make a substantial contribution to New Zealand’s international commitments under the Paris Agreement.
- Emissions pricing needs a supporting package of low-emissions policies and institutions including legislation, regulations, an independent expert body, a fair distribution of costs and benefits, and widespread understanding and support from business and the wider population.

The purpose of this chapter is to examine emissions pricing as a crucial policy lever to incentivise businesses and individuals to make decisions that lower their GHG emissions.

The chapter will explain the why and how of emissions pricing. It will give a sense of what price levels may be needed to transform New Zealand's economy to achieve a low-emissions future. It will also examine the similarities and differences between the two main forms of emissions pricing: an ETS (sometimes called a "cap and trade" scheme), and a carbon tax.

The chapter will critique New Zealand's existing policy and arrangements for emissions pricing and make findings and recommendations for how these need to change to achieve outcomes consistent with its transition to a low-emissions economy.

4.1 Emissions pricing corrects a "negative externality"

An emissions price is the price that emitters of greenhouse gases (GHGs) pay for each unit of gas they release to the atmosphere. The price reflects the costs arising from the contribution of emissions to global warming. In the modelling of Chapter 3, the price of emitting GHGs was an important influence on the actions of businesses and households to lower their emissions. Chapter 2 pointed out that New Zealand's main initiative to mitigate climate change to date has been to set up and operate an ETS – a form of emissions pricing.

Emissions pricing is an example of using market incentives to correct a "negative externality" – when firms or households, without any direct adverse consequence for themselves, take actions that inflict harm on others. Factories generating air pollution that causes harm to the local population is an example of a negative externality. Putting a price on negative externalities applies the principle of "polluter pays". Making the polluter face the full social cost of their actions is sometimes referred to as "internalising" the external cost.

When negative externalities affect only one or a few other people, the problem is unlikely to require a government to intervene to solve it, particularly if property rights are well defined (Coase, 1960). For example, the neighbours of a farmer who fails to maintain their boundary fence could suffer damage from wandering cattle. The neighbours can expect the farmer either to compensate them, mend the fence, or both. Failing that, they can take the farmer to court.

However, a type of negative externality can occur where many people have rights in common to use property (called a "common property resource"), rather than the exclusive rights of a private owner. In such cases, people typically do not consider any negative impacts that their use may have on the value or productivity of the resource for others. People rationally focus on satisfying their own resource needs first. A collective solution among the community using the resource may develop, but it is by no means assured (Ostrom, 2007).

If everyone behaves rationally but individually, the resource will become overused and depleted, even to the point of its productivity falling to zero. This has come to be called the "tragedy of the commons" (Hardin, 1968) (see Box 4.1 for an example). Climate change is a tragedy of the commons on a global scale – where the common property is the earth's atmosphere that everyone shares and depends on.²⁸

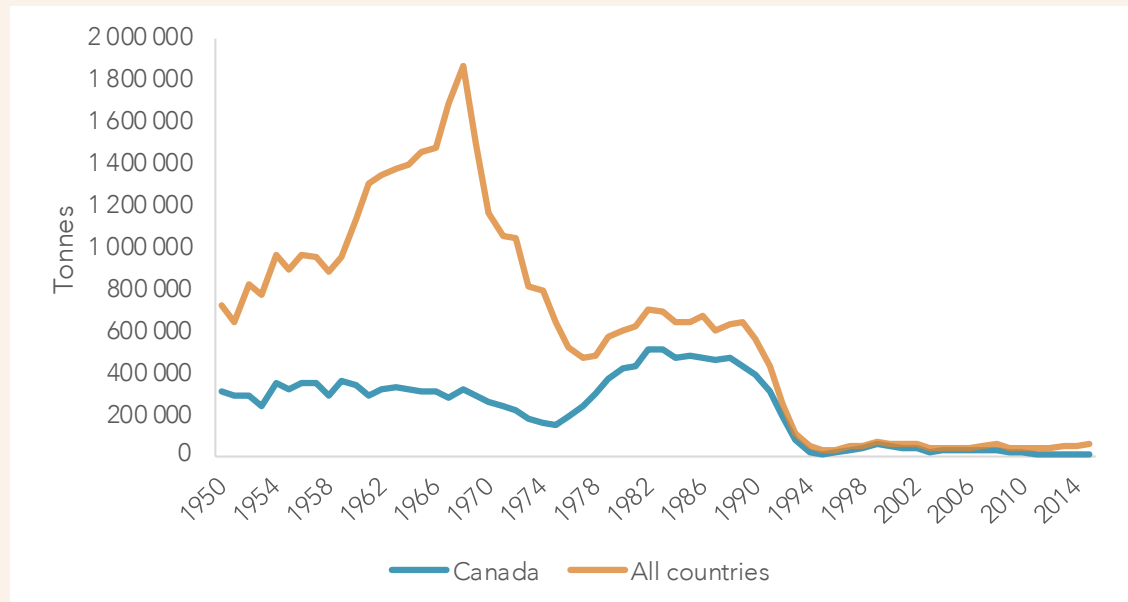
Box 4.1 A tragedy of the commons: the collapse of the Atlantic cod fishery

For 400 years off the eastern coast of Canada, the Newfoundland Grand Banks cod fishery was one of the most abundant in the world. Colonial settlers recounted stories of lowering baskets into the ocean and pulling them up, teeming with Atlantic cod, *Gadus morhua*.

²⁸ Lord Nicholas Stern has described the reality of climate change as the "greatest external effect in human history".

Between the mid-19th and 20th centuries, yearly catches in the northwest Atlantic were reasonably stable. But by the late 1960s, nearly 2 million tonnes of cod were caught each year. This dramatic peak precipitated a crash in fish populations. By 1992, the fishery had completely collapsed (Figure 4.1).

Figure 4.1 *Gadus morhua* capture in the Northwest Atlantic



The collapse of the fishery was the result of several issues (Hutchings & Myers, 1994).

- The imprudent use of new technology: Large trawlers equipped with sonar and other navigation tools caught fish at a rate higher than the fishery's ability to replenish.
- Scientific uncertainty allowing political inertia: Concerns were raised from the 1970s about the reduced number and size of cod. However, uncertainties in the science let regulators avoid making unpopular decisions to limit yearly catch quotas.
- A tragedy of the commons: The government failed to intervene largely because a transition away from a dependence on fisheries was unpopular, despite growing awareness that it was environmentally unsustainable. This led to individuals seeking short-term profits at the expense of the wider social good.

Source: FAO (2016).

So how can pricing externalities avert the outcomes from a tragedy of the commons? Pricing externalities incentivises people and businesses to take due care and responsibility for the full costs they impose on others (ie, including the external costs). Once faced with the full costs of a product they consume, households may choose to reduce their consumption, or switch to alternative, less-harmful products. Firms will have an incentive to look for alternative, less-damaging production methods.

To price harmful GHG emissions, governments can use three main types of instruments: taxes and charges based on emissions volumes, subsidies for avoiding emissions, and tradable permit schemes.

Taxes and charges based on emissions volumes

Volume-based emission taxes and charges require individual emitters to face the financial cost of each tonne of GHG emitted. Then, each emitter weighs the cost of

emissions control against the cost of emitting and paying the tax; the end result is that polluters undertake to implement those emission reductions that are cheaper than paying the tax, but they do not implement those that are more expensive. (IPCC, 2007, p. 755)

Taxes and charges are also known as price-based approaches; that is, they set an explicit price on a unit of pollution.

Subsidies for avoiding emissions

Subsidies aim to incentivise emissions reductions through rewarding certain behaviours or activities. Types of subsidy include tax exemptions, financial subsidies (such as preferential financing or credit guarantees), and feed-in tariffs.²⁹ For instance, the Australian Emissions Reduction Fund provides support to businesses and farmers to adopt new practices and technologies to reduce Australia's GHGs.

Subsidies, such as those for fossil fuel exploration, investment or use, can work against reducing emissions (Chapman, 2015; OECD, 2017c).³⁰ Not putting a price on a negative externality is, in effect, a subsidy from a social wellbeing point of view – that is, by not requiring an emitter to face the full cost of their actions, society is effectively subsidising their actions.

Transferable permit schemes

Transferable permit schemes require emitters to have (and surrender) a permit for each tonne of GHG emitted. On the other hand, those who sequester carbon (such as forest owners) can earn permits (and then sell them if they choose). The scheme works by setting a cap on the net quantity of emissions (ie, by issuing that number of permits or allowances), with participants trading emission permits among themselves. It also has the effect that if

it is less costly for a company to reduce emissions than to buy allowances, the company will reduce its own emissions. Similarly, if a company can reduce emissions below its requirements, so it has excess allowances, those allowances can then be banked for future use or sold in an open market to a firm that finds it more difficult (costly) to reduce emissions. (C2ES, 2015, p. 3)

Permit scarcity through setting a quantity cap is critical because this generates a price on GHG emissions that is high enough to incentivise abatement. These systems are also known as quantity-based approaches, as they work by only allowing a certain quantity of emissions allowances to be distributed (or auctioned).

Efficiency of emissions pricing

Properly designed and implemented, emissions pricing is a powerful, efficient (ie, least-cost) way to reduce emissions. The key is that every emitter or absorber of GHGs across the economy faces the same price for each tonne of CO₂e emitted or absorbed.

The effect of this single price is that emitters are each incentivised to choose mitigation options that all cost less than the price, and none of those that cost more. Conversely, the absorbers are encouraged to invest in all absorption options that cost less than the value of the subsidy or allowance they earn. Collectively, agents are incentivised to find and implement the least costly ways to reduce GHG emissions, invest in their absorption, or both. Figure 4.2 illustrates this for a set of potential projects to reduce emissions.

In this way, emissions pricing can avoid two types of inefficiency.

- Emitter A reduces emissions by one tonne at a higher cost than Emitter B who takes no action but has less costly abatement opportunities (a parallel case could exist for two absorbers).
- An absorber absorbs one tonne of an emitter's emissions at a higher cost than the emitter could have reduced them.

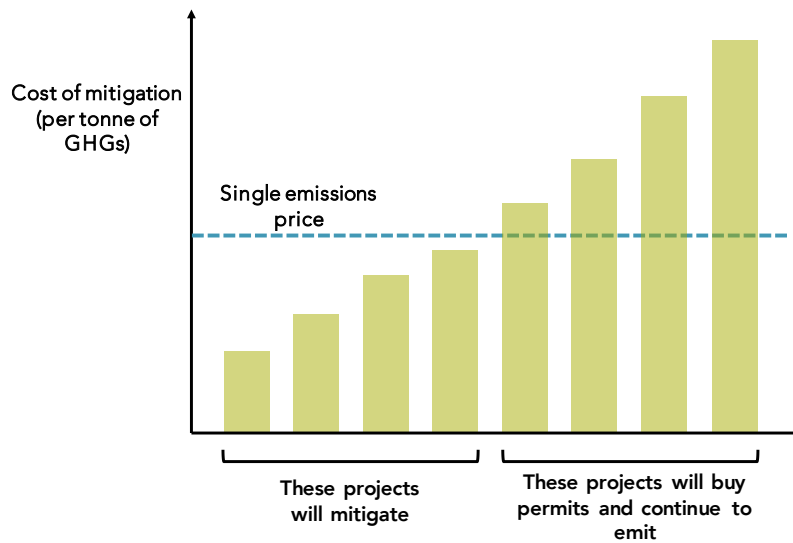
In addition, pricing has another important efficiency property: it can decentralise options and evaluations about the cost of mitigation or absorption to individual agents across the economy. The alternative –

²⁹ Feed-in tariffs aim to accelerate investment in renewable energy by providing a set price (above the retail or wholesale electricity price) to renewable energy producers for each unit of energy produced and exported to the electricity grid.

³⁰ New Zealand has a variety of subsidies that support the fossil fuel sector: see, for example, APEC (2015).]

gathering all this information at some central point to make decisions about which options to pursue – would be impractical and very expensive.

Figure 4.2 The efficiency of a single price in reducing emissions



The level of the emissions price in an economy will strongly influence the overall reduction in emissions. A higher price will incentivise a greater reduction than a lower price.

A government's choice of price instrument will depend on several factors, including deciding whether it is better to specify the price of emissions or their quantity. Taking one example, New Zealand chooses to protect its common-property fisheries using a quantity mechanism: a system of Individual Transferable Quotas (ITQs) that limits fishing catch to keep fish stocks within sustainable limits (Box 4.2).

Another factor to consider are the transaction costs of any scheme of emissions pricing. Transaction costs include the administrative costs of the agency running the scheme, and the compliance costs of businesses and individuals who participate (either voluntarily or compulsorily).

Box 4.2 Fisheries and individual transferable quotas

Established in 1986 via the Fisheries Amendment Act, New Zealand's Individual Transferable Quota (ITQ) system is a market-based approach that aims to ensure the long-term environmental and economic sustainability of New Zealand's fisheries.

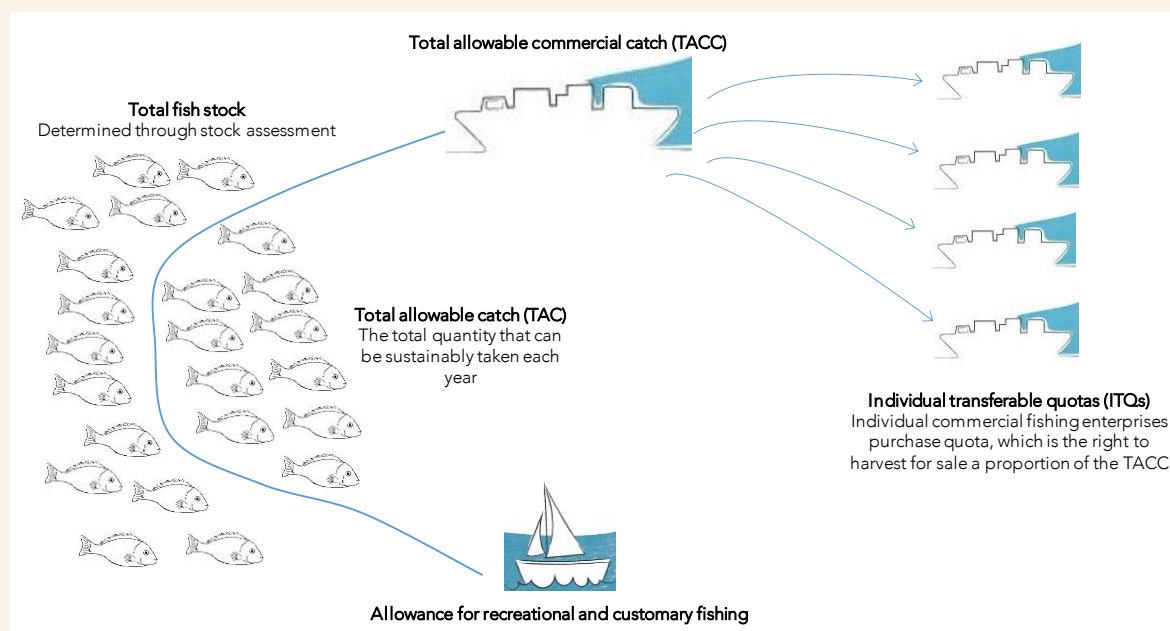
The ITQ system is part of a wider quota management system based on the principle of achieving a maximum sustainable yield (MSY). With reference to environmental, economic and social factors, every year the Minister of Fisheries sets a yearly total allowable catch for each fish species within each fisheries management area of New Zealand's exclusive economic zone. The levels of the total allowable catch are designed to sustain the MSY for each species, and are further specified into a total allowable commercial catch: – this is the total allowable catch minus allowances for recreational and Māori customary fishing (Figure 4.3).

Each total allowable commercial catch is divided into ITQs that individuals or companies may hold, and which entitle them to an associated yearly catch entitlement. This entitlement is to a share of the total allowable commercial catch – an amount of the species that the ITQ owner can fish each year. These quotas are property rights and quota holders may trade their quotas for each species (Lock & Leslie, 2007). No centralised trading exchange exists but quota holders are free to buy and sell quotas.

Concerns about certain aspects of the ITQ system have been raised, such as aggregation of quota by large companies and subsequent exclusion of smaller fishers, with impacts on local communities

(Gibbs, 2008). Yet, on balance, analysis suggests that the positives of the system have considerably outweighed any negatives (Mace et al., 2014).

Figure 4.3 Simplified model of the quota management system



Source: MPI (2017b).

Key factors for the economic success of the ITQ system include simple and standardised rules for quota definition and trading, long-term market stability, and low levels of government intervention in the trading process (Kerr et al., 2003). Key factors for its environmental success include development of high-quality technical guidance on achieving MSY, a clear focus on environmental principles and biological diversity, and support for innovative science (Mace et al., 2014).

4.2 Controlling emissions: permits versus an emissions tax

Many agree that putting a price on emissions needs to be a key part of de-carbonising an economy. Yet some debate is ongoing about whether quantity permits/allowances or a carbon tax³¹ is the better way to implement emissions pricing. This section unpicks that debate to prepare for findings and recommendations later in the chapter about the best way forward for New Zealand.

The “duality” between prices and quantities

The discipline of economics has developed an important insight that a *duality* or equivalence exists between quantities of goods and services and their prices. In 1974, American economist Martin Weitzman published a classic paper called “Prices vs Quantities” (Weitzman, 1974). In the paper he analysed “the question of whether it would be better to control certain forms of pollution by setting emission standards or by charging the appropriate pollution taxes” (p. 477).

It turns out that, in a world of certainty, duality ensures that it makes very little difference. But uncertainty is real and present, and the answer then depends on the relative cost of getting prices or quantities wrong when decision makers set one of them and let the market determine the value of the other.

³¹ This chapter uses the terms “emissions tax” and “carbon tax” interchangeably. The term “carbon tax” is in more commonly used, but a large quantity of New Zealand’s GHGs is not carbon dioxide but methane. Therefore, strictly speaking, the broader term “emissions tax” is more accurate.

Setting quantities gives certainty on the level of emissions, yet creates the risk that the corresponding price (determined by market decisions) will turn out to be costly. Conversely, setting prices gives certainty about the price of emitting a unit of GHGs, yet creates the risk that the corresponding quantities (determined by market decisions) will turn out to be costly. The answer to the Weitzman question will depend on these relative costs (Table 4.1).

Table 4.1 Relative merits of setting prices versus setting quantities of emissions

Control variable for GHG emissions reduction	Cost of errors in the non-control variable
Price (eg, set by a carbon tax)	Quantity of reduction is too little: the cost is insufficient progress towards meeting a carbon budget or point-in-time GHG target.
	Quantity of reduction is too big: emission reductions are greater than needed, so more costs are incurred than necessary.
Quantity (eg, set by a cap on emissions)	Emissions price is too high: business and households have insufficient time to adjust, leading to high costs.
	Emissions price is too low: opportunity is missed to make reductions in emissions more ambitious. Investments in low-emission projects are discouraged.

The answers to two other questions bear on the decision to set quantities or prices.

- How easy or hard is it to reverse an over or under shoot in the variable that is market determined (ie, the price if the quantity is set or the quantity if price is set)? For instance, if the reduction in the quantity of pollutant is too small, the damage to the environment could be very large and difficult to reverse.
- What information is revealed when the market determines the variable (price or quantity) that is not set? For instance, a small reduction in quantity when price is set, or a high jump in price when quantity is set suggests emissions reductions are difficult and costly. In turn, this suggests that marginal costs of mitigation are high, or that some other barrier is getting in the way of adjustment.

Comparing carbon taxes and emissions trading schemes

The basic features of carbon taxes and emissions trading (permit) schemes are straightforward. The following description is based on Leining (2017).

Under a carbon tax, obligated parties must pay a specified levy to the government for each tonne of emissions for which they are liable.

Under an ETS, obligated parties must surrender a tradable emission unit for each tonne of emissions for which they are liable. The government limits the supply of emission units, which then sets the price based on unit supply and demand. ETS participants can potentially acquire eligible emission units to meet their obligations by:

- receiving them for free;
- buying them at auction (which generates government revenue);
- buying them from other participants (which creates incentives for others to reduce their emissions and sell surplus units);
- earning them by ETS removal activities (such as forestry); and
- buying them from external (domestic or international) offset projects.

While a carbon tax and an ETS each price emissions by the tonne, the variety of ways that obligated parties can obtain ETS units (ie, permits) – as opposed to the single option of paying a tax – is an obvious

difference. Even so, a tax and an ETS are similar and can replicate each other in many ways (Goulder & Schein, 2013). Some similarities are that:

- tax exemptions can have a similar effect to free allocations of emissions units;
- both provide government revenue if in different ways;
- removal activities (such as forestry) could be rewarded with a subsidy rather than an emissions unit for each tonne removed;
- by offering emission units at a fixed price, the government can fix a price of emissions similar to a tax;
- agent A purchasing one tonne of emissions from agent B who removes one tonne is similar to A paying the tax and B receiving a subsidy of the same value;
- both require effective measurement, monitoring, and reporting of emissions and enforcement of penalties for non-compliance; and
- both require choices about the point of obligation for surrendering emissions units or paying the tax.

This rather long list reinforces the essential similarity between pricing emissions through a carbon tax or an ETS and is a point to note when considering whether New Zealand should continue with its existing ETS, or abandon it for a carbon tax. Yet the choice should focus most on five significant differences that distinguish the two instruments.

- New Zealand already has the legal and institutional machinery for an ETS in place, together with the familiarity of participants and administrators with how it works. Because of this, New Zealand would not have to incur the cost of investing in these again if it continues with its ETS, which it would do if it built a carbon-tax regime from scratch.
- As noted, a carbon tax and an ETS allow the government to set respectively the price and the quantity of emissions and allow the market to set the other. The costs and benefits of these may differ because of uncertainty and the potential cost of the market-determined variable turning out to have the “wrong” value (Table 4.1).
- A carbon tax cannot incorporate international carbon trading but an ETS can. An obligated party may be able to buy ETS units outside the regime from a foreign source. The foreign party reduces its emissions over and above what it otherwise would have done and this offsets the emissions of the obligated party. An offset mechanism of this sort is not available with a carbon tax.³² This is a deficiency because carbon trading outside a regime’s boundaries can be an efficient way to reduce global emissions.
- Emission permits give owners a transferable property right (to emit GHGs) and this right has a value in the marketplace. Carbon taxes do not have this feature. Property rights in permits have several potential benefits:
 - they can enable the holder to hedge risk (eg, by purchasing at today’s price and holding permits to emit later when the permit price may have changed);
 - a “thick” market in permits can assist with price discovery, liquidity and incentives to innovate; and
 - the presence of owners of valuable property rights can restrain political tampering and help assure business and others about the stability and longevity of an ETS (Levin et al., 2012).
- Markets for emission permits have the scope to create futures, forward and derivative markets related to them. A carbon tax does not have the same scope. These related markets can provide additional ways to hedge risk or for the government to signal commitment. In the latter case, by contracting in the futures

³² However, government-to-government emissions trading could exist alongside a carbon tax.

market to buy a large volume of permits in, say, 10 years' time at a price higher than the current price, the government can signal its commitment to a high and rising emissions price over time.

The similarities and differences between carbon taxes and an ETS must be considered when deciding whether New Zealand should continue with its ETS (in its present or a modified form) or switch to a carbon tax.

In summary, a carbon tax and an ETS are similar instruments in many ways and are aimed at the same objective. Each can be a powerful and effective way to incentivise businesses and households to take actions – investment decisions, consumption decisions, and decisions to innovate – that reduce GHG emissions.

The power of each form of emissions pricing lies in the ability to decentralise decisions across an economy, unlock local knowledge and initiative, be neutral as to the means (eg, which technology, which sector, which consumption choices?) and achieve the desired emissions reduction at least cost. This power is why one form of emissions pricing should be the central prong of a country's strategy to lower its GHG emissions.

However, carbon taxes and ETSs also have differences that are important to the decision as to which approach New Zealand should adopt as its centrepiece for driving change towards a low-emissions economy.

F4.1

Carbon taxes and emissions trading schemes (ETSs) are different forms of emissions pricing that have much in common. Each is a potentially powerful instrument that can act across the economy in a decentralised manner to reduce greenhouse-gas emissions at least economic cost.

Yet, carbon taxes and ETSs also have important differences such as whether the emissions price is fixed and the quantity of emissions is uncertain or vice versa. These differences bear on the decision about whether New Zealand should adopt a carbon tax or an ETS as the centrepiece of its transition to a low-emissions economy.

Should New Zealand replace its ETS with an emissions tax?

As noted, the fact that New Zealand already has a functioning ETS with its supporting laws and other institutional arrangements, as well as familiarity of participants with the system, makes a big difference to whether New Zealand decides to keep the NZ ETS, or replace it with an emissions tax. As these "assets" are sunk investments, their cost should not enter the evaluation of options going forward. Yet, retaining the NZ ETS would not incur such costs again. On the other hand, starting afresh to build an emission-tax system *would incur* the cost of building up a whole new set of supporting assets.

The additional benefits of emissions pricing using a carbon tax rather than an ETS would have to be large to outweigh the significant cost of dismantling the NZ ETS and setting up and becoming familiar with a new system. As noted, differences emerge in the realistic case of uncertainty. The uncertainty that is more damaging depends on the relative costs of different "errors" in the uncertain variable. The costliest appear to be:

- undershooting emission-reduction targets;
- an emissions price that is unexpectedly high and imposes high costs on affected firms and households; and
- an emissions price that is unexpectedly low and imposes high costs on investors who have committed to low-emissions investments (eg, in forests or other long-lived assets).

The first of these risks would be present under an emissions tax, but not under an ETS where the emission reductions can be specified by setting "caps" on the number of units issued. The second and third risks occur under an ETS but not under an emission tax. Yet within an ETS they can be mitigated by setting a

suitable price ceiling and price floor³³. This risk analysis seems to show little reason to incur the high costs of replacing the NZ ETS with an emissions tax.

The other differences between an emissions tax and an ETS also point in favour of an ETS because an ETS:

- allows international trading in emission reductions (when the time is right); and
- creates property rights and markets that enable risk management, price discovery, and commitment mechanisms that help insure against short-term political tampering.

The strongest argument for an emissions tax is that, in some respects, it is simpler and easier to understand than an ETS. But this is a more convincing argument when no emissions-pricing system exists, or when a country lacks the administrative and governance capacities to create and run a sophisticated permit market. Neither of these circumstances applies to New Zealand.

Yet, suppose New Zealand were to transition from the NZ ETS to an emissions tax. To gain a better grasp of just what challenges this transition would involve, Leining (2017) set out some required key steps and decisions.

NZ ETS participants collectively hold a large volume of “banked” New Zealand Units (NZUs) and NZ Assigned Amount Units (AAUs):³⁴ as of June 2017, the bank of NZUs and NZ AAUs totalled about 128 million units, of which about 82 million were held by individuals or organisations involved in forestry (EPA, 2017). Since 2008, participants have operated under policy settings that enabled them to bank NZUs and NZ AAUs under assurance of their long-term eligibility for surrender in the NZ ETS to legally emit GHGs.

A formidable challenge in a transition would be how the government would handle these banked NZUs and NZ AAUs. In acquiring and holding banked units, participants have made substantial investment decisions. The government would need to identify a process for running down banked NZUs and NZ AAUs. For example, the government could buy back banked units at a fixed price or accept banked units in place of carbon tax payments.

The government’s transitional process for managing banked NZUs and NZ AAUs would need to be legally, fiscally and politically acceptable. The government would need legal advice on whether its process constituted a taking of private property for which fair compensation was required (Guerin, 2002). At unit prices ranging from NZ\$18 (the NZU price in mid-2017) to NZ\$25 (the government’s price ceiling), this could have a market value ranging from NZ\$2.3 billion to NZ\$3.2 billion. However, banked units are expected to decline over time – particularly from their use to cover liabilities from harvesting forests.

Other challenging steps would be to:

- set the level of the emissions tax and the process for updating it over time;
- design transitional processes and new regimes for forestry registered under the NZ ETS, and continue with appropriate safeguards against emissions leakage (see next section); and
- ensure continuing effective detection of non-compliance and enforcement.

None of these steps would be straightforward.

Leining (2017) summarises some key considerations in favour of retaining and reforming the NZ ETS rather than replacing it with a carbon tax.

Decision makers currently face information gaps regarding New Zealand’s technical and economic mitigation potential, sectors’ responsiveness to emission pricing and the relative cost of purchasing international emission reductions. In this context, it would appear to be easier technically and politically

³³ However, if a price ceiling is set low it could re-introduce a risk of the first type – undershooting an emissions-reduction target because the price ceiling is not a high enough price to restrain emissions to the extent needed. This could leave the government exposed to the fiscal risk of having to purchase from other countries any shortfall in emission reductions.

³⁴ Assigned Amount Units are tradable “Kyoto units” under the Kyoto Protocol. From July 2010 to December 2012, the forestry sector could convert NZUs allocated to them for carbon removals into NZ AAUs that could be sold to overseas buyers or surrendered within New Zealand to cover future emissions.

for the government to set a quantity cap aligned with our targets and nominate price safeguards against unacceptable extremes than to determine a single efficient carbon price consistent with delivering on our targets and change it over time in response to domestic emission trends. The latter shifts considerable price risk for delivering mitigation to meet national targets from market participants to taxpayers. (p. 29)

F4.2

The additional benefits of emissions pricing using a carbon tax rather than an ETS would have to be large to outweigh the significant cost of dismantling the NZ ETS and setting up and becoming familiar with a new system. While the two instruments are similar in many ways, a reformed NZ ETS is likely to perform better given that New Zealand has an established ETS and has an urgent need for substantial domestic emission reductions to achieve its targets.

4.3 Specific issues in emissions pricing

Emissions leakage and free allocation

A controversial effect of emissions pricing is raising the costs of domestic firms exposed to international competition from firms in other countries that face either a zero or lower price on their emissions. Possible negative impacts are:

- domestic firms may not be able to compete or even be forced to close;
- over time, production may re-locate and grow in countries without emissions prices; and
- global emissions may stay the same or even increase if production in other countries is more emissions-intensive than the lost New Zealand production. Further, such production shifts could be hard to reverse even after emissions price parity is reached in the other countries.

These effects are called “carbon leakage” or “emissions leakage”. Several New Zealand firms or whole industries claim they are in this position. While relatively few in number, they are significant in scale. Concerns have been raised about aluminium, methanol, urea, dairy, steel and oil & gas production. For example, New Zealand Steel submitted:

In a similar vein, we ask that New Zealand Steel is only exposed to a carbon cost that is approximately equivalent to our competitors. Any unilateral increase to New Zealand Steel’s current net carbon costs would result in the “perfect storm” to our business.New Zealand Steel operates in a challenging, difficult environment where we are often at a disadvantage vis-à-vis many of our trading partners. Put simply, unless our competitors face a similar carbon cost profile then we will be unable to effectively compete in the global steel market place. (sub. 64, pp. 7–8)

In relation to New Zealand’s dairy and oil refining industries, Fonterra and Refining NZ submitted:

A global approach must be taken in order to prevent carbon leakage, especially for food production. Due to our efficient pastoral grazing system and healthy cows, New Zealand dairy farmers are amongst the most emission-efficient in the world. We produce less than half the world average (0.9 vs. 2.5 kgCO₂e/kgFPCM) and less than a quarter of the world’s least efficient producers (7kgCO₂e/kgFPCM).³⁵ There is no global benefit to shifting milk production from New Zealand to (less efficient) milk producers elsewhere. (sub. 88, p. 2)

Overly onerous targets which lead to Refining NZ’s closure may result in unintended consequences, such as the production of New Zealand’s fuel requirements offshore by less energy efficient, more carbon intensive refineries together with increased CO₂ emissions in longer shipping supply chains. Closure of Refining NZ would, paradoxically, increase GHG emissions globally (carbon leakage). (sub. 129, p. 3)

On the other hand the evidence to date on the deleterious effects of emissions pricing on competitiveness is weak. See Arlinghaus (2015) for a review of empirical findings.

³⁵ FPCM = fat and protein corrected milk.

The problem of emissions leakage would not exist in the presence of a uniform global emissions price. But the world is currently far from that ideal. In the meantime, a common policy response is to award firms in the category of “emissions-intensive, trade-exposed” (EITE) a total exemption from emissions pricing or, within an ETS, an allocation of free units. New Zealand policy includes instances of exemption (eg, agriculture is outside the ETS) and free allocation (all firms within the ETS that are EITE). For more information, see Climate Change Response Act 2002, Part 4, Subpart 2.

A serious downside to total exemption is that businesses face a zero emissions price and so face no incentive to reduce their emissions. Relative to paying the full social costs of their inputs, these businesses are subsidised. Several submitters have pointed to the adverse consequences of this for forestry (Oji Fibre Solutions, sub. 71; Scion, sub. 67; Waikato Regional Council, sub. 48; NZ Institute of Forestry, sub. 73; Te Rūnanga o Ngāi Tahu, sub. 83). As Oji Fibre Solutions points out:

Present policies that favour agricultural land use over forestry land use by exempting the former from any cost of emissions have the effect of increasing the cost of land and therefore reducing the profitability of afforestation. Such subsidies are untenable if the Paris Agreement targets are to be met. (sub. 71, p. 2)

Free allocation is a better approach provided it is designed to provide a full price incentive for firms to reduce emissions *at the margin*. To explain what this means, consider that the number of free units allocated to an EITE firm is based on its level of emissions in recent years. Then its free allocation protects the firm from international competitors up to this level. For anything beyond this level, the firm faces the full emissions price (and will need to pay for and surrender emission permits). This incentivises firms to reduce emissions through investing in new technology or smarter practices, or simply by reducing output. Each reduced tonne of emissions is worth the price of an emissions unit (ie, permit) to the firm. Say this is \$25. The \$25 saved is either because the firm does not have to buy an additional unit, or the firm does not have to use one of its freely allocated units, which it can then sell for \$25. Pacific Aluminium’s submission describes how this works:

The current scheme incentivises abatement in companies that carry out EITE activities. By providing an allocation to EITE activities on the basis of their production against a historical baseline, the allocation provided does not vary with the actual emissions of the activity at the facility. This means that any saving in emissions at the facility sees at the margin the full price of carbon in the NZ economy, providing a significant incentive for the EITE activity to abate where possible. (sub. 21, p. 4)

Yet New Zealand’s ETS scheme determines the number of free units for a firm by multiplying its *current* output by an historical average emissions intensity in a given recent historical period for the type of activity that the firm is conducting.³⁶ Although this method still provides an incentive for the firm to lower its emissions intensity, it largely snuffs out its incentive to curb its emissions by reducing output of an emissions-intensive product and, perhaps, increasing its output of an alternative low-carbon product.

Free allocation of emission units for EITE firms costs the government revenue. Also, the justification for free allocation will diminish as other countries increasingly impose comparable emissions pricing on their firms in the same industry. As that happens, and given plenty of prior notice, protection for EITE firms should be gradually withdrawn.

F4.3

Both an ETS and an emissions tax can be designed to protect emissions-intensive, trade-exposed (EITE) firms from emissions leakage by allocating free emissions units or a level of tax exemption to the firms. New Zealand’s method of allocating units incentivises firms to reduce their emissions intensity but not reduce emissions through reducing output. Free allocation costs the government revenue. The case is strong to withdraw the free allocation of units to EITE firms over time as competing firms in other countries also face emissions pricing.

³⁶ The default years for determining emissions intensities are the financial years 2006/07 to 2008/09. See MfE (2018).

Use of revenue from emissions pricing

Through a carbon tax or auctioning permits (units) in an ETS, governments can raise substantial amounts of revenue. For example, at a carbon price of \$25 a tonne of CO₂e, taxing or selling units to cover 50% of New Zealand's gross GHG emissions in 2015 would raise around \$1 billion (with no free allocation of units). How could and should governments use such revenues to benefit the economy and society more generally? Several possibilities exist, such as the three noted below.

- *Reduce distortionary taxes.* Revenue-raising taxes (such as income taxes and GST) distort incentives to earn, save or invest. A carbon tax or ETS does not; rather, it reduces economic inefficiency by putting a price on an unpriced negative externality. So pricing emissions and using the revenue from either of them to reduce a distortionary tax can pay a double dividend.
- *Invest in specific initiatives.* These initiatives could relate to mitigating emissions such as funding research and development (R&D) on new low-emissions technologies, funding schemes to foster the uptake of low-emissions technologies, or investing in public transport and cycleways. Several submitters, such as O-I New Zealand, supported this use of revenue:

O-I sees value in investment in research and development and innovation, and would like to see the government explore the potential for the ETS to generate funds, which could be hypothecated for investment in research into technologies to reduce carbon emissions, particularly in the agricultural sector (sub. 85, p. 6)

- *Support vulnerable households, communities and businesses.* Emissions pricing could cause substantial economic hardship for some households such as poorer households facing higher heating and transport costs (Chapter 9). Also, as noted above, full emissions pricing can potentially put EITE firms out of business. Providing these firms with tax exemptions or free allocations of ETS units is the most common way to assist them. Effectively, by foregoing the revenue that the government would otherwise have collected, the government spends it.

F4.4

A carbon tax or auctioning permits (emission units) in an ETS can enable a government to raise potentially large amounts of revenue. Several legitimate options are available to the government to decide how it spends this revenue. Those options include reducing distortionary taxes, investing in specific initiatives to enable emissions reductions at lower cost, and supporting vulnerable households, communities and businesses.

Stability and predictability

Decisions that help the transition to a low-emissions economy often involve taking a long view. Examples are planting a forest or investing in long-lived assets such as electricity generation plants, vehicles and buildings. An important aspect of these decisions is not just what emissions pricing and rules are in force today, but what businesses and households expect them to be like over the next 10, 20 or 30 years. If the stability of policy settings is uncertain, or confidence in them is lacking, then potential investors will hold back from committing to lowering their emissions. The source of policy instability is often political – lack of consensus across the main political parties, or lack of resolution of current arrangements that are clearly unsustainable (eg, an economic pathway that continues to rely on revenues from fossil fuel). Several submitters expressed the vital need for stability and predictability in emissions pricing and policy.

[W]e will only be able to reduce emissions in all sectors if we have coherent, predictable government policies that match the new global ambition. This will need to include efforts to support the path towards a global price that is supported by a linked emissions market, enduring and long-term political accord to encourage and stimulate alternative energy investment, and a meaningful price on carbon that will engender real behavioural change. (Z Energy, sub. 110, p. 8)

During the investigation into the UK Climate Change Act, members of my staff met with a number of private sector companies. They found a general frustration with the lack of stability in climate change policy. Without a measure of predictability, companies cannot manage the risks of moving to a low-carbon economy. Nor can they invest with confidence in low carbon technologies. (Parliamentary Commissioner for the Environment, sub. 54, p. 4)

A mechanism to provide certainty to business and ensure economic stability in relation to climate change controls is essential. Advice and reporting from a Climate Change Committee may help smooth fluctuations in policy and approach of successive governments. (Fertiliser Association, sub. 61, p. 12)

The main uncertainties for investment into a low-emissions future is legislative change. New Zealand's regulatory framework should provide efficient signals, incentives and long-term stability for businesses and consumers to make informed investment and purchasing decisions. (Vector, sub. 63, p. 17)

Business seeks predictability and stability of the conditions and frameworks in which they operate so they can plan with greater confidence, knowing that the assumptions they make about the future are broadly likely to hold. We are mindful that investors in the upstream petroleum sector, and large industrial enterprises, are generally looking at an investment horizon of 5 to 30 years. (PEPANZ, sub 65, p. 4)

Chapter 7 examines the institutional, governance and implementation options for improving policy stability through legislation (a Climate Change Act) and accompanying bodies (such as an independent Climate Change Commission) and processes.

F4.5

Because decisions that impact on GHG emissions often involve a planning horizon of many years, the stability of policy settings and institutional arrangements for emissions pricing is vital. If the stability of policy settings is uncertain, or confidence in them is lacking, then potential investors will hold back from investing to lower their emissions.

International emissions trading

A key component of New Zealand's strategy to date to meet its GHG reduction targets has been to purchase reductions through participating in international carbon markets. In the first Kyoto commitment period (2008–2012), participants in the NZ ETS were free to purchase international credits to offset their emissions. Some purchased large amounts at prices of less than NZ\$1 a tonne of CO₂e, then banked them or exchanged them for emissions units in the NZ ETS (known as NZ units, or NZUs). Between 2008 and 2012 New Zealand therefore collectively accumulated a large surplus of international credits.

New Zealand plans to meet its 2020 emissions target (covering the 2012–2020 period) partly by relying on this surplus of international credits despite the source of some credits being from emissions-reduction projects in countries that lacked credibility in reducing emissions beyond business as usual (Simmons & Young, 2016).

The economic logic of allowing trading in emissions reductions internationally is straightforward. The logic is similar to the benefits of free international trade in goods and services: economic efficiency and comparative advantage. If another country can reduce emissions at a lower cost than is possible in New Zealand, it is economically rational to purchase the service from that location. Having a unified global market for carbon with a single global price has the same logic as having a single emissions price within a domestic economy.

While the focus of this inquiry's Terms of Reference is reducing New Zealand's domestic emissions, it is desirable for New Zealand to retain the option of purchasing emission reductions from other countries. This is because of the economic logic just described. Yet any use of this option needs to consider the following factors.

- The integrity of international units and the institutional arrangements for supporting international emissions trading are paramount. While nations under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) are working to develop sound multilateral arrangements, these are unlikely to be in place for some time. One possible avenue is for two countries, each with a well-developed ETS, to reach agreement on bilateral trades. Another is for two or three countries to come together in a "climate team" through which one country agrees to "invest" in a "host" country to enable that host country to reduce its emissions below its first Nationally Defined Contribution (NDC). Payments are conditional on reductions being achieved and verified (Box 4.3) (Kerr et al., 2018).
- Correctly accounting for the costs and benefits of domestic reductions is important. Measures that reduce domestic emissions may create other environmental benefits, social benefits, or both. These

measures may not be considered by ETS participants in their decisions to reduce emissions or purchase international units. The potential environmental and social benefits include better air and water quality, learning-by-doing benefits that lower future costs,³⁷ enhancing New Zealand's reputation, and future economic opportunities from domestic R&D.

- Correctly accounting for large capital costs, such as investing in a new plant to produce low-emissions process heat for many years to come, is important. It is the annual-equivalent of the capital cost that is relevant to compare with the price of international units. Also relevant are expectations about future prices over the lifetime of the investment. Current prices of international units may be modest but, as other countries restrict their international supply as they strive to reduce their own emissions, prices could be much higher in future years.

The sums involved in international trading can be very large. As an illustration, The Treasury (2016a) estimated that the potential economic cost of purchasing credits to meet New Zealand's 2030 target could range from \$14 billion to \$37 billion over 2021–2030. The variation is mainly due to uncertainty about the price of credits.

Even so, it is stated by some that reducing New Zealand's domestic emissions would be much more costly than achieving equivalent reductions in the rest of the world due to the country's national circumstances (MfE, 2013; Michael Reddell, sub. 111). In New Zealand's first NDC submitted under the Paris Agreement, the Government argued:

The likely cost to the New Zealand economy of meeting the 2030 target in terms of GDP is greater than that implied by other Parties' tabled targets. This is due to a number of factors, such as already achieving a high level of renewable electricity generation, and almost half of New Zealand's emissions originating from agriculture. (New Zealand Government, 2015; p. 5)

Comprehensive analysis of the costs of meeting New Zealand's commitments is limited. Prior to the Paris negotiations, modelling commissioned by the Ministry for the Environment (MfE) suggested that roughly 65% to 80% of New Zealand's 2030 target should be met through purchasing emissions reductions in other countries (Infometrics, 2015; Landcare, 2015), and that a per tonne price of CO₂e of up to \$300 would be required to make it desirable to meet the target purely with domestic reductions. However, caveats to the models used include assumptions of a zero carbon price for forestry and agriculture, no emissions policies beyond pricing, and no consideration of co-benefits or New Zealand's ability to meet its future commitments. Because of these caveats, the modelling does not provide a definitive assessment of New Zealand's cost-effective mitigation potential through to 2030.³⁸

Adrian Macey submitted that the opportunity cost of spending large sums on purchasing international credits would be high. He noted that

the scale of the required purchasing modelled by Treasury would be a severe imposition on the economy, with costs over the period 2020–2030 of the order of 14–20 billion dollars, potentially even more depending on carbon prices. The prospect of spending three times Vote: Environment every year for ten years on purchasing units or offsets (or two and a half times New Zealand's annual aid budget) risks being politically and economically unsustainable. (sub. 103, p. 1)

As noted, the cost of international credits is likely to rise over time as commitments by other countries increase in ambition and become more difficult to achieve. Also, purchases cost money that could otherwise be invested in reducing New Zealand's domestic emissions. In turn, this delays New Zealand's low-emissions transition and relinquishes the co-benefits of such a transition. Delaying this transition risks leaving New Zealand with an even wider gap between its emissions and its future commitments beyond 2030.

In summary, the choice between abating domestically and through purchasing emission reductions from other countries needs to be carefully weighed. At one level, the choice is a straightforward matter of choosing the least-cost option. When international credits are of a high integrity, investing in reductions overseas may provide a way to deliver global emissions reductions at lower cost to New Zealand. Even so,

³⁷ This approach has also been described as "building a platform for future domestic reductions at lower cost".

³⁸ The Commission's own modelling included agriculture and forestry in the NZ ETS. The modelling estimated that New Zealand could reduce its domestic emissions to reach net-zero emissions by 2050 if those emissions prices were to rise to between \$150 and \$250 a tonne by 2050.

accounting for costs must be done correctly in terms of capital costs, reputation costs, co-benefits, and future costs and opportunities.

As noted previously, international emissions trading is suited to countries operating an ETS and not suited to carbon tax regimes. Further, under a national ETS, the market-determined price for emitting one less tonne of CO₂e in a country provides important information about the marginal costs of abatement in that country – which can then be compared with abatement costs in other countries. Carbon-tax systems fix prices and do not provide this important information.

F4.6

The choice between abating domestically and through purchasing emission reductions from other countries must be carefully weighed. When international credits are of a high integrity, investing in reductions overseas may provide a way to deliver global emissions reductions at lower cost to New Zealand. Even so, comparing international and domestic abatement costs must be done correctly in terms of capital costs, reputation costs, co-benefits, and future opportunities.

Carbon sequestration

Sequestration of carbon dioxide (CO₂) through growing forests is an important contributor to New Zealand's net emissions of GHGs.³⁹ Emissions pricing can incentivise removals of GHGs in a similar way to reductions in emissions: under the NZ ETS, the government provides credits in the form of NZUs (as emission units) to eligible forestry activities that sequester CO₂ (Chapter 2). New Zealand's ETS is the only ETS globally to include credits for forestry sequestration of CO₂.

Forest owners earn units as their forests grow and sequester carbon, and relinquish units if they harvest, or deforest their land by converting it to, say, farmland. Forest owners can sell units to emitters or bank them in anticipation of harvesting. To date, this feature of the ETS has been largely ineffective at incentivising new forestry planting. Reasons include low unit prices, and little certainty on future unit supply, price management or future forestry accounting rules (Chapter 10) (Leining, 2017).

Carbon sequestration in forests works on a biological cycle – absorbing carbon during growth and releasing carbon when trees are cut down, or decay and die naturally. At harvest time, the use of the wood determines the timing of carbon release. Burning the wood as a biofuel releases CO₂ quickly, but using it for furniture can lock in the carbon for many decades. This variation complicates any emissions pricing scheme for forestry.

The NZ ETS currently assumes that a high proportion of the carbon is released at harvest. But the accounting rules are likely to change in 2021 to allow forest owners the choice of an "averaging" method. When forests are harvested on a regular cycle, this method allows forest owners to earn credits up to the average that their forests will store over their life-cycles without the need to relinquish units at each harvest and removing the risk that unit prices will have moved against them.

Even with these complexities, an ETS is a better emissions-pricing mechanism to incentivise forestry compared to a carbon tax. A carbon tax itself cannot incentivise carbon sequestration unless supplemented by a sequestration subsidy. The two would have to work in harmony to mimic the acquisition and relinquishing of units under an ETS, but with no ability to bank units as a hedge against future price uncertainty.

F4.7

An ETS is a better emissions-pricing mechanism to incentivise forestry than a carbon tax. Unless supplemented by a sequestration subsidy, a carbon tax cannot incentivise carbon sequestration. The two would have to work in harmony to mimic the acquisition and relinquishing of units under an ETS, but with no ability for forest owners to bank units as a hedge against future price uncertainty.

³⁹ This assumes that net emissions of GHGs are gross emissions into the atmosphere less the removal of GHGs from the atmosphere (see Chapter 2).

Chapter 10 explains forestry in more detail, including providing a more integrated treatment of alternative land uses such as permanent forests (carbon farming), animal farming and horticulture.

Points of obligation

The point of obligation in emissions pricing defines the point at which an entity (eg, producer or consumer) is obliged to report certain information and pay the carbon tax or relinquish emission units under an ETS. The point of obligation should be chosen (as much as possible) to:

- obtain comprehensive coverage of emissions;
- minimise transaction costs (of effective reporting, monitoring and compliance); and
- provide the most clearly targeted incentives to reduce emissions.

As Leining et al. (2017a) note:

An ideal system would have minimal administration costs, a broad coverage of emissions from each included sector with effective transmission of emission price incentives, and effective monitoring, reporting, and compliance systems. (p. 6)

An obvious point of obligation in a supply chain is the point at which emissions actually occur. Yet, a point of obligation that better achieves the three criteria above might lie “upstream” or “downstream” of the emissions point. For example, virtually all petrol will end up being used in internal combustion engines and emitting a highly predictable quantity of CO₂. It will therefore reduce transaction costs – while still achieving comprehensive coverage and the right incentives – to make the point of obligation the importer or the domestic refiner of bulk petrol rather than the vehicle user.

Coverage and the right incentives will happen providing the business entity at the point of obligation “passes through” the emissions price and this continues through the supply chain to the final consumer. Final consumers then respond to the higher price of the emissions-intensive product or service either by consuming less or switching to a lower-emissions substitute. Alternatively, each business in the supply chain will have an incentive to find lower-emissions options that will give them a competitive advantage. In other words, the point of obligation will not affect the incentives of any party to mitigate. Also, if markets operate effectively, the point of obligation will not affect how the economic burden is shared across parties in the supply chain.

If the government is concerned about who is bearing the economic burden, it is possible under an ETS to use free allocation (Leining et al., 2017a):

If for equity, political, or competition and leakage reasons the government wishes to protect some firms or consumers, free allocation can be used strategically to alter the distribution of costs. The point of obligation also does not need to be the point of free allocation. (p. 7)

Where there are many relatively small upstream producers, the desirable point of obligation may be further downstream (such as large processing plants). An example is placing the point of obligation with large milk processors after on-farm ruminant livestock emissions are generated. Compared with requiring many individual farmers to be responsible for their own on-farm emissions, this will save on transaction costs. But it risks failing to incentivise farmers to produce with lower emissions per unit of output through on-farm mitigation measures such as selective breeding, altering feed mixes, or the use of vaccines. The differences between high- and low-emitting producers of the same products can be considerable (Anastasiadis & Kerr, 2013).

Where a suitable point of obligation does not exist upstream or downstream of many small emitters, a solution is to set a size threshold to exclude small emitters. In doing so, a trade-off exists between emissions coverage and administrative/compliance costs. The threshold definition needs to be clear, not able to be manipulated, and not incentivise firms to break into smaller units to avoid emission obligations (Leining et al., 2017a).

Finally, it is possible, and may make sense, to adopt a hybrid approach to points of obligation:

This would entail setting a default point of obligation in the sectoral supply chain, while allowing for other firms (either upstream or downstream) to opt in (or be required to participate) as a point of obligation accompanied by a carving-out of their emissions from the liabilities assigned to the default point of obligation. (Leining et al., 2017a, p. 11)

Doing this could improve transparency and political acceptability at the cost of increased administrative complexity. An example is that a large energy-using firm could be required to pay for its emissions directly rather than rely on the obligation of the fuel producer or importer.

F4.8

The point of obligation to pay for emissions needs to achieve a good balance between broad coverage, low administration costs, and effective transmission of emission price incentives combined with effective monitoring, reporting, and compliance. Placing points of obligation upstream or downstream of actual emission sources (as well as at source) and using minimum-size thresholds may help to achieve the best balance.

Using a shadow price for emissions

A “shadow price” is the theoretical price of a good or service within an economy that indicates the value or cost of having one more unit of it. If markets are working well (ie, consistent with economic efficiency) then the market price and the shadow price will coincide. If they are not working well, market prices will give the wrong signals and there is a case for public authorities to make decisions on resource allocation using shadow prices rather than market prices.

The shadow price of one tonne of GHG emissions is the damage to the planet from global warming from having one additional tonne of GHGs in the atmosphere. This whole chapter is about the desirability of making this shadow price a real cost that emitters face. If that is not the case, either because no emissions price exists or it is too low, agents who are concerned about climate change should use the shadow price to guide their decisions.

For example, suppose a public hospital is replacing its heating system: it can choose a coal-fired boiler, a gas-fired boiler or heat pumps powered by clean electricity. Suppose each investment will last 40 years and GHG emissions are not priced. A megawatt hour (MWh) of heat from each source costs \$40, \$50 and \$60 respectively, taking account of both capital and operating costs. This would make investing in a coal-fired boiler the least-cost option. However, if emissions per MWh are 1, 0.5 and 0.1 tonnes of CO₂e respectively, and the correct shadow price of emissions is \$30 a tonne, the costs per MWh become \$70, \$65 and \$63 respectively. This reverses the cost order so that investing in heat pumps becomes the least-cost option.

When emissions prices are absent or too low, governments should consider using a shadow price of emissions in their investment decisions. Examples of such decisions include investments in transport, water and energy infrastructure, buildings, and car fleets. These investments involve not only large resources but, once made, become sunk, irreversible and long-lived. Getting them wrong can lock in high emissions for a long time. The UK Government adopted the use of a shadow price of carbon in 2007.

Explicit carbon pricing can be usefully complemented by shadow pricing in public sector activities and internal pricing in firms. Governments, firms, and institutions often use shadow carbon pricing to help reorient investment decisions, anticipate future pricing or future changes in the carbon price, or account for indirect impacts on emissions (e.g., when public infrastructure investments affect emissions). The United Kingdom adopted the use of a shadow price for carbon in 2007 as the basis for incorporating carbon emissions in cost-benefit analyses and impact assessments. Institutional investors and lenders often incorporate a shadow carbon price into their environmental impact assessments and cost-benefit analyses as well. (Stiglitz & Stern, 2017, p. 12)

The European Investment Bank and the World Bank also use a shadow carbon price in their cost-benefit analyses of projects (Stiglitz & Stern, 2017).

A New Zealand example is KiwiRail’s recent decision to abandon its electric-powered locomotives and invest in an all-diesel fleet. It can be argued that KiwiRail should have used realistic shadow prices for the emissions saved over the life of the investment in its business case analysis of this decision (KiwiRail, 2016). Auckland

Council noted the NZ Transport Agency’s recommended use of a shadow carbon price (or “social cost of emissions”) and argued for a standard figure to apply across the public sector.

Developing and/or endorsing a social cost of carbon for use in business cases across the public sector would provide clear guidance and reduce duplication of research across the public sector. At present there is no agreed social cost figure. The NZ Transport Agency Economic Evaluation Manual uses \$40/tonne, although the rationale is not clear. (sub. 97, p. 14)

A key subset of the Commission’s recommendations in this inquiry is that the Government should establish a system in which emissions are priced at the level that reflects their harm, and will achieve New Zealand’s emissions-reduction targets. If this happens, government agencies will not need to use shadow prices that differ from the actual emissions prices. If, however and for whatever reason, emissions prices are absent or too low, then a case certainly exists for the government to use a shadow price of emissions to guide its investment decisions.

F4.9

It is preferable to have a system in which emissions are priced at a level that reflects their harm, and will achieve New Zealand’s emissions reduction targets. If, however, emissions prices are absent or too low, then a convincing case exists for governments to use a shadow price of emissions to guide their investment decisions.

Pricing co-benefits and co-harms

The theory of pricing negative and positive external effects is quite general and applies to any co-benefits (and co-harms) of mitigating emissions – to the extent they are not currently priced. The co-benefits of mitigating emissions can be large – switching away from fossil fuels reduces air pollution and switching land use from dairy to forestry can improve water quality.

The co-benefits of mitigation can be substantial and are therefore often an important element in analyses by policy makers. Observational and modelling studies indicate that 3 million premature deaths are attributable to ambient air pollution and 4.3 million premature deaths to household pollution (WHO 2016). The global average marginal co-benefits of avoided mortality are estimated at US\$50–380/tCO₂ (West et al. 2013). In 2011, the United Nations Environment Programme (UNEP) estimated that fast action to reduce emissions could avoid 52 million tons (or 1 to 4 percent) of crop losses per year (UNEP 2011). (Stiglitz & Stern, 2017, p. 16)

These co-benefits increase the value of reducing GHG emissions for society. Co-benefits are relevant to setting carbon prices but, because they vary by circumstances (place and type of activity), they cannot be reflected in a single uniform addition to an emissions price. The additional harm of not mitigating could be addressed with either:

- a separate tax or subsidy scheme;
- a separate permit requirement;
- regulation; or
- shadow pricing the co-benefit or co-harm in cost-benefit appraisals.

F4.10

The co-benefits of mitigating GHG emissions can be substantial, such as better air and water quality. The co-benefits increase the value to society of reducing GHG emissions. Policy options that, in addition to emission pricing, could incentivise businesses and people to consider co-benefits include a separate tax or subsidy scheme, a separate permit scheme, direct regulation, or a shadow price in cost-benefit appraisals.

4.4 New Zealand's system of emissions pricing

This section examines New Zealand's current system of emissions pricing and how it got to where it is today. Taking account of recent and proposed reforms, it assesses the extent to which that system is likely to meet the objectives of a good system of emissions pricing. This section then examines what further reforms are needed to achieve those objectives.

New Zealand's system of emissions pricing: a brief history

Chapter 2 includes a brief description of New Zealand's main current form of emissions pricing – the NZ ETS. This is New Zealand's main policy instrument to reduce emissions and fight climate change. Parliament passed legislation establishing the NZ ETS in September 2008.

New Zealand's consideration of emission pricing began in the 1990s. In 1999, the government selected emissions trading as the preferred option for the first Kyoto commitment period. In 2002, the Labour-led government introduced a comprehensive climate-change policy package that included a carbon tax on the energy and industry sectors to be implemented from 2008. It was to have a price ceiling of NZ\$25 a tonne, to approximate the international price of emissions. Revenue generated by the tax was to be returned to the economy through the tax system. Exemptions were to apply to exposed industrial producers in exchange for entering into "Negotiated Greenhouse Agreements" to achieve world's best practice in emissions intensity (Leining, 2017).

Much of the detailed design for the carbon tax was carried into the later design of the NZ ETS. The carbon tax had been expected to start at NZ\$15 a tonne and rise over time up to the level of the price ceiling. However, after New Zealand's projected emissions against its Kyoto commitment changed from overachievement to underachievement, the government launched a review of its climate-change policies. Then, following the 2005 election, the Labour-led government lost sufficient support for the carbon tax from its coalition partners and it abandoned the tax in December 2005 (Leining & Kerr, 2016a).

On the back of growing interest in emissions trading internationally, the Labour-led government launched the design of an ETS in April 2007. The scheme was the first in the world to aspire to cover all GHGs and all sectors of the economy. It also innovated in applying an upstream point of obligation in the energy sector. It did not incorporate government auctioning of permits to generate revenue (following the adverse reaction to the carbon tax proposal). Instead, the scheme allowed unlimited buying and selling of units in the carbon trading market set out in the Kyoto Protocol, which allowed emitters to purchase overseas credits to "pay" for their emissions. Essentially, rather than setting its own domestic emission caps and prices, New Zealand would take prices from that market and those prices would drive domestic emissions reductions. The scheme provided for ongoing free allocation to exposed industrial emitters to mitigate competitiveness and carbon-leakage concerns.

The National-led government elected in late 2008 immediately launched a review of the NZ ETS (under its confidence-and-supply agreement with the ACT Party). The review led to the following amendments enacted in 2009 (Leining, 2017):

- a halved obligation to surrender units (one-for-two) to December 2012 that lowered effective prices in non-forestry sectors;
- a price ceiling of NZ\$25 a tonne to December 2012 (so, only \$12.50 under the one-for-two deal);
- free allocation based on current rather than historical output to EITE industrial producers, with a slow yearly phase-out of one percentage point; and
- deferral of the start date for the entry of biological emissions from January 2013 to 2015.

From 2011 to 2017, a further series of government decisions affected the NZ ETS:

- a second review (2011) extended indefinitely the one-for-two measure and the \$25 price ceiling, and deferred indefinitely the phase-out of free allocation, and the introduction of biological emissions from agriculture;

- a de-linking of the NZ ETS from the Kyoto market in mid-2015 resulting in international trading in units not being possible since, which has led to a rise in the price of NZUs to around \$22 in early 2018 from a low price of \$1.45 in February 2013 (Leining & Kerr, 2016a; Leining et al., 2017b);
- a phase-out of the one-for-two obligation for non-forestry sectors, with full obligation to apply from January 2019; and
- in-principle decisions in July 2017 on unit supply, price management and international linking (see the next section for more detail).

In October 2017, a new government came into power with an ambitious agenda to reduce domestic GHG emissions.

Over its life to date, a broad consensus exists that the NZ ETS has been ineffective in inducing significant emission reductions, particularly domestically. Many submissions to the 2015/16 review of the NZ ETS expressed this view in no uncertain terms as illustrated by this quotation from Permanent Forests New Zealand Ltd:

The NZ ETS has had a 'test run' under CP1 Kyoto rules. It failed to achieve any meaningful emission reductions across our economy (or generate real carbon offsets), but worse has created deep cynicism amongst carbon market players and the financial sector, and expectations are now set that the ETS is a farce, it does no real work, carries no responsibility, and provides for cost avoidance, arbitrage, playing the market, but is too risky for serious investment engagement. (Submission no. 54, p. 1)

The main reasons for the ineffectiveness of the NZ ETS are low emission prices, sector exemptions and policy uncertainty leading to uncertainties about future rules and prices. As Leining (2017) summarises,

to date the system has had no substantial impact on domestic emissions or business decisions. The causes for this are specific and well-understood. First, under the combination of unlimited access to low-cost overseas units and a half-price unit obligation for non-forestry sectors, the domestic emission price has been too low to incentivise change. Second, since late-2012, participants have had no certainty on future unit supply and price management or on future forestry accounting rules, and therefore no credible long-term price signals to drive transformational low-emission investment. (p. 4)

F4.11

The NZ ETS has been ineffectual to date in achieving domestic GHG reductions. The key reasons have been low emissions prices, mainly driven by openness to low international prices, sector exemptions, and policy uncertainty leading to business and investor uncertainties about future rules and prices.

NZ ETS reforms announced in July 2017

In July 2017, the then government announced four important in-principle reforms to the NZ ETS. The four reforms, relating to the supply of emission units, price management and international linking, are to:

- auction emission units by 2021 under an overall limit (essentially a cap), an option that has been available in legislation since 2012 but not yet implemented;
- allow NZ ETS participants to purchase international units up to a quantity limit to help meet their obligations (offshore purchasing is not possible now, but could become so in the future);
- implement an alternative (higher) price ceiling to replace the current fixed-price option of \$25 a tonne once auctioning or linking is in place; and
- fix and coordinate settings on unit supply, the price ceiling and international linking five years in advance and update them on a rolling basis.

At the same time (July 2017), the government said it would not change the basis of free allocation of units to EITE industrial producers until at least 2021, and that biological emissions from agriculture would remain outside the ETS for the foreseeable future (MfE, 2017m).

The new government's coalition agreement (between the Labour and New Zealand First parties) has just one measure relating to emissions pricing. This is to introduce agriculture into the Emissions Trading Scheme if recommended by the Climate Commission, with a 95% free allocation to the agriculture sector and revenue recycled to agricultural innovation, mitigation, and forestry planning. (New Zealand Labour Party & New Zealand First, 2017)

Sections 4.5 and 4.6 below assess these proposed changes to the NZ ETS as part of a wider assessment of emissions pricing in New Zealand and its desirable future form.

The international environment of the NZ ETS pre- and post-Paris

Lack of access to a sound and trustworthy system of multilateral trading is a feature of the current post-Paris Agreement environment that is unlikely to change for a long time. This feature is strikingly at odds with a key assumption behind the original design of the NZ ETS that such access would exist.

The NZ ETS was initially calibrated for a world which no longer exists (if it ever did): one in which New Zealand could rely on the international market to set an appropriate domestic emission price, and allow its domestic emissions to increase as long as they were offset globally. Under the Paris Agreement, all countries must transition to net zero emissions, there is no integrated carbon market governed by internationally agreed rules, and there is no convergence toward a single efficient global emission price. (Leining, 2017, p. 22)

As previously noted, a major cause of the NZ ETS's ineffectiveness was participants' access to international credits. The ready supply of these at low prices and, in many cases, of questionable integrity, enabled New Zealand to meet its first targets for the Kyoto Protocol period with no significant reduction in domestic emissions. In addition, many participants and the government acquired large positive balances of units.

In response to these problems, the Government cut off access to international units in 2015.

This history suggests that New Zealand requires further reform of its ETS that gives it control of domestic emissions and emission prices. Box 4.3 describes the limited opportunities that currently exist under the Paris Agreement for countries to meet their emissions obligations offshore, and the ongoing work to develop new multi-party trading arrangements.

Box 4.3 The Paris Agreement and international carbon trading arrangements

Article 6 of the Paris Agreement allows the use of carbon markets to meet NDCs through "internationally transferred mitigation outcomes". However, currently no top-down framework exists for such transfers: they must be made government to government in a way that avoids double counting under the targets of the seller and buyer. ETS linking qualifies under Article 6, but would present significant challenges for New Zealand. For example:

- ETS linking would reduce New Zealand's sovereignty over domestic emissions and emission prices;
- the NZ ETS design is not easily compatible with two-way ETS linking given the characteristics of other ETSs currently operating and planned (Leining et al., 2017b); and
- given its target gap, New Zealand would want to link the NZ ETS with a net seller with a stable and well-established ETS, and such systems are yet to emerge.

The Paris Agreement provides for the creation of a new central market mechanism that both governments and private entities could access, but the rules guiding such a mechanism are unlikely to be developed until well into the future. As a result, global emission prices are likely to remain highly variable in a system where targets and policies are developed from the bottom up.

The other approach of the Paris Agreement for internationally transferred mitigation outcomes is a government-to-government "cooperative" approach that lets countries coordinate trading among themselves, provided they follow accounting principles approved by the UNFCCC. An example of this approach is a voluntary and cooperative "climate team model" being explored between the

governments of New Zealand and Columbia. New Zealand would “invest in” emission reductions in Columbia that are over and above Colombia’s NDC. The payments would flow in direct proportion to verified reductions within an agreed price range and maximum budget.

Source: Leining (2017); Kerr et al. (2018).

4.5 Emissions pricing objectives

Any assessment of an emissions pricing system needs to be based on a clear idea of outcomes sought and a set of criteria for a good system. This section sets these out as a prelude to assessing the NZ ETS in its current form and making recommendations for future reform.

Desirable outcomes for a system of emissions pricing

The desirable high-level outcomes for an emissions-pricing system for New Zealand are:

- economically-efficient reductions in emissions that achieve New Zealand’s point-in-time and emissions-budget targets over a long period;
- fair and just distribution of the burden of reducing emissions;
- enough stability and certainty to incentivise innovation and large, irreversible investments in low-emission infrastructure and other ventures; yet, also enough flexibility to adapt to new developments, such as information about technology;
- seamless operation alongside other instruments that complement it to help reduce emissions, or aim at different objectives; and
- no significant problems in the system’s operation at or beyond the international border.

Criteria for a good emissions pricing scheme

To achieve the outcomes above, an emissions pricing system for New Zealand should be assessed against the following criteria (adapted from the list in Leining (2017)). The system should:

- maintain control over domestic emissions and emissions prices;
- raise domestic emissions prices over time in line with New Zealand’s progressively more ambitious international targets and objectives for domestic emissions reductions;
- have substantial policy and price predictability to support efficient low-emissions investment;
- distribute emissions-reduction responsibilities, costs and risks fairly and efficiently across NZ ETS sectors, non-NZ ETS sectors, the government and taxpayers; and
- integrate well with arrangements in place to achieve emissions reductions offshore (assuming those arrangements are robust and trustworthy).

The system should also:

- mitigate potential emissions leakage to other jurisdictions;
- achieve enduring environmental integrity, transparency, compliance and enforcement;
- manage uncertainties and risks (environmental, economic, fiscal and social) and adapt to new information;
- interact efficiently and effectively with other policies that may be needed;
- raise and manage revenue strategically; and
- achieve broad and enduring public and cross-party acceptance.

4.6 What changes to emissions pricing in New Zealand are desirable?

How well does the current system of emissions pricing – the NZ ETS – perform against the above desired outcomes and criteria? The analysis following will take into account the reforms announced in July 2017, and the potential for further reform, particularly the reform proposals that came out of an ETS dialogue process led by Motu Economic and Public Policy Research (Kerr et al., 2017). This process brought together diverse experts from government, businesses, non-governmental organisations and research organisations to discuss options for reforming the NZ ETS.

The current New Zealand ETS has only some of the required features

The NZ ETS has some of the features needed to run a market that prices emissions across the economy in a comprehensive and consistent way (ie, all gases, all sectors). These features, if fully implemented, would incentivise actions to achieve national emission-reduction targets cost-effectively. However, decision makers have yet to implement some features and New Zealand's poor record on lowering its emissions has been the result (see Chapter 2).

As noted, a key failure has been low carbon prices owing to cut-price offers domestically and participants' undisciplined access to international credits. Figure 4.4 shows the sharp fall in the price of NZUs from 2011 and the price recovery from 2015 following the ending of access to international credits and the NZ ETS becoming essentially a domestic scheme.

Figure 4.4 Price of NZUs, 2009–2017



Source: OM Financial Limited and CarbonMatch (pers. comm, December 2017).

An effective ETS also needs to align annual or longer-period caps on unit supply with agreed carbon budgets, the levels for which would be recommended by an independent Climate Change Commission (as proposed in Chapter 7). Such alignment would define credible paths towards New Zealand's long-term targets to meet its international commitments.

Other failures to date have been lack of certainty and credibility for ETS participants about future unit supply. Without this, participants struggle to form expectations about future prices. This certainty and credibility will only come with clear long-term policy direction and cross-party political buy-in to it. Topics lacking certainty and credibility for future direction include free allocation of units, the inclusion of agriculture in the NZ ETS, the rules for forestry and mechanisms for updating future unit supply as new information about technological innovation and diffusion, behavioural responses and climate risks becomes available. Many submitters agreed that the uncertain policy framework for the ETS has been a serious weakness including Pacific Aluminium and the Guardians of New Zealand Superannuation:

It is important to have certainty as to the regulatory framework for climate policy. This is not the same as having certainty over the carbon price. What matters to decision making is having an understanding

of the regulatory framework and that the major parties of Government keep to that framework even while having differing views about the settings for the NZ ETS. (Pacific Aluminium, sub. 21, p. 6)

A stable policy environment on carbon pricing related matters. The policy environment must be sufficiently stable to make investors comfortable with the idea that carbon pricing at economic levels will prevail. It should not be subject to election cycles. (Guardians of NZ Superannuation, sub. 32, p. 9)

Valuable achievements of the NZ ETS include building the institutional arrangements for NZUs (ownership, responsibilities, points of obligation, systems for measurement, monitoring and verification) and the experience and familiarity of participants in operating the system. These achievements should not be thrown away lightly – they are valuable assets. As Leining (2017) comments:

If changing instruments mid-course delays implementation of a more ambitious price signal by starting a new complex legislative process, re-opens contentious political debates, disrupts market confidence in government rulemaking, and devalues assets created and investments made under the previous instrument, then the environmental, economic and fiscal costs could outweigh hoped-for gains. (p. 34)

F4.12

Some basic building blocks of an effective ETS are present in the NZ ETS, but lack of others has led to low prices and tepid responses from participants. As a result, the NZ ETS has not reduced domestic emissions or increased domestic removals to anything like the extent needed to achieve a significant reduction in New Zealand's domestic greenhouse-gas emissions. A key problem is lack of certainty and credibility about future unit supply and the pathway to achieving New Zealand's long-term targets to meet its international commitments.

Assessment of the current NZ ETS

New Zealand's decision in 2015 to de-link the NZ-ETS from international trading was a valuable step towards restoring an effective domestic emissions price. The phasing out of the one-for-two arrangement will also support a higher emissions price. But these are stopgap measures. They provide no visibility of the arrangements for determining future unit supply and therefore for forming future price expectations.

The in-principle reforms to the NZ ETS announced by the previous Government in July 2017 are further steps that would go some way to remedying the scheme's past deficiencies. These reforms would both help and hinder New Zealand to follow a low-emissions strategy as noted below.

- *Government auctioning of units* will provide a component of unit supply along with free allocation of units and credits earned through emission removals. In addition, auctioning generates revenue for the government that it can use strategically to support New Zealand's overall transition to a low-emissions economy (eg, to cushion adverse impacts on vulnerable groups or to fund R&D).
- *Participants may be able to use international units to partly meet their obligations up to a limit.* This reform recognises the need to limit access to international units. Yet it gives no guidance about how the limits will be set. In any case, no practical and trustworthy means for participant access to international credits exists for now.
- *Implementing a higher price ceiling than the current \$25 for each tonne of CO_{2e}.* This is the right direction of travel, but is vague on substance and does not provide enough information for participants and investors to make effective decisions for a low-emissions future.
- *Fixing and coordinating settings (for unit supply, a price ceiling and international linking) over a five-year rolling horizon.* Again, this sort of coordination is essential, but needs to be articulated as part of a wider strategy for domestic emissions reduction. Arguably, also, five years is too short a time horizon relative to what is needed for long-term investment decisions.

As noted, many submitters expressed dissatisfaction with the past performance of the NZ ETS and with the uncertainties about future settings even with the announced changes. The arrival of a new Government with

ambitious aims for emissions reductions creates other uncertainties at least in the short term. However, the Government has signalled its intention to settle policy and commit to it over the long haul.⁴⁰

The overall assessment of the Commission is that while reforms of the NZ ETS have been ongoing, the scheme's current characteristics do not yet meet the criteria for a good system of emissions pricing. The further in-principle reforms announced in July 2017 would take the scheme in the right direction, but are insufficient to provide strong or clear enough signals to participants, or to households, businesses and investors who are not direct participants. Current uncertainties need to be resolved as soon as possible to achieve a robust and well-designed emissions-pricing scheme.

F4.13

Reforms of the NZ ETS are ongoing, but the features of the NZ ETS do not yet meet the criteria for a good system of emissions pricing. The further in-principle reforms announced in July 2017 would take the NZ ETS in the right direction, but are insufficient to provide strong or clear enough signals to participants, or to households, businesses and investors who are not direct participants.

Reform proposals from the Motu low-emissions future dialogue process

This section examines NZ ETS reform proposals that have emerged from a recent dialogue process on a low-emissions future for New Zealand led by Motu Economic and Public Policy Research (Leining & Kerr, 2016b; Kerr et al, 2017). The Commission is respectful of the amount of research and scholarship that the Motu Research group has invested over more than a decade in many aspects of climate-change policy, including the NZ ETS. The dialogue process is an extension of these efforts because it has brought in other experts and organisations to build common understanding and agreement on proposals for reforming the NZ ETS.

The additional recommended changes that came out of the dialogue process go further and would involve faster action than the four in-principle reforms announced in July 2017. The changes aim to make the NZ ETS an effective system of emissions pricing and the centrepiece of an overall strategy of emissions reduction. The six recommended changes are described in Box 4.4.

Box 4.4 Additional NZ ETS proposed reforms from the Motu dialogue process

1. *Set an initial fixed five-year cap and fix future caps for a full five years in advance. After one year, and on a rolling basis after that, a cap would be set for year six to support market expectations five years ahead. Unit supply for years one through five would remain fixed.*
2. *Add a price floor to be implemented as a reserve price at auction. Units not sold at auction would be shifted into a unit reserve, an action that would reduce domestic supply and offer a form of government banking. A price floor will maintain a minimum price at auction and adjust market supply downward in the event of unintended over-allocation or unexpected changes in market conditions. A price floor gives greater confidence about returns to low-emissions investors (eg, forest owners).*
3. *Implement the price floor and set a price ceiling by creating and using a unit reserve that would sit within the NZ ETS cap. The combination of a price floor with a price ceiling would create a "price band" that safeguards against both downside and upside price risk. Importantly, the NZ ETS market would continue to set the emission price within the limits of the price band. The narrower the price band, the closer the system would be to a carbon tax. Placing the reserve within the cap limits the fiscal risk from the price ceiling, which is a problem in the July 2017 proposal. The price protection would be "soft" since the amount of price relief would be limited by the size of the reserve.*

⁴⁰ Noting, of course, that no government in New Zealand can absolutely bind a future government (see Chapter 7).

4. *Add indicative 10-year trajectories to the cap and price band to guide future extensions.* This would impose on government the discipline of forecasting corridors for unit supply and prices, and provide a 15-year horizon to guide NZ ETS participants and investors.
5. *Enlist independent advice.* Decisions on setting emission caps, price limits and international linking in an ETS require sound technical information but ultimately are political in nature. Providing for independent expert advice (see Chapter 7) would support evidence-based and transparent decision making, which, in turn, improves the chances of both public and cross-party acceptance and support.
6. *Introduce auctioning and the price band (with a higher ceiling) as soon as possible rather than wait until 2021.* Waiting would extend uncertainty for market participants and investors and increase the risks of stranded assets and fiscal cost. Reducing New Zealand's domestic emissions in line with its targets will require emission prices considerably higher than \$25 a tonne. As confidence in the future of the NZ ETS grows, emission prices could easily pass \$25 a tonne. This increase makes it urgent to raise the price ceiling.

Source: Kerr et al. (2017); Leining (2017).

The Motu dialogue recommendations are a well-crafted package of measures that substantially meet the criteria for an effective ETS. They address the weaknesses in the NZ ETS that compromise its ability to deliver effective emissions pricing and New Zealand's emissions targets for 2021 to 2030 and beyond.

F4.14

A well-crafted package of reforms is needed to fix the weaknesses in the NZ ETS that compromise its ability to deliver effective emissions pricing and New Zealand's emissions targets for 2021 to 2030 and beyond. The reforms need to provide a good balance between control over unit supply (ie, an effective cap) and protection against damagingly volatile emissions prices. They also need to provide much-needed stability, transparency and forward guidance to support decision-making by investors to lower their net emissions.

Should an ETS have a price ceiling, a price floor, or both?

The Motu dialogue recommendations argue for a price ceiling and a price floor for NZUs, with the market determining the price between those limits. The Motu proposal has "soft" versions of floor and ceiling prices. The floor would be a reserve price that operated in any government auction of NZUs. Trading outside the auction among private participants might still see units change hands at prices below this reserve price. The ceiling price would operate in the following way: the government retains a reserve quantity of units within the ETS cap. Reserve units are only released on the market if the market price reaches the ceiling. If the reserve is exhausted, the price is allowed to rise, and at a certain point a review is triggered.

The July 2017 in-principle decisions for reforming the NZ ETS included lifting the existing price ceiling of \$25 in the NZ ETS, but did not include instituting a price floor.

An ETS with a price ceiling and a price floor can be thought of as a *hybrid* between a carbon tax and a pure ETS. The narrower the band between the floor and the ceiling the closer this hybrid would be to a carbon tax, and the wider the band, the closer to a pure ETS. After examining an extensive research literature, Goulder and Schein (2013) find that, while on many dimensions a carbon tax and pure ETS are similar, a consideration of their strengths and weaknesses in the areas where they differ leads to favouring the hybrid to either pure form.

We show that most of the attractions of pure cap and trade [ie, a pure ETS] are also enjoyed in large part by the hybrid and that, given the hybrid's additional attractions, it is easier to make the case for the

hybrid than for the pure cap and trade. Many of the hybrid's attractions stem from the exogeneity of allowance prices⁴¹ that arises when its price ceiling or floor is engaged. (p. 3).

Even so, the issue of whether to modify a market by putting limits on the prices that emerge through market trading requires careful consideration of the pros and cons, and clear reasons for any decision to impose them. Table 4.2 sets out these pros and cons in the case of an ETS.

Table 4.2 The pro and cons of ETS price ceilings and floors

	Pros	Cons
General	<p>Can reduce price volatility and put a brake on prices subject to noise, speculation or irrational exuberance or pessimism.</p> <p>In common with a carbon tax, the exogeneity of an ETS price floor and ceiling helps reduce policy errors under uncertainty and avoid problematic interactions with other climate policies. For example, supplementary policies to reduce emissions could be rendered ineffective under a pure ETS (Goulder & Schein, 2013; Shobe & Burtraw, 2012).</p>	<p>Risks distorting price signals and creating inefficient behaviour or gaming. Risks suppressing price discovery, including the valuable information that high or low market prices reveal.</p> <p>Risks underachieving or overachieving a targeted reduction in emissions as defined by the unit cap. In particular, underachievement could risk environmental harm if the damage function rises steeply.</p>
Price ceiling	<p>Mitigates the risk under uncertainty from setting a unit cap that sends the price unexpectedly high to the detriment of emitters who do not have time or the ability to adjust (ie, they have inelastic demand in the short run).</p> <p>Gives participants comfort that the emissions price will not exceed the ceiling, and so lessens emitters' concerns and the risk of political pressure to weaken the ETS.</p>	<p>Dulls the price signal that sharp adjustment is needed, and suppresses information about the size of the marginal cost of abatement needed to achieve the cap.</p> <p>Could prove fiscally costly if the government must purchase emission reductions internationally to offset the excess domestic emissions caused by keeping a lid on the unit price and exceeding the cap.</p>
Price floor	<p>Mitigates the risk that those fearful of a low unit price in the future will not undertake investments to reduce emissions.</p> <p>Builds confidence that ETS prices will not collapse as they did in New Zealand and other countries in the recent past.</p>	<p>Risks lowering emissions even more than required to meet the cap. If the cap is set correctly to meet emission-reduction targets, this imposes an unnecessary cost on the economy by incentivising greater emissions reductions than are needed.</p> <p>Government as the major supplier of units could be accused of using its monopoly power to boost the price of what it is selling.</p>
Price ceiling without a price floor	<p>Can be simpler to have a price ceiling without a price than having both.</p>	<p>Risks an unintended effect of limiting the upside of investments in low-emissions technology while not limiting the downside risk, inhibiting such investments (Burtraw et al., 2006).</p>

On the overall balance of considerations, the Commission agrees with the arguments that an ETS is best operated with a price ceiling and a price floor along the lines recommended by Motu, Goulder and Schein (2013). The Commission is inclined to favour setting the ceiling and floor to form a broad rather than a narrow band within which the market has scope to determine the emissions price, and reveal the underlying cost of mitigation and the expected costs of mitigation in the future. Price movements will be influenced by the supply of units in the market, over which the Government has substantial control, but also other

⁴¹ "exogeneity of allowance prices" means that the allowance prices are set by the government rather than set in a market. But in this instance the government sets only the price ceiling and floor, while the market sets the price in between those limits.

influences (such as technology changes) over which it has little control. The wide bands proposed should have the effect of limiting “noise” from short-term volatility.

F4.15

While risks exist in operating the NZ ETS with a price ceiling and a price floor, the consequences, were these risks to materialise, would be moderate and could be mitigated. The risks are not as serious as the risks of operating a pure ETS – from volatility in price that could impose high costs on emitters who have limited opportunity to adjust in the short term, dis-incentivise investments in low-emissions technology, and inhibit the impact of some supplementary policies.

R4.1

The Government should reform the NZ ETS rather than replace it with a carbon tax. The reforms should provide a good balance between control over unit supply (ie, effective emissions caps) and protection against excessive volatility in the price of emission units. The reforms should also provide the institutional and regulatory underpinnings for a credible and efficient market in emission units, as well as transparency and forward guidance to incentivise long-term investments in lower emissions.

4.7 Emission prices to transform to a low-emissions economy

This section indicates the sort of levels of emission prices likely to be needed to drive the quantity of emission reductions to achieve the Paris Agreement target of keeping the rise in global temperatures to well below 2°C above pre-industrial levels. Because of the many uncertainties about such issues as future technology, demand response, fossil-fuel prices, and climate sensitivity, it is possible to give only a very broad indication of these price levels. The indications are by no means predictions or forecasts.

Some form of emission pricing currently exists in more than 42 countries or regions of the world. Of the schemes implemented or scheduled as of 2017, half consist of an ETS and half consist of a carbon tax, with the former covering two-thirds of priced emissions. Yet in 2017 these pricing schemes covered only around 15% of global emissions; of these, three quarters were covered by a carbon price of below US\$10 a tonne of CO₂e (Leining, 2017, p. 18; Stiglitz & Stern, 2017, p. 35). For certain, current coverage and levels of emission prices are insufficient to induce emissions reductions consistent with the temperature objective of the Paris Agreement. Future prices will need to be much higher.

Evidence on level of future prices

Three lines of evidence provide indications of the emission prices needed to achieve changes that would deliver the Paris Agreement objectives: technology roadmaps, national modelling exercises, and global energy-economy models (called Integrated Assessment Models or IAMs) (Stiglitz & Stern, 2017, p. 25).

Technology roadmaps

Technology roadmaps seek to identify the carbon price points at which it becomes economic for businesses to invest in new low-emissions technology in particular sectors or industries (eg, power generation or industrial heat). These prices are called “switching prices”. Not surprisingly they are often uncertain and can vary significantly across countries according to local conditions, and over time when technological change is rapid. Further, a higher switching price will be needed to displace existing carbon-intensive assets where capital is sunk, compared to where the two competing choices are both new.

Illustrating these aspects, the International Energy Agency’s publication *Energy, Climate Change and Environment: 2016 Insights* (IEA, 2016a) gave indicative switching prices for investment in onshore wind generation in competition with coal-fired generation (Table 4.3).

Table 4.3 Switching prices for onshore wind in three countries, US\$/tonne CO_{2e}

	New onshore wind versus existing coal generation	New onshore wind versus new coal generation
United States	10	0
Germany	80	60
China	30	20

Source: (IEA, 2016a).

Notes:

1. Germany has less favourable wind conditions than China and the United States.
2. The analysis uses 2015 information on fossil-fuel prices and the cost of renewable energy. It is intended to illustrate the policy implications of varying circumstances rather than provide up-to-date information on the cost of switching to a different energy generation technology.

Another important influence on switching prices is the cost of capital, especially where this cost is higher or lower than for the baseline case of the existing mature technology. In a background note for the High-level Commission on Carbon Prices, Finon (2017) estimated switching prices for two low-emissions technologies for power generation (coal with carbon capture and storage (CCS) and nuclear) to replace two fossil-fuel alternatives (gas combined-cycle gas turbine (CCGT) and conventional coal) for three capital-cost scenarios for the low-carbon options:

- an 8% “baseline” capital cost, equal to the capital cost for the fossil-fuel generation;
- 12.5%, reflecting risk aversion towards the low-carbon technology; and
- 5%, incorporating a government guarantee on loans for the low-carbon technology.

Assuming each of these capital costs, the switching prices for coal with CCS relative to conventional coal are (in euros⁴²) 35, 54 and 20 a tonne of CO_{2e} respectively. To displace gas CCGT (a lower-carbon fuel than coal), the switching prices required are higher at 85, 120 and 50 euros respectively.

Stevenson et al. (2018) report likely switching prices to induce investors in electricity generation to replace New Zealand’s few remaining fossil-fuel generation plants. These plants (coal and gas at Huntly and gas CCGT in Taranaki) have a high value because of their ability to supply during dry-years, and for seasonal or short-term imbalances between both demand and renewably generated supply (Chapter 12). Huntly coal could be retired at an emissions price of around NZ \$40 a tonne of CO_{2e} and the Taranaki gas CCGT at a price of around \$60 a tonne of CO_{2e}.

New Zealand also currently relies on open-cycle gas turbines for generation capacity to handle peak demands. Retiring these turbines, while maintaining energy security, would entail investing in greater storage. This would be more expensive and require higher emissions prices to be economic. Two examples are around \$150 a tonne of CO_{2e} for producing and storing of hydrogen as a reserve feedstock, and \$170-\$280 a tonne of CO_{2e} to supply and operate a reserve biomass gas plant (Stevenson et al., 2018).

Future emission prices: what does modelling tell us?

Chapter 3 describes the modelling undertaken for this inquiry by the Concept-Motu-Vivid (CMV) consortium. Modelling exercises at a national scale can provide insights on prices needed for an economy to decarbonise and transition to low emissions. Those exercises can deal with some of the limitations of technology roadmaps (for instance, by considering interactions between sectors).

The CMV modelling indicates that emissions prices will need to rise many times above the current level of \$21 a tonne of CO_{2e} if New Zealand is to reach targets for low emissions by 2050. To reach a target of 25 megatonnes of CO_{2e} by 2050 (around 60% below 1990 levels) will require emissions prices to rise to between

⁴² A New Zealand dollar is worth approximately 60 euro cents, so the switching prices in NZ dollars are approximately 58, 90 and 33 for coal with CCS to replace conventional coal, and 142, 200 and 83 for coal with CCS to replace gas CCGT.

\$75 and \$152 a tonne by 2050, according to the modelling. The lower price occurs along a pathway in which emissions-reducing technologies develop more rapidly.

The more ambitious target of reaching net zero emissions by 2050 will require significantly higher prices. According to the modelling, prices will need to rise to \$157 a tonne of CO₂e by 2050 even with more rapid technology change. Without that, they will need to rise up to \$250 a tonne by 2050. Even so, all but one of these emissions prices are in the range of estimates of what will be required in other developed countries to meet the Paris Agreement to keep temperature rise to below 2°C. One of the New Zealand trajectories is below the range.

In earlier work on New Zealand low-emissions scenarios for Globe NZ, Vivid Economics (2017b) grouped options for change in the economy into three categories: those induced at low, medium and high emissions prices where:

- low was under NZ\$50 a tonne of CO₂e;
- medium ranged between \$50 and \$100 a tonne of CO₂e; and
- high was above \$100 a tonne of CO₂e.

Options that would be cost-effective at a low (or even zero) emissions price include afforestation, many forms of improved energy efficiency, and, increasingly as their price falls, electric vehicles (EVs). Economic options in the medium-cost range are likely to include electric heating for mid-level industrial heat and EVs for freight. Technology options in the high-cost range include CCS and the electrification of high-temperature heat.

IAMs produce global scenarios of future socio-economic and technical development that are consistent with global temperature targets such as below 2°C in the Paris Agreement. Differing model assumptions and structural features produce a wide range of results as indicated in the following quote from Stiglitz and Stern (2017):

While there is a consensus across models on the technical changes that are needed to maintain climate change below 2°C, models fail to agree on the carbon price required to trigger those changes. Based on the assessment provided in IPCC (2014c), scenarios that limit warming to below 2°C with a greater than 66 percent probability imply carbon prices increasing throughout the 21st century, but with prices ranging from US\$15 to US\$360 (in 2005 United States dollars) per tCO₂e in 2030, and from US\$45 to US\$1,000 (in 2005 United States dollars) per tCO₂e in 2050 (p. 32)

Some causes of the variation make intuitive sense and are worth noting. In general, the emissions price required to meet the 2°C target is lower:

- *in baseline scenarios with faster per capita growth, more expensive fossil fuels, or preferences for low-energy consumption patterns* (eg, regarding diets);
- *the higher the credibility of signals about future emission prices*. In models where emission reductions in the short term are only based on knowledge of current prices and costs, higher prices are required over the short term. Near-term emission prices therefore must be assessed in the context of the credibility of signals about long-term prices;
- *the better the potential for low-carbon technologies*. The availability, costs and penetration of new technologies are difficult to model or forecast because they are driven by many factors such as innovation and learning, and institutional and financial constraints (Acemoglu et al., 2012); and
- *the higher the ability to re-allocate resources across the economy*. IAMs vary in their constraints on technology penetration, on whether they allow installed capital to be scrapped early, or in their limits on the re-allocation of workers across sectors.

F4.16

Substantial modelling and other evidence exists to indicate that emissions prices will need to rise far above their current levels if New Zealand is to decarbonise its economy over the next several decades. Even so, it is notable that emissions prices required to achieve a given emissions-reduction target will generally be lower:

- the better the potential for deploying innovative technologies to reduce emissions;
- the higher the credibility of signals about future emissions prices; and
- the greater the flexibility in the economy to re-allocate resources from high- to low-emitting activities and sectors.

4.8 Complementary measures to emissions pricing

A key message of this report is that an effective system of emissions pricing should form the centrepiece of a strategy to reduce emissions. But the strategy needs other elements to back up pricing and even take the lead in situations where pricing is not powerful enough because of market or government failures, or distributional considerations. An effective package of complementary measures can also lower the emissions price that would otherwise be needed. This section briefly examines these other measures and situations in relation to emissions pricing, and indicates where later chapters in this draft report deal with them in greater depth.

Institutions and laws

Markets invariably sit and operate within an institutional infrastructure and work well, or not so well, according to the quality of that infrastructure. In the case of the NZ ETS, the basic transaction unit is the NZU – the legal right to emit one tonne of CO₂e. To make the market work, a register for ownership and its transfer, and a means of linking physical emissions to the surrender of units (or the physical removal of tonnes of CO₂e from the atmosphere with the earning of units) are needed. Fortunately, the NZ ETS already has these basic underpinnings in place.

Stable legal and institutional foundations are also needed for choosing and implementing the size of emissions caps, free allocations of units, auctioning, price ceilings and floors, guidance on future prices and/or quantities, and possibilities for international trading in emissions reductions. Chapter 7 explores the idea of an independent expert body – a Climate Change Commission – that would make recommendations on these matters, based on evidence, for the government of the day to adopt, modify or reject.

Infrastructure and planning

City design, transport infrastructure and land-use plans have a significant influence on how people live and work and therefore on emissions. Decisions in these areas are not purely market based – and there are spatial and network externalities to consider. It is important that large, long-lived, city-shaping investments fully internalise the social costs of emissions (Chapter 15). For infrastructure investment decisions to align with a low-emissions future, will require business cases/project appraisals to use appropriate emissions prices over the expected lifetimes of investment options.

Other infrastructure areas for attention are supporting infrastructure for electrified transportation (Chapter 11) and a low-emissions electricity system (Chapter 12).

Performance standards and direct regulation

In some situations, price signals are known to be relatively ineffective in changing behaviour. Evidence of this is the existence of investments that would lower emissions, yet nothing is invested despite a positive return (even in the absence of a carbon price). For instance, a landlord may fail to invest in better insulation for their rental property because the tenant pays the energy bills for heating, and the landlord perceives they would not recoup the cost through higher rents. Also, most tenants are unwilling to invest owing to a lack of long-term, secure tenure.

In these situations, minimum standards may be a more effective solution. Another example is a car owner who has weak incentives from the emissions-price component of fuel prices to demand a car with high fuel efficiency. A solution may be to set fuel-efficiency standards. New Zealand is one of a small number of developed countries without such standards (Barton & Schütte, 2015) (Chapter 11).

Innovation and dissemination

While emissions pricing encourages emitters to seek out new technologies that reduce their emissions, investing in innovation remains subject to another sort of market failure – insufficient reward in the face of the tendency of new knowledge to spill over and benefit others. Support for innovation should operate alongside emissions pricing. Chapter 6 contains a full treatment of policies to support both innovations that mitigate or remove GHGs, and the dissemination and deployment of new low-emissions technologies. An important result to note, as mentioned above, is that the greater the potential for, and actual use of, innovative technologies that reduce emissions, the lower the emissions prices that will be needed to reach a given emissions target.

Distributional impacts

Applying an emissions price at moderate or high levels across the economy could have significant adverse impacts on some businesses and households. Bringing in emission-price increases gradually and signalling them well in advance will give most of those affected time to adjust. As noted, the free allocation of NZUs is a way to combine emission pricing with transitional protection for domestic firms who could suffer from foreign firms, not subject to emission pricing, taking their market share even though they have global emissions that are the same or greater.

Broadly speaking, it is vital for emissions pricing to remain credible, sustainable and the centrepiece of a low-emissions strategy. To do so, it must be based on sound market institutions and remain socially and politically acceptable. Attending to the distributional impacts of emissions pricing is necessary to achieving this outcome. Chapter 9 covers distributional issues and policies.

The importance of policy coherence

Policies other than emissions pricing that influence emitters of GHGs should mutually reinforce emission pricing. But some policies can be counterproductive or duplicative. In the mutually reinforcing category are policies that remove non-price barriers to behaviour change such as providing information or access to finance. Two examples in the latter category are hidden or explicit subsidies to fossil-fuel exploration and use, and regulations that dictate very high-cost ways to reduce emissions.

Any area that has co-benefits from reducing GHGs calls for policy coherence. For example, the electrification of transport will reduce emissions and improve air quality, with benefits for human health. Reducing stocking rates on dairy farms or planting trees will reduce emissions and improve the water quality in streams, rivers and lakes. In theory, emitters could be rewarded for both benefits through two separate pricing schemes. In practice, the additional benefit of cleaner air or water is more likely to be encouraged through regulation, a grant scheme or the use of a positive shadow price in public cost-benefit analysis.

Complementing emissions pricing with other, well-designed policies then, is both theoretically sound and needed in practice (Stern, 2015; Stiglitz, 2013).

F4.17

An effective system of emissions pricing should form the centrepiece of a strategy to reduce emissions. Yet the strategy needs other elements to back up pricing and take the lead in some situations where pricing is not powerful enough because of market or government failures, or distributional considerations.

4.9 Conclusion

Emissions pricing should be the central policy lever to incentivise businesses and individuals to lower their GHG emissions. It is a powerful lever because it sets a single emissions price across the whole economy and provides a strong incentive to reduce emissions at least cost. Emissions pricing also decentralises decisions to invest, innovate and consume across the economy to people who have the best information about opportunities to lower emissions given their circumstances.

The two main forms of emissions pricing – an emissions tax and an ETS – have much in common. The choice between them is less important than the need to implement a scheme that gives a strong signal that GHG emissions are harmful and need to be curbed. The chosen scheme also needs to be credible and stable over time through being well-designed, well-implemented and founded on broad cross-party and social support.

However, a carbon tax and an ETS also have differences that raise the issue of whether it is better to have certainty in the price or the quantity of emissions, the ease of trading internationally, the scope for participants to handle risk, or a combination of them. An ETS is better at delivering emission reductions and allowing trading between emitters and removers of GHGs. As New Zealand already has an ETS that is functional and well-understood by participants, it should keep the NZ ETS and not replace it with an emissions tax. But the NZ ETS needs to be reformed to improve control over unit supply (ie, effective caps on emissions) and protect against emissions prices that are damagingly high or low. The reforms should also improve forward transparency and policy stability to incentivise long-term investments in lower emissions.

New Zealand's emission prices under its past and current versions of the ETS have been too low to incentivise meaningful reductions in emissions. All evidence points to the need for emission prices to rise to at least \$75 a tonne, and possibly, if new emissions-reducing technologies are slow to emerge, to more than \$200 a tonne, over the next three decades. Prices at these sorts of levels will flow naturally from the government setting effective emissions budgets which then translate to emissions caps in a reformed NZ ETS.

An overall strategy to reduce emissions needs to be a package. It would have an effective system of emission pricing at its centre and other policies to complement pricing. These other policies would take the lead in situations where pricing is not powerful enough because of market or government failures, or distributional considerations.

5 Innovation

Key points

- Innovation can and should play a central role in New Zealand's transition to a low-emissions economy.
- Innovation comes in many forms and is unpredictable. Yet it is the closest thing to a "silver bullet" to enable humanity to meet the challenge of avoiding damaging climate change. It also holds out the opportunity to combine the transition to low emissions with dynamic and creative improvements in national wellbeing.
- While the form, timing and impact of innovation are highly uncertain, a country's policies and institutions significantly affect its innovation performance. They need to enable and encourage researchers and business organisations to both create new low-emissions technologies and deploy existing low-emissions technologies.
- The processes of innovation and economic change are strongly path dependent. This can make it difficult to shift an economy from polluting to clean technologies. Delay in making the transition can increase the productivity gap between the polluting and clean technologies and make the transition longer and costlier in terms of slower growth during the transition.
- A strategy to support low-emissions innovation needs to combine an effective emissions price with direct support for research, deployment and adoption of low-emissions innovations. Stronger emissions pricing will incentivise more innovation in clean technologies. But relying on pricing and direct regulation alone – without subsidising innovation – would be sub-optimal.
- New Zealand's record as an innovative economy is mixed. Lacklustre productivity growth in the economy partly reflects low investment in research and development (R&D) for business and other issues in its innovation ecosystem, including a patchy record at commercialising research and skill shortages. Yet within this broad picture, pockets of successful innovation exist.
- Transitioning to a low-emissions economy calls for directed technical change in New Zealand's energy and transport systems, land use, buildings and industrial processes. In many areas New Zealand will be a technology taker. This requires capacities and resourcing to identify, absorb, adapt and deploy technologies from offshore. Yet in certain areas, New Zealand should invest in the full menu of basic and applied research, commercialisation, infrastructure and skills.
- Existing government R&D and infrastructure support for high-emissions technologies should cease immediately. Resources and policy attention should switch to backing clean technologies.
- New Zealand's strategy for its transition to low emissions should have a strong focus on innovation. Innovation should have priority alongside emissions pricing, targets and budgets, and the laws and institutions supporting them. Given the imperative to reduce emissions, the Government should devote significantly more resources to low-emissions innovation than the modest and inadequate current allocation.
- Well-designed and implemented support for low-emissions innovation is likely to have payoffs for New Zealand's wider economic performance and its international reputation. Another payoff is making a material contribution to combatting dangerous climate change at a global level.
- The right climate policies are likely to trigger new waves of global investment, innovation, and discovery. If a country designs its policies to foster learning and flexibility, then new opportunities will arise. The transition to low emissions may represent a very attractive path that could, if economic history is a guide, stimulate dynamic, innovative and creative growth.

Interestingly once innovation is taken seriously ...a whole new set of policy conclusions emerge most of which are related to ...knowledge spillovers and complementarities. (P Aghion et al., 2014, p. 5)

Innovation can and should play a central role in New Zealand's transition to a low-emissions economy. New technologies can enable production of existing products with reduced emissions (eg, a vaccine that reduces methane emissions from dairy cows), or can spawn new low-emission industries that disrupt and replace emission-intensive industries (eg, synthetic meat replacing animal farming). While innovation comes in many forms and is unpredictable, it is the closest thing to a "silver bullet" that will enable humanity to meet the challenge of avoiding damaging climate change.

This chapter will:

- indicate the power of existing and future innovations to reduce greenhouse gas (GHG) emissions;
- explain the modern understanding of the sources of innovation and its uptake in an economy in terms of path dependence and the concept of an "innovation system";
- show that, in the face of New Zealand's challenge to transition to a low (or zero) emissions economy, supporting innovation in clean technologies has a key role to play in addition to emissions pricing;
- note the evidence that New Zealand's poor productivity performance relates to weaknesses in its innovation system, and argue for using the imperative to transition to low emissions as an opportunity to boost innovation and achieve better economic performance and higher incomes more generally;
- consider New Zealand's position as a small developed country with an unusual economic structure and emissions profile (eg, high export dependence on its primary sector, predominantly a technology taker, high proportion of agricultural GHGs) and what these features imply for an optimal innovation strategy to lower emissions; and
- make findings and recommendations for how the government can best exploit the "engine of innovation" and the "technology diffusion machine" to tackle the important and urgent need to lower New Zealand's GHG emissions.

5.1 Innovation for a low-emissions future

The transforming power of innovation

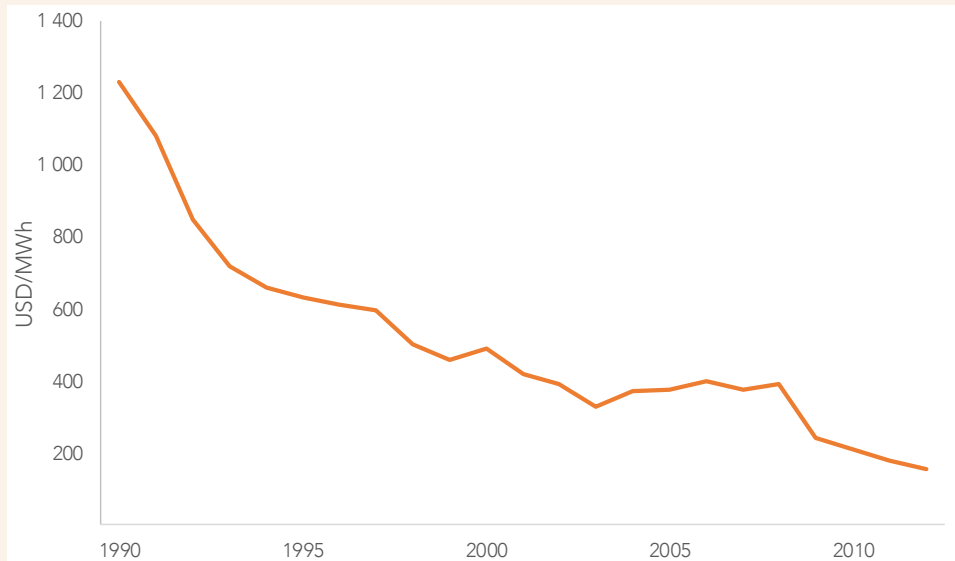
Technological and institutional innovations – arising from applied science, persistent trial and error by gifted entrepreneurs, cultural factors, and political, economic and financial reforms – have been the main driver of the remarkable economic growth and increasing living standards that many nations have experienced since the dawn of the Industrial Revolution (Mokyr, 2016). Existing innovations have already made possible large reductions in emissions in many economic activities. The challenge now is to turn these known technologies into daily realities. Future innovations will also be key to the transition to a low-emissions economy. Box 5.1 describes some examples of existing and likely future innovations that can lower GHG emissions.

Box 5.1 Examples of the power of innovation to lower emissions

Example 1: the dramatic falls in the cost of solar and wind generation

Continuous technology improvements and scale economies have seen the cost of generating 1 megawatt hour (MWh) of electricity from solar photovoltaic panels drop from over US\$1 200 to around US\$150 in 2013 and the cost is still falling (Figure 5.1). Solar power is emissions free in its operation and even over its lifecycle curtails 94% of the carbon emissions of equivalent coal-powered generation. It also eliminates the emissions of sulphur and nitrous oxides, mercury and particulates that come from burning coal – major contributors to 3.7 million premature deaths in 2012.

Solar-generated electricity can be deployed on rooftops in towns and cities, in remote locations or in giant solar farms occupying many hectares and with capacities up to 1 gigawatt.

Figure 5.1 Delivered price of energy from solar photovoltaic panels, 1990–2013

Source: New Climate Economy (2014).

While New Zealand's solar potential is less than many other countries, it is well endowed with wind energy. Ongoing cost reductions are likely to make generating electricity from wind the least expensive source of installed electricity capacity within a decade. Current costs (in US currency) in the United States in 2016 were:

- 2.9 cents per kilowatt hour for wind;
- 3.8 cents per kilowatt hour for natural gas combined-cycle plants; and
- 5.7 cents per kilowatt hour for utility-scale solar.

Example 2: innovation lowers emissions from air travel

Air travel for both passengers and freight is growing faster than any other transport mode. Upwards of 50 000 planes are expected to be flying by 2040 – up from around the 20 000 in service today. Emissions from aircraft fuel combustion constitute 2.5% of global GHG emissions.

Innovations that lower emissions from aircraft fall into the categories of incremental and radical. Incremental improvements in aircraft and engine design continue to deliver significant improvements in fuel efficiency. For example, the engine maker Pratt & Whitney improved fuel use by 16% by adding a gear to its turbofan engine design. Another engine maker, Rolls Royce, is using strong, light carbon fibre for its newest generation of lightweight engines.

More radical changes may come with hybrid and battery-powered engines, but these engines will require overcoming weight challenges. Intermediate options include the use of biofuels. The Carbon War Room has noted sustainable aviation fuels as having “the greatest potential for achieving carbon-neutral growth in aviation”.

Behavioural innovations include flying less at low altitudes (where fuel efficiency is lowest) and not using aircraft engines to move planes on the ground (where they spend 10% to 30% of their transit time).

Source: Hawken (2017)

Given the importance of innovation to a low-emissions future for the planet, it is vital that policies and institutions are conducive to the uptake of existing innovations, and to stimulating new low-emissions innovations. The next section examines the most important ways that policies and institutions can help deliver these outcomes.

Incentives to innovate for low emissions

Positive incentives

Putting a price on GHG emissions creates incentives for businesses to innovate – to find different means with lower emissions to produce the same good or service, or to find a substitute product that can be produced with clean technology. Every tonne of emissions avoided is worth the price of an emissions permit, or avoiding having to pay an emissions tax. The higher the price or the tax, the stronger the incentive. Entrepreneurs that come up with new and cost-effective ways to reduce emissions will make profits. Yet, with low emissions prices to date in New Zealand and elsewhere, the incentives have been quite weak.

Despite weak pricing, much innovation in areas such as wind and solar power, green supply chains and electric vehicles has already occurred. Some entrepreneurs strive to fulfil a social need, some believe they can eventually satisfy wants better with clean rather than polluting technology, and some see future, if not current, profits as attractive because they foresee emissions prices rising over time.

But the process of innovation is subject to its own market failure that is quite distinct from emissions causing climate damage. This failure arises because useful new ideas or inventions tend to lead to “knowledge spillovers”. These spillovers potentially benefit numerous other people and businesses who pick up the new idea or practice and copy it. The beneficiaries may include people far in the future because knowledge is cumulative – new knowledge builds on past knowledge. These beneficiaries do not have to pay for these benefits and, conversely, the knowledge creator is not rewarded for providing them. This outcome is sub-optimal. Because the marginal social benefit of an additional innovation will often exceed its marginal private benefit (to the innovator), too little innovation will happen relative to what is desirable for society.

Over a long period, societies have developed different means to tackle this market failure. These mechanisms support and incentivise innovation and knowledge creation as well as spreading the benefits of knowledge widely (Box 5.2).

Box 5.2 **Institutions and policies that support knowledge creation and use**

A variety of institutions and policies exist to support innovation and innovators and partly overcome the tension between knowledge creation on the one hand, and knowledge diffusion and use on the other. None of them is a perfect solution. Typically, countries adopt a mixture; the challenge is choosing the best level of each, and the balance between them.

Intellectual property rights

Intellectual property rights include patents, copyright and trademarks. They establish property rights for intellectual goods somewhat like property rights that exist for ordinary goods and services. A problem with intellectual property rights is that they give monopoly power over the use of something that requires no resources (because knowledge is non-rival) for another firm or consumer to use. Given this, and the cumulative nature of knowledge, unlimited monopoly power could have very high social costs. Therefore, intellectual property rights are generally limited. For example, patents are time limited, require the applicant to publicly disclose the nature of the invention, and allow others to use the knowledge to conduct further research.

Subsidising open science

Open science involves communities of scholars with commitment to high standards of research judged largely by peers. This requires laying out research results in a very open way. The incentive for individual scientists is mostly the recognition for being the first to make a discovery, rather than any monetary reward. The culture of the community entails great respect for originality and disapproval of any form of plagiarism or lack of acknowledgement of the intellectual precedents of a person’s research. Open science comprises a package of incentives that encourage the creation, and dissemination of knowledge. Downsides are that it can be expensive for taxpayers and, because science is often isolated from market signals, few incentives may exist to make research relevant to society’s needs.

Public subsidies for private R&D

Public subsidies for private R&D come in the form of either tax concessions or grants to firms that undertake spending on R&D.

Direct government purchase of research

The government purchases research directly, either by choosing among offers from potential research providers or through direct funding of research organisations (such as, in New Zealand, Crown Research Institutes).

Facilitating links to internalise spillovers

Formal and informal networks and other links between researchers and users of research encourage knowledge creation, dissemination and use. Such networks can be described as part of a “national innovation system”. The system generally works better when flows are two-way, with feedback loops from users to researchers and vice versa.

Prizes

Governments or private benefactors can offer large inducement prizes for the first person or organisation that develops a solution to a serious problem. A famous example is the British Admiralty’s offer in 1714 of a large prize to the first solution to determining longitude – critical for accurate marine navigation. The longitude rewards system stimulated much ingenious research and building of devices, and the prize was eventually awarded to clockmaker John Harrison. He worked along quite different lines to the scientific orthodoxy of the day by inventing an extremely accurate ship’s clock or chronometer.

Source: Blakeley et al. (2005).

In climate change, the world faces an extremely serious and complex challenge. Reducing emissions is likely to require many, varied innovations. Even where technologies already exist to reduce emissions to very low or zero levels, this may be costly. Incentivising innovation has the potential to speed up emission reductions and lower their costs. Accordingly, innovation has a very important role to play in the transition to low emissions while continuing to grow incomes and wellbeing.

Regulatory incentives and disincentives to innovation

Regulations can incentivise innovation. But they can also discourage or even prevent it. Policymakers should consider this when designing regulations, yet they often do not (Blind, 2012). For example, technology standards can force the use of a specific technique or practice to reduce emissions, such as using scrubbers on industrial smokestacks (Asafu-Adjaye, 2005). On the one hand this stipulation can prompt firms to adopt new methods; on the other, it can inhibit the development of superior, lower-cost solutions, or even the use of an existing lower-cost solution.

A better approach is to design regulations to be technology neutral. For instance, regulations could specify minimum performance standards (such as for vehicle exhausts or energy efficiency) and leave it to manufacturers to find the best means to achieve these standards. Yet, even this poses a risk of not incentivising the optimal level of performance – a level that could be higher or lower than the standard.

Regulations designed to achieve objectives other than lower emissions (eg, product safety) also pose risks. These risks can have the effect of inadvertently inhibiting low-emissions innovations. For example, safety regulations that require approvals of new products create a high barrier to radical innovations that carry some, as yet unquantified, risks. Chapters in Part 4 describe cases where existing regulations are barriers to new, low-emissions technologies in sectors such as electricity, agriculture and transport.

Subsidies to emissions-intensive activities discourage innovation

While emissions pricing incentivises low-emissions innovation, subsidies to high-emissions activities dis-incentivise it. This is because private decisions about where to direct innovation effort and resources

depend on relative payoffs and the subsidies reduce the relative payoff to lowering emissions. One striking example consists of the extremely large subsidies that still exist around the world for fossil-fuel exploration, development and use. These subsidies were estimated to be worth between US\$55 billion and US\$90 billion every year between 2005 and 2010 across the 34 member countries of the Organisation for Economic Co-operation and Development (OECD) (OECD, 2015a). UN Secretary General Antonio Guterres has stated that by subsidising fossil fuels, humanity is “investing in its own doom” (Guterres, 2017).

The New Zealand Government does not provide official figures on fossil fuel subsidies in New Zealand. The OECD calculated New Zealand fossil-fuel support at \$78 million in 2016 (including budgetary transfers and tax expenditures) (OECD, 2018b). Another estimate suggested a slightly higher figure of \$88 million a year of total government support provided to the oil and gas industry in 2016/17 (Loomis, 2017). Subsidies include concessionary tax deductions for petroleum mining activities and R&D funding for the oil industry. As noted, these subsidies reduce the payoffs to innovations in clean energy.

F5.1

Innovation in clean technologies is a key enabler of transitioning to a low-emissions economy while growing incomes and wellbeing. Innovation is positively influenced by pricing emissions, by direct government support for low-emissions innovations, and support for its deployment and adoption. Innovation is discouraged by subsidies to emissions-intensive activities.

F5.2

Fossil fuel subsidies act in direct opposition to New Zealand’s transition to a low-emissions economy. New Zealand provides approximately \$78-88 million per year worth of government support to fossil fuel production and consumption.

R5.1

The Government should phase out all subsidies that support the ongoing production and use of fossil fuels.

Transitioning from polluting to clean technologies: theory and evidence

The transition to low emissions has, at its heart, a transition from an initial economic structure dominated by polluting technologies to an economic structure dominated by clean technologies. This change is profound and challenging, not least because of the powerful path dependencies that exist in much economic life. These path dependencies have several causes such as economies of scale, network effects, lock-in to existing assets and infrastructure, and (importantly for technological progress) the cumulative nature of knowledge. The National Energy Research Institute (sub. 53), for instance, notes that “[o]ne significant barrier to innovation is the extent of commitment to current technologies - for example replacing dirty plant early incurs both a write-off and a new investment” (p. 8).

Cost reductions in clean technologies depend strongly on learning and experimentation from R&D and deployment (ie, learning by doing). They also depend on complementarities between a new technology, new networks (such as smart electricity grids), new institutional arrangements, new financial models to secure investment, and the development of new skills in the labour force (P Aghion et al., 2014).

Theory

Shifting an economy from its current high-emissions trajectory requires leaning against these path dependencies. Acemoglu et al. (2012) apply modern economic thinking about growth, productivity and innovation to the technology aspects of this challenge (Box 5.3).

Box 5.3 The environment and directed technical change

A seminal paper by MIT, Harvard University, and University of California authors Acemoglu, Aghion, Bursztyn, and Hemous (AABH) appeared in the *American Economic Review* in 2012. It illuminated the role of policy in shifting an economy from “dirty” to “clean” technology.

The model analyses a highly stylised economy – it has one final good that can be produced with either a dirty input or a clean input. Effectively the economy has two sectors – dirty and clean. Use of the dirty input has a negative external effect and degrades the environment which, in turn, lowers citizens’ wellbeing. The environment has a capacity to renew itself, but it can also suffer a “catastrophe” if its condition degrades beyond a certain point.

An important feature was to model the determinants of technical progress in each sector – unlike in most climate-economics models that assume external factors determine technological progress. AABH note that technical change flows from the directed research of scientists in the dirty or clean sectors according to the relative private returns to the research. These returns will be higher when:

- the market share of a sector is larger: this reflects that knowledge goods have high fixed costs and low marginal costs and so exhibit increasing returns to scale; and
- the technology of a sector is more advanced: this reflects the “standing on the shoulders of giants” character of knowledge that occurs because earlier discoveries lay a platform for later discoveries.

Clearly, the effects of both market share and technology development contribute to path dependence.

AABH use the model to investigate several important questions, starting from an initial state in which the dirty sector is much larger than the clean sector. The model generates the following results.

- Under free-market conditions when no policy interventions address either the environmental damage from the dirty input or positive knowledge spillovers, the growth path of the economy always leads to environmental disaster (because cumulative pollution from the dirty sector reaches a tipping point).
- If the clean and dirty inputs are sufficiently substitutable for each other, a temporary research subsidy to the clean sector can turn the downward path of the economy around. The subsidy redirects technical change to clean technologies to the point where they are dominant enough in use for clean-technology research to continue without the subsidy. The shift to the use of clean technology is also enough to make growth sustainable and avoid environmental disaster. The following quote describes the contrast between the free-market and research-subsidy paths.

No firm has an incentive to produce clean research because it can neither pay the best scientists nor overcome the network effect of the incumbent dirty technology to deploy its innovation. The economic system stays locked in fossil fuels. In an alternative path, the system is given enough of a ‘push’ to overcome initial switching costs so that cleaner technologies are fully developed and adopted, eventually displacing fossil fuels. (P Aghion et al., 2014, p. 7)

- Delay in implementing the subsidy for clean research is costly because of the increase in environmental degradation, the bigger the intervention needed when it does happen, and a longer period of slower growth during the transition (the latter two are both because technology in the dirty sector has moved further “ahead” during the delay).
- Optimal policy requires *both* emissions pricing and research subsidies (ie, a policy aimed at each market failure).
- Use of emissions pricing (ie, a carbon tax or an ETS) alone is “second-best”, but would be distortionary. This distortion is because only using emissions pricing would require a much higher emissions price than under optimal settings and impose a substantially greater cost in the form of lower consumption than using both instruments.

- Numerical simulations of the model suggest optimal environmental regulation should include an immediate switch of R&D resources to clean technology, followed by a gradual switch of all production to clean inputs. The simulations suggest delay costs could be substantial – equivalent to a decline in consumption of 8.5% for a 10-year delay.

Source: Acemoglu et al. (2012).

Perhaps the most important insight of Acemoglu et al. (2012) is for policy to support the creation and adoption of new technology *in addition* to an effective emissions price. Failure to support clean technology to overcome the path dependence on the old (polluting) technology will reduce the effectiveness of emissions pricing. It will require higher emissions prices and higher costs than otherwise needed, in turn heightening the risks of political resistance.

The AABH model has a possible scenario in which the clean sector is supported and develops so effectively that it completely supplants dirty technology because clean technology becomes cheaper and better. At that point, an emission price becomes unnecessary. This situation of old inferior technologies dying out is quite common. Some are predicting this change will happen with the internal combustion engine regardless of carbon pricing (Arbib & Seba, 2017). Yet, an optimal policy always includes a carbon price for any emissions in AABH's model.

The insight from the model that comes a close second in importance is the need for an immediate start on support for clean technology. Delay is costly because it further opens the gap between the stages of development and uses of the old and new technologies.

If delay causes a larger gap between polluting and clean technologies, society risks bearing the cost of a longer and harder transition period. While innovation re-focuses from the more-advanced polluting sector to the less-advanced clean sector, the growth of final output is likely to slow. Yet, as P Aghion et al. (2014, p. 8) note, while the transition will divert resources, it will not do so permanently:

...the tying up of additional resources necessary to trigger the transition may also inhibit the endogenous drivers of growth, especially if the transition is protracted. It will take a certain period of time before there is higher and cleaner growth, powered by a "clean innovation machine". But once the clean technology has gained sufficient productivity advantage, the clean innovation machine can be left on its own.

Traditionally, public support for R&D is called for to support development of technologies that are further from market (which clean technologies generally are), but nonetheless have long-term potential (Dechezleprêtre et al., 2016).

A striking illustration of a firm trying to counter powerful network effects and other causes of path dependence exerted by an "old technology" industry is Tesla, the electric vehicle (EV) company. Tesla is giving away its intellectual property. It has granted public access to all its EV patents to speed up development of EVs by other firms and create broad pressure for investment in EV infrastructure. Of course, political action by vested interests can add to the resistance – car dealers have acted to block the sale of Tesla cars in some US states.

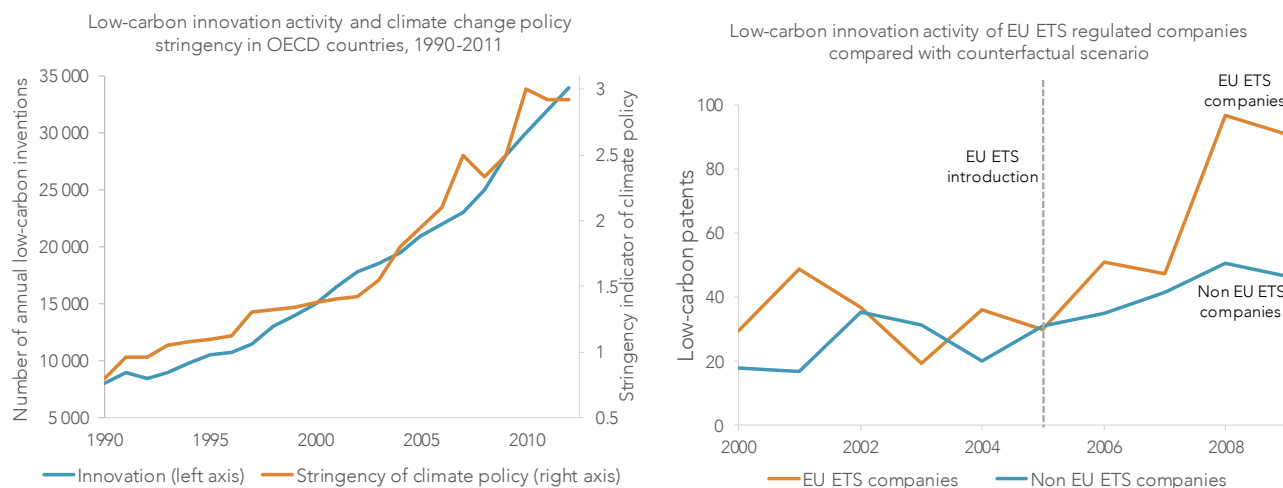
Evidence of the effectiveness of public policy support for clean technologies

Considerable evidence exists to back the need for, and the effectiveness of, public policy support for new, clean technologies.

Evidence for path dependence exists in the form of firms directing their innovation efforts to areas where they already excel. The evidence comes from cross-country patenting data in the auto industry (Philippe Aghion et al., 2012). The research showed that clean innovation is path dependent at the firm and industry levels – those that start with a greater stock of clean technology patents, innovate in clean technology at a faster rate in the future.

Ample evidence exists that climate-change policies induce innovation in low-carbon technologies. One example is a strong positive relationship found in OECD countries from 1990 to 2012 between the number of low-carbon inventions (measured by patent filings) and the stringency of climate policy in the country (Dechezleprêtre et al., 2016). Another study compared the number of patents in low-carbon technologies produced by firms covered by the European Union's ETS with firms not covered. Before the ETS was in place, the two groups of firms exhibited roughly similar innovation activity (as measured by the patents). After the policy was in place, the innovation activity of the group within it quickly began to diverge upwards (Calel & Dechezleprêtre, 2016), (Figure 5.2).

Figure 5.2 Responses of low-emissions innovation to climate-change policies



Source: Dechezleprêtre et al. (2016).

Evidence indicates that the impacts of policies to incentivise low-carbon innovation are generally both large and rapid. They can therefore help economies break from their existing high-carbon trajectories to low-carbon trajectories.

In addition, knowledge spillovers from innovation in clean technologies can have wider economic benefits and could stimulate growth and higher productivity. As might be expected, spillovers from R&D in a relatively unexplored area of technology tend to be larger than from an area of mature technology. Using patent citation data, Dechezleprêtre et al. (2017) consistently found up to 40% more high spillovers from clean technologies than conventional technologies associated with GHG pollution. They also used firm-level financial data and found a greater positive impact of knowledge spillovers from clean technologies on the market values of firms.

F5.3

The transition to a low-emissions economy will require policies that lean against path dependencies that can lock-in polluting technologies and patterns of production. These dependencies arise from market size, scale economies, the cumulative nature of knowledge, network effects, sunk investments and political pressures from vested interests.

F5.4

A good low-emissions strategy needs both an effective emission price and support for innovation that creates, disseminates and deploys low-emission technologies. Relying on emissions pricing alone will require higher prices than otherwise needed, which, in turn, will likely impose unnecessary economic and social costs.

F5.5

Delay in supporting clean technologies is undesirable. The productivity gap between polluting and clean technologies will increase during the delay period and make the transition longer and costlier in terms of slower economic growth during the transition.

F5.6

Evidence indicates that policies to incentivise the development and uptake of clean technologies may be highly effective. Impacts can be both large and rapid and, as such, can help economies break from their existing high-carbon trajectories to low-carbon trajectories. Evidence also indicates that low-carbon innovations induce greater economic benefits through larger knowledge spillovers compared to innovations in mature high-carbon industries.

Key elements of a good innovation system

If, as argued above, government support for clean innovation is a critical plank of an overall strategy to transition to a low-emissions economy, what form should that support take, and what are the broader, system features of economies that successfully innovate? Box 5.2 earlier described different forms of policy support. Different features and how they each play a part and complement each other are sometimes described as making up a “national innovation system” (Box 5.4).

Box 5.4 **A national innovation system**

Successful business innovation involves more than narrowly defined R&D. It can include such dimensions as:

- identification of opportunities;
- fostering research-business links;
- testing and demonstration;
- adaptation to local conditions;
- investment in technology, deployment, training and skills;
- funding and finance; and
- market research and marketing.

Typically, only a minority of firms have capabilities across all these dimensions.

At a national level, K. Smith (2006) argues that successful innovation systems are characterised by institutional arrangements (which may differ significantly across countries) that take care of five broad problems:

- **Identification of innovation opportunities** – opportunities are rarely obvious and often emerge from a complex interplay between government, businesses, financial systems and research infrastructures. Exploiting opportunities is not usually an automatic market process, but an action an innovation system may perform well or badly.
- **The creation and distribution of knowledge capabilities** – this is much broader than R&D. It includes non-R&D inputs to innovation and the distribution of knowledge through relationships, intermediaries, people mobility, and education and skills.
- **Business finance and development** – commercial success depends on far more than a good idea. The ability to develop and finance a business idea rests on complementary assets such as

management capability, a conducive financial system (Chapter 6), and logistical and marketing capabilities.

- **Risk and uncertainty management** – risk and uncertainty are inherent in innovation. A basic problem is the mismatch between the shorter time horizon of profit-seeking firms and their investors, and the longer time horizon of most research endeavours. The system needs mechanisms to bridge this gap.
- **Infrastructure provision** – much innovation is infrastructure-dependent. Infrastructure for innovation is either physical (eg, a broadband network) or knowledge-based (eg, public research institutes and universities). Infrastructures are typically expensive to create and operate. Infrastructures also tend to pose financing, governance and regulatory challenges no matter which sector (private or the public sector) provides them.

A typical successful modern economy is innovative in specialised areas where the above capabilities have been built up and evolved over long time periods. Examples include Denmark in wind technology, Taiwan in laptop computers and Germany in machine tools. The challenge of transitioning to low GHG emissions faces all economies. It is pervasive and not confined to particular sectors. Using innovation to meet the challenge will require, to varying extents, addressing these five broad problems. Along the way, the challenge may also provide both business and the country with new opportunities to prosper by innovating in particular clean technologies.

Source: K. Smith (2006); The Treasury (2008).

How far should governments direct research and innovation to specific areas?

Section 5.2 will examine New Zealand's innovation system and how well it performs. Before doing that, it is important to consider how far a government should direct an innovation system to specific areas and ends rather than leaving scientists, innovators and entrepreneurs to pursue their own interests and dreams (so-called investigator-led research). Further, could a specific area ever be so important to command exceptional treatment?

At one end of a spectrum, the government or another research funder may take no view on what the goal is, other than research excellence. The topic may have no apparent connection to improving human lives. Sometimes, paradoxically, such research does lead to breakthroughs in understanding that eventually make huge contributions to economic, environmental or social progress. But not often.

Most government support for research and innovation carries an expectation that it will improve society, the economy or the environment. Yet, in many cases, the government does not decree the specific projects to which research funding is to be applied, or the precise outcomes sought. Respecting university autonomy and academic freedom, much support for university research falls in this category.

A third category of government funding for research and innovation is more directive. The funding is to achieve desirable outcomes within distinct areas such as agricultural productivity, medical devices, pharmaceuticals, space exploration or saving endangered species. This type of directive research funding is common in OECD and other economies. Areas are usually chosen for their perceived economic, social or environmental importance to the country. Yet the total funding, and the absolute and proportional funding that each area receives, is a product of many forces and is ultimately political. This outcome is a reflection of multiple pressures on a limited government budget.

That said, the planet faces grave risks from harmful climate change. Innovations in energy and transport systems, agriculture and other industries hold out the best hope for substantially eliminating GHG emissions and saving the planet for humans and other species to enjoy, while maintaining and improving living standards. A failure by the global community to stop or severely curb these emissions would have potentially grave and irreversible consequences. So the case to direct substantial public resources towards science and

innovation to help solve the problem is convincing. New Zealand acting alone cannot solve the problem, but it needs to make its fair contribution as a developed economy.

F5.7

The risks of harmful climate change are very serious. Yet the application of research and knowledge offers the prospect of substantially cutting GHG emissions. A convincing case therefore exists for government resources to target low-emission innovation as an exceptionally important part of a country's public funding for science and innovation.

Absorbing knowledge from other countries

For a small country like New Zealand, the majority of world knowledge is created overseas – for example, less than 0.2% of OECD R&D expenditure occurs within New Zealand. New Zealand is predominantly a knowledge taker rather than a knowledge maker. But being a smart follower does not happen automatically. It requires similar capabilities to creating knowledge – technical and management skills, and the ability to tailor innovation to local conditions. New clean technologies can flow from overseas to New Zealand firms through several channels including trade, investment and people flows, and as “embodied” knowledge in imported capital equipment (DeLong & Summers, 1991).

Notably, a firm's ability to absorb and apply knowledge from leading-edge firms to itself is significantly improved if the firm itself invests in R&D (Griffith et al., 2000).

Skills

The substantial change and disruption in the transition to a low-emissions economy also implies that, alongside the new technologies themselves, a parallel evolution is needed in skills to use them and in shifts in the labour force (Chapter 9).

One of the preconditions for a smooth decarbonisation of the overall economy is that the vocational education and training system adapt in a timely way to changing skill demands. Another is that labour market institutions and policies support the necessary reallocation of labour from shrinking to growing firms and activities. This is all the more important as there are concerns about job destructions related to the shift to a low-carbon economy connected to threats of carbon leakage. (OECD, 2015a)

The key overall message

The key overall message is the need for an innovation system geared to the objective of transitioning the economy to low emissions, and for the various complementary parts of that system to be in tune and working well together. That means not only adequate R&D support for clean technologies, but also that finance, skills, knowledge sharing, infrastructure, market conditions and regulatory regimes are aligned to support the widespread changes needed across the economy to achieve low emissions. The Morgan Foundation sums this up:

Strong carbon prices and national policy direction combined with meaningful, broad-based support for research and development (for example through tax credits) would hopefully go a long way to encouraging low carbon innovation. (sub. 127, p. 22)

Further, as Andy Reisinger (sub. 28) argues, a successful transition also requires policy certainty across these complementary areas that sends a consistent signal to potential investors in new technology (see also Chapter 4 and Chapter 7).

F5.8

The effective creation and application of low-emissions knowledge and technologies depend on different facets of the national innovation system being present and working well together. The facets include:

- clear objectives;
- identification of innovation opportunities;
- domestic and international links between firms, investors, and researchers;

- timely provision of complementary infrastructure;
- adequate risk capital, management capability, skills and training; and
- flexible markets for resource reallocation from shrinking to growing firms and activities.

F5.9

Both the government and the private sector have important roles to play in a national innovation system geared to achieving a low-emissions transition. The government's role includes setting credible and transparent goals and policies, and enabling market forces to mobilise businesses to redirect resources from dirty technologies towards clean technologies. Clearly the government cannot, and should not, substitute for the market.

5.2 Current support for low-emissions innovation in New Zealand

This section examines New Zealand's innovation system at present – both generally and in relation to the goal of transitioning to low emissions. The Commission's assessment is that some current features are positive for that goal, but considerable scope exists for improved resourcing and design. Further, the proposed changes are likely to be beneficial not only for de-carbonising New Zealand's economy, but also for enhancing its performance more generally.

Description of current support

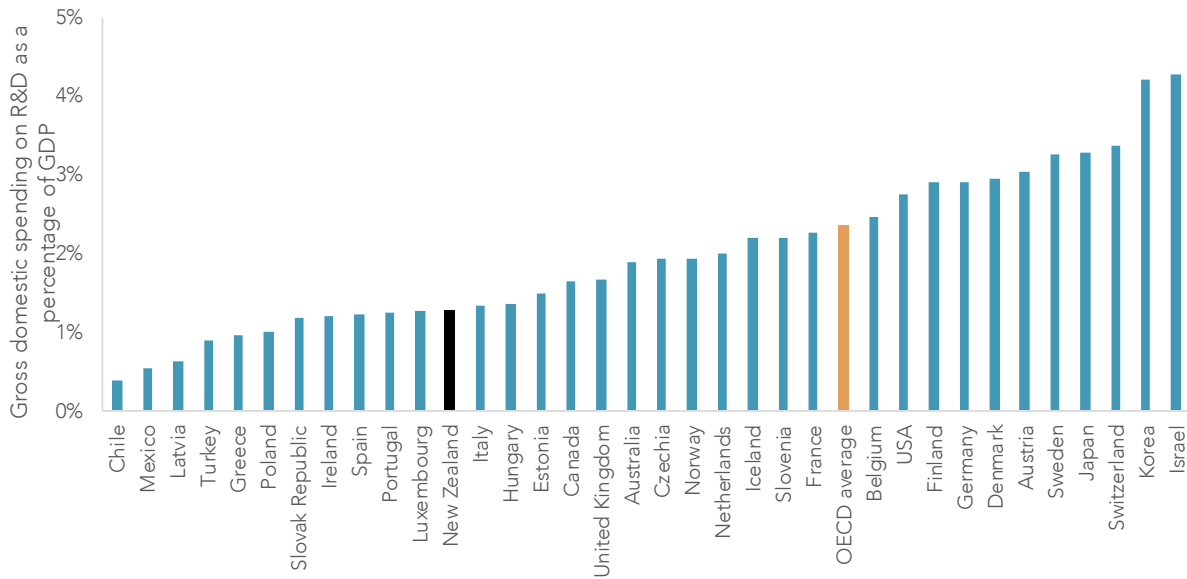
Government support for science and innovation

The New Zealand Government spent \$1.32 billion in 2015 on support for science and innovation. It plans to lift this to around \$1.66 billion by 2021. The current spend is around 0.4% of Gross Domestic Product (GDP) and 1.7% of total government spending. The proportion of spending aimed at climate change is small – according to the 2016 R&D survey the proportion of total R&D in the broad category of "Environment" is 10% (StatsNZ, 2017d) and this category includes many other areas than climate-change mitigation.

Both New Zealand's public and private-sector investment in R&D as a share of GDP is well below the OECD average (Figure 5.3). New Zealand is also unusual in that the business sector funds less than 40% of total R&D; the average proportion in the OECD that the business sector funds is close to 70%.

Government funding support for R&D and innovation more broadly flows through two main channels.

- **Research funding to tertiary education institutions.** This funding includes specialist research centres and networks, such as Centres of Research Excellence. A large proportion of the funding is non-directive and flows to universities through the Performance Based Research Fund (Ministry of Education (n.d.)). These funds are administered through the Tertiary Education Commission with policy advice from the Ministry of Education.
- **Support for public-good research and business R&D.** This is administered through the Science and Innovation Directorate of the Ministry of Business, Innovation and Employment (MBIE). Recipients include Crown Research Institutes, businesses, universities, and other private- and public-sector researchers.

Figure 5.3 Public and private R&D spending as a percentage of GDP, 2015

Source: OECD

Research organisations that undertake low-emissions R&D in New Zealand sometimes with private-sector partners include:

- universities that carry out “blue sky” and/or targeted research, such as through the MacDiarmid Institute for Advanced Materials and Nanotechnology and the Centre of Excellence in Electric Power Engineering;
- MBIE, which funds multiple programmes such as the National Science Challenges – one being The Deep South, which aims to enable New Zealanders to adapt, manage risk, and thrive in a changing climate;
- Crown Research Institutes which, with dedicated interests in agriculture (AgResearch), horticulture (Plant & Food), land care (Landcare Research), and forestry (Scion), undertake applied research into ways to reduce or absorb emissions;
- the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) and the Pastoral Greenhouse Gas Research Consortium (PGgRc), which research ways to curb agricultural GHGs; and
- Motu Economic and Public Policy Research, which is a non-government trust that has a programme of research on climate-change impacts and mitigation in New Zealand including forestry, agriculture and emissions pricing.

Most of the research carried out by these organisations is funded directly or indirectly by government. Only the NZAGRC and the PGgRc focus exclusively on climate-mitigation research. Only the university institutes, the Crown Research Institutes, the NZAGRC and the PGgRc research and develop low-emissions technologies.

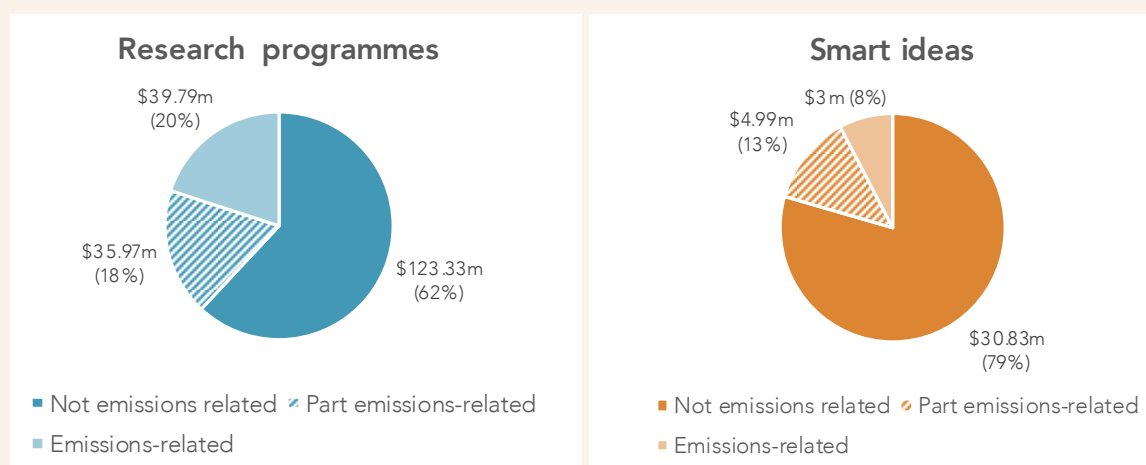
Research organisation such as these may receive their own dedicated funding, but can also seek funds from sources that offer pools of contestable funding. One source is the Endeavour Fund (Box 5.5).

Box 5.5 The Endeavour Fund and low-emissions research

The Endeavour Fund, administered by MBIE, invests around \$200 million each year in projects and programmes chosen for their potential for long-term transformational impact for New Zealand including its economic performance, a stronger society, and the sustainability and integrity of the environment. The two selection criteria are research excellence and impact. The two categories for applications are *smart ideas* (specific projects) and *research programmes*.

MBIE announced decisions on the 2017 round of the Endeavour Fund late in 2017. Figure 5.4 shows the funding in the two categories of research programmes and smart ideas that went to research related to a low-emissions transition, to research partly related to a low-emissions transition, and to research in unrelated areas.⁴³ The proportions of funding going to research relating partly or more fully to lowering emissions are significant. For a single outcome area, they are relatively high. It suggests that the funders believed a high number of quality applications had the potential to make an impact in transitioning to low emissions. Yet, in terms of the Commission's conclusion in the previous section, reducing emissions is not just another (important) outcome area. It is an imperative that needs to be treated with urgency and high priority.

Figure 5.4 Endeavour Fund 2017 Research Funding Allocations



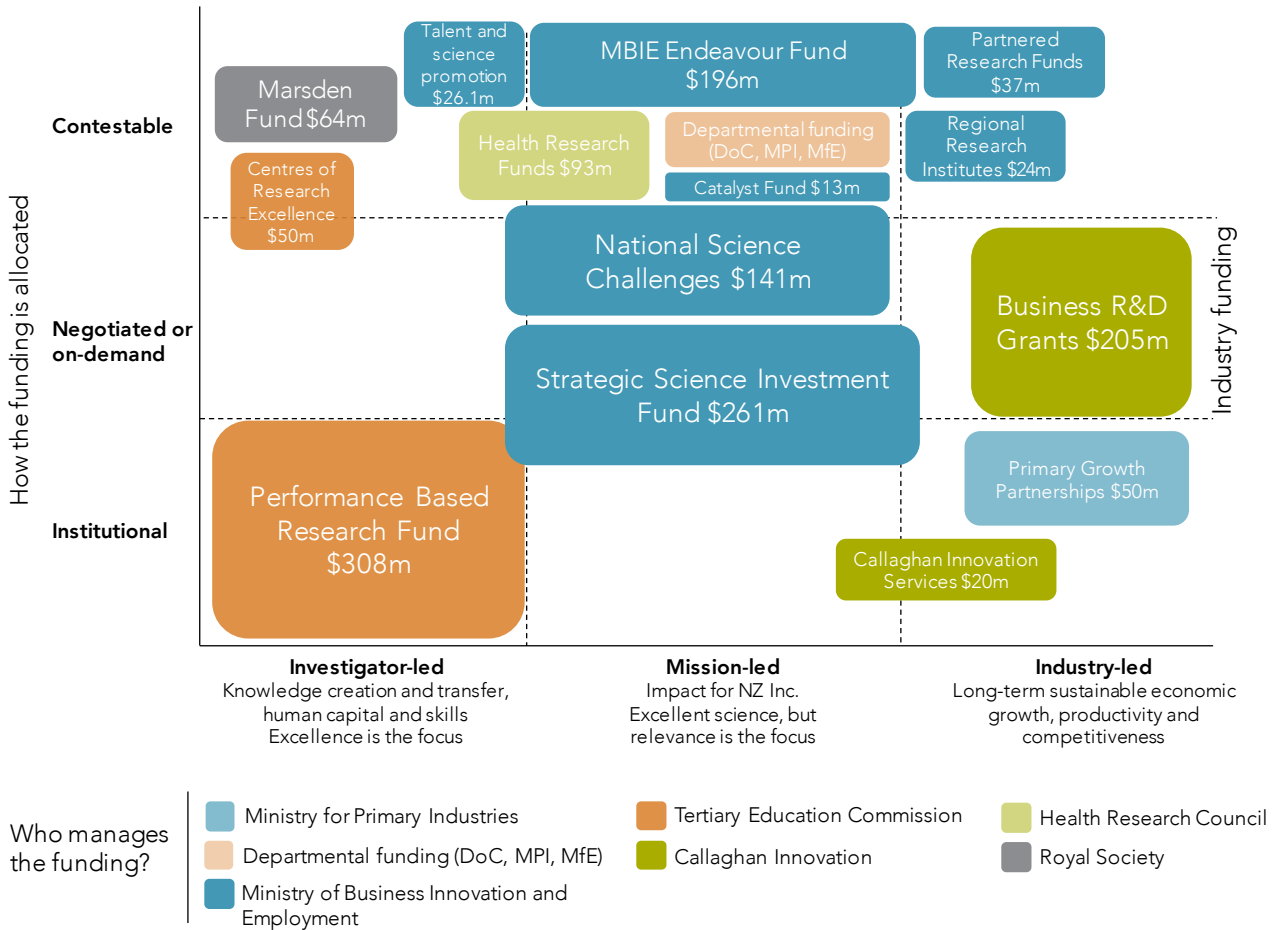
Source: NZ Productivity Commission analysis of MBIE information.

The wider public-funding landscape for science and innovation

The Endeavour Fund sits within a wider landscape for science and innovation funding in New Zealand. The landscape is shown in Figure 5.5. Directive funding programmes sit in the centre of the figure. It is through these programmes that the government has the most influence on the purposes of the research that it funds. It also has some influence through its contributions to the industry-led programmes in the right column.

⁴³ Classified by the Commission based on the brief descriptions of the projects and programmes on MBIE's website.

Figure 5.5 New Zealand’s science and innovation public funding landscape



Source: MBIE (2017d).

Table 5.1 describes three of the schemes (apart from the Endeavour Fund) that have large budgets – the Strategic Science Research Fund, the National Science Challenges and business R&D grants awarded by Callaghan Innovation – plus several of the more specialised funding streams

The government has the potential – through its funding and objective-setting – to influence the extent to which these schemes focus on research and innovation relevant to a low-emissions economy. The table describes the extent to which they do.

Table 5.1 Mission-led and industry-led research support schemes funded or co-funded by government

Scheme	Purpose	Annual funding (mostly 2017/18) and degree of focus on low emissions
Strategic Science Investment Fund	Funding for investment in mission-led research programmes and research infrastructure that are of enduring importance to the economy, environment and wellbeing. The Fund also provides funding for the seven Crown Research Institutes.	Over \$260m. Priorities are defined in the Fund’s investment plan 2017–2024. Low-emissions innovation is not identified as a priority.
National Science Challenges	Eleven big challenges that if successfully met will have major and enduring benefits to New Zealand. Crown Research Institutes must	\$141m. No challenge is specifically focused on lowering GHG emissions (<i>The Deep South</i> challenge focuses on aspects of climate change and adapting to it).

Scheme	Purpose	Annual funding (mostly 2017/18) and degree of focus on low emissions
	strategically align some of their R&D with the challenges.	
Callaghan Innovation and business R&D grants	Several different grant schemes aimed at stimulating New Zealand businesses to invest more in R&D. A Global Expert scheme to put New Zealand firms in touch with international experts. New government is committed to increasing business R&D and is looking at introducing an R&D tax credit.	\$205m for grants. R&D is not a specific priority area. Little sign of firms being awarded grants with a focus on lowering emissions. A Global Expert scheme is driven by business demand. A scanning role to find potential low-emissions technologies from overseas is not part of the scheme.
Primary Growth Partnership (PGP)	A joint venture between government and primary industry that invests in innovation to increase the market success of primary industries. Programmes include R&D, education and skills, and technology transfer.	\$39m government contribution (2016/17), with matching co-funding from industry. \$235m total investment by government over the life of 22 PGP programmes (to mid-2017). Around 5 programmes have some focus on lower emissions – often as a co-benefit with improved water quality.
NZ Agriculture Greenhouse Gas Research Centre (NZAGRC)	A partnership between New Zealand researchers and industry bodies in the agricultural GHG area. The partnership aims to bring cost-effective, simple solutions to New Zealand farms, and contribute world-leading mitigation solutions to the international science community.	Average of \$4.8m a year over 2009–2019 (funded from the PGP). Fully focused on reducing agricultural emissions. Chapter 10 has further information.
Pastoral Greenhouse Gas Research Consortium (PGgRc)	A consortium that aims to deliver knowledge and economically viable mitigation practices and products that help New Zealand farmers manage their GHG emissions. The pastoral farming sector leads the consortium in partnership with government and the NZAGRC.	Government funding average of \$3.1m a year over 2013–2019, matched by the sector. Fully focused on reducing on-farm emissions. Chapter 10 has further information.
Global Research Alliance on Agricultural Greenhouse Gases	An alliance of 49 countries focused on R&D and deployment of technologies and practices to help grow more food without growing GHG emissions. New Zealand hosts the Secretariat.	Contribution by New Zealand government of around \$6m a year over 2010–2020. Fully focused on reducing emissions from livestock farming. Chapter 10 has further information.

Source: MBIE, PGP, NZAGRC, PGgRc and Global Research Alliance on Agricultural GHG websites.

Current government support for other aspects of the innovation system

Finance

The government encourages the private venture capital market to supply adequate risk capital to early-stage business innovators through the New Zealand Venture Investment Fund (NZVIF). No sector bias is apparent in fund allocation; indeed, most investment decisions are taken by private-sector partners. A small number of the 267 investee companies have a focus on innovations to lower emissions. These companies include, for example, CNano, Ray Power Systems, and SolarBright. Chapter 6 has further information on finance for low-emissions investment.

Public procurement

Public procurement is recognised as an important instrument of innovation policy. Across OECD countries, public procurement expenditures average 13% of GDP. Smart government purchasing can demonstrate low-emissions technologies, and help to develop the supply side of the market. Government can be influential in sectors where its expenditures are large (such as transport and construction). Public procurement can promote low emissions through life-cycle costing that includes the social cost of emissions, and by market dialogues with potential suppliers to encourage innovative tenders and new business models (Baron, 2016).

Leadership and guidance on best practice in public procurement rests with a unit called New Zealand Government Procurement within MBIE. While dedicated to raising standards for procurement across government, its focus is on commercial best practice and conventional value for money, rather than fostering innovation in priority areas such as low-emissions investments and technologies.

Prizes

As noted above, prizes for developing innovative solutions to difficult problems can be an effective way to incentivise knowledge creation, follow-on development, and subsequent knowledge sharing. Callaghan Innovation awards a biennial “C-prize” of \$100 000 in a competition that challenges entrants to come up with technologies that deliver solutions to real industry problems. The 2017 challenge stipulated solutions delivered by the “next generation of wearable technology”.

The Prime Minister’s Science Prizes are awarded each year. The five prizes have a combined value of \$1 million. The top prize is awarded to “an individual or team for a transformative scientific discovery or achievement, which has had a significant economic, health, social and/or environmental impact on New Zealand or internationally”. The 2017 MacDiarmid Emerging Scientist Prize of \$200 000 went to University of Otago scientist Dr Carla Meledandri applying nanotechnology to two very different areas: reducing tooth decay, and gas capture and storage with the potential to mitigate GHG emissions. In a radio interview Dr Meledandri said the prize money would make a huge difference to paying for additional staff, travel and collaboration, and equipment (Meledandri, 2018).

Assessment of New Zealand’s support for low-emissions innovation

By OECD standards, the public and private resources devoted to research, science and innovation in New Zealand are not large. Even for these investments, New Zealand struggles to leverage them to raise its productivity and incomes (Conway, 2016; Wakeman & Conway, 2017).

Funding either does not give priority to low-emissions innovation or it is minor

New Zealand has many different programmes for supporting science and innovation. The funding in these programmes could be awarded to R&D in low-emission technologies. But many of the programmes either base their funding decisions on research excellence and impact regardless of the sector (which are good criteria), or they have priorities that do not include reducing GHG emissions. As noted, the sector-neutral Endeavour Fund has awarded funding to research related to, or partly related to, reducing GHG emissions in significant amounts for a single topic area. But the absolute amounts for each programme or project are relatively small.

Some programmes are dedicated to lowering GHG emissions, especially in animal agriculture. This is appropriate given New Zealand economic specialisation in animal agriculture and the unusually high proportion of its total GHGs that come from that sector. But the amounts devoted to these specialist programmes are small – a few million dollars each a year. Other primary industry areas also receive some emphasis – for example, forestry and horticulture through the CRIs Scion and Plant and Food respectively. Yet again, these efforts are modest relative to the potential and probable need for these sectors to expand and make a significant contribution to reducing emissions.

New Zealand also has strength in some forms of energy research. Yet these do not appear to be strongly or systematically supported. New Zealand has nothing comparable to Scottish research into tidal power or the huge investments in developing wind power in Denmark and more recently in the United Kingdom. As the former Parliamentary Commissioner for the Environment, Jan Wright, has remarked, New Zealand has some

of the best wind in the world, and trains many engineers; yet it has had to import Danish expertise and engineers to build its wind farms.

Research strengths exist in materials science in centres such as the MacDiarmid Institute for Advanced Materials and Nanotechnology, and GNS Science, but they are relatively small operations (eg, the MacDiarmid Institute received less than \$3 million in core funding in 2015). Again, no systematic slant exists to favour research and innovation for low emissions.

Relatively small prizes seem to be effective in motivating research and innovation to solve practical problems. Potential therefore exists to make greater use of this approach to drive innovation that searches for low-emission solutions.

Government agencies use of other levers to support low-emissions innovation is patchy

No serious attempt has been made to use government procurement as a lever to encourage low-emissions innovation. Likewise, investment to date in research infrastructure to support low-emissions innovation (eg, in tidal power or distributed energy) has been minimal even though the Strategic Science Investment Fund provides for strategic investments in “infrastructure projects that have high national benefits that will not emerge in the course of usual business because of the public nature of the benefits, and the scale, complexity, long duration and multi-user nature of the investment”.⁴⁴

NZVIF, the government institution for improving flow of risk capital to innovative start-ups, has no special focus on low-emission technologies (see Chapter 6). Auckland Council (sub. 97) notes that “[s]tart-ups that are supported by government and who lead in the innovation space are not currently supported to scale...” (p. 55).

Some parts of government have appreciated the need to support investments in complementary infrastructure and to support a reform of regulations to encourage low-emissions innovation and new technologies. Yet the thinking and efforts have been sporadic and not part of an overarching theme or strategy for a radical transition to a low-emissions economy.

Strategic fit and conclusions

This assessment needs to consider New Zealand’s status as a small, developed country with a distinctive emissions profile and then ask: What does that imply for a publicly-supported innovation strategy? Should New Zealand, for example, focus its innovation strategy on a few niche areas of high importance given its emissions, and focus on being a smart follower for the remaining areas? This approach has a convincing logic. New Zealand will mostly continue to be a technology taker, including in low-emissions innovation. In terms of niche areas, this logic is likely to lie behind New Zealand’s public investments in the science of agricultural GHG emissions and in seeking innovative ways to reduce them. Yet efforts to date appear to fall short in depth and scope if New Zealand is serious about its GHG-reduction targets.

Several conclusions follow from the above examination and assessment of how well New Zealand’s innovation system measures up in supporting the transition to a low-emissions economy.

- The investments in the NZAGRC, the PGgRc, and the Global Research Alliance on Agricultural Greenhouse Gases are limited in size and scope.
- New Zealand could be giving significantly more support to other existing areas of strength in its innovation ecosystem that relate to reducing emissions such as materials science and energy. The National Energy Research Institute, for instance, point to improving geothermal generation as worthy of attention (sub. 53). Arguably, increased support in these areas would also reap broader economic returns.
- Opportunities exist to raise the profile of low-emissions innovation in several large science and innovation programmes, and in financing early-stage development by making low-emission innovation a strategic priority. The Auckland Council (sub. 97) and the Morgan Foundation (sub. 127) each argued for a National Science Challenge focused on the deployment of low-emissions technologies and the

⁴⁴ Strategic Science Investment Fund, Investment Plan 2017–2024, p. 8.

transition to a low-emissions economy. The Manufacturers' Network thought that supporting climate change mitigation research could be made a core part of Callaghan Innovation's mandate (sub. 52).

- Even if most new low-emissions technologies that can assist New Zealand to reach its low-emissions targets come from overseas, the identification, dissemination and uptake of them by New Zealand firms can be very slow (Conway, 2016). Information and coordination failures, path dependence and returns to early adopters not commensurate to their risks can all play a role in causing this.

In relation to the last point, New Zealand has no institution that scans internationally for new low-emissions technologies to import and adapt to help New Zealand transition to low emissions. BusinessNZ (sub. 89) noted:

As a technology-taker, with the right diffusion policies, New Zealand can benefit from the rapidly falling costs of new technology especially in the energy sector, and in turn minimise any efficiency losses that might be associated with the early adoption of higher-cost, lower-emissions technology. Currently there is no efficient way for business to peer inside the global new knowledge, research and development 'cupboard'. The Commission might want to look at knowledge and technology transfer tools and approaches that business and universities use to monitor and access knowledge, research and development related to transitioning to a low-emissions economy... (p. 8)

One possibility would be to expand the role of the Global Expert service in Callaghan Innovation. It could actively scan international developments in low-emissions technologies and feed relevant information to New Zealand firms and industry associations. Another potential location for the function would be the unit within New Zealand Trade and Enterprise that promotes foreign investment into New Zealand.

An example of a technology developed offshore (by researchers at MIT in Cambridge, Massachusetts) that could be highly relevant to New Zealand is a new "air breathing" battery that can potentially store large amounts of electricity for months for about a fifth of the cost of current storage technologies (Matheson, 2017). New Zealand's growing dependence on wind and other renewable generation, together with its vulnerability to low hydro-generation capacity in dry years, make this new technology highly relevant.

A possible model for a national agency that scans globally for domestically relevant technologies is Fundación Chile. The non-profit corporation has "a national purpose of delivering high-impact technological solutions through transference, adaptation, research, and development. This demanding task has required [links] with more than 160 international organisations, companies, governments and technological centres, among others, in 35 countries" (World Bank, 2014).

Overall, the current suite of government programmes lacks the strong strategic focus on low-emissions innovation needed for New Zealand to transition to a low-emissions economy with the greatest net benefit. Making the most of available technologies and investing in innovative new technologies will likely not only reduce the emissions price required for the transition; they may also open new economic opportunities for business investments with good returns, high-skill jobs, and profitable export opportunities.

Some of the best opportunities in New Zealand are likely to lie in agriculture. Chapter 10 has an example illustrating the high potential returns – of the order of hundreds of millions dollars annually – if investment in R&D led to a successful vaccine that lowered methane emissions from farm animals by 30%.

Strong support for low-emissions innovations may only need to be temporary. The rationale for public support is technological path dependence and knowledge spillovers. These reduce private returns to investments in new clean technologies relative to their returns to society and are most present when the economy is dominated, as it currently is, by high-emission technologies, skills and infrastructures.

F5.10

Current government investment in science and innovation to support a low-emissions transition lacks a clear strategic focus and priority commensurate with the imperative to succeed in achieving the objective, and to taking bold action. Current investments are inadequate in size and scope.

Strong support for innovation as part of an overall low-emissions strategy would be likely to:

- make more emission reductions possible at lower cost;
- lower the emissions price necessary for achieving target emission reductions;
- create economic opportunities in the form of attractive business investments, highly skilled jobs, and the potential for profitable export opportunities; and
- enhance New Zealand's reputation internationally through developing innovative, low-emissions technologies that help the world as well as New Zealand to reduce GHG emissions.

F5.11

In many areas New Zealand will be a technology taker. From this follows the need for a capacity and resourcing to identify, absorb, adapt and deploy a wide range of technologies from offshore. At the same time, in areas relevant to New Zealand's emissions profile, and areas of existing research strength in climate mitigation, the country should invest in the full menu of basic and applied research, commercialisation, infrastructure and skills.

5.3 Harnessing the full potential of innovation

The twin themes of this chapter are:

- concerted government support for new, clean technologies is required to break the forces of path dependence exerted by the old emissions-intensive economy; and
- an opportunity exists in so doing to boost New Zealand's existing tepid productivity performance to become a more innovative economy with higher productivity growth.

The first theme flows from the analysis by Acemoglu et al. (2012) about technological path dependence and the insufficiently strong private incentives to invest in knowledge and innovation because innovators are not rewarded for positive spillovers from them. When applied to the challenge of shifting from a GHG emission-intensive economy to clean technologies, this analysis points to the need for concerted policy support, at least for a transitional period, until the "clean innovation machine" is self-sustaining in continuing the shift from the existing trajectory.

The second theme flows from innovation being a key driver of productivity growth in advanced economies. New Zealand's innovation and productivity growth performance has been disappointingly low for decades. The quality of New Zealand's policy settings is generally good. For many years this was seen as a paradox. Part of the explanation is geographic – the combination of New Zealand's small market size and its distance from other markets. This combination limits the intensity of competition and weakens international connections – both of which are important for a firm's performance. However, other important parts of the explanation are a firm's investment in knowledge assets (crucial to its ability to benefit from technological diffusion of national and global best practice) and the flexibility of the economy to reallocate people, physical resources and finance from lagging to leading firms (Conway, 2016; de Serres et al., 2014).

Absorptive capacity of firms

The above conclusions emerge from the Commission’s research in recent years about the causes of New Zealand’s slow productivity growth. This research uses comprehensive data on individual New Zealand firms and their characteristics. Harris and Le (2018) have written a recent paper in this research programme. Their paper examines the “absorptive capacity” of New Zealand firms, which refers to the capacity of firms to learn – usually by using knowledge from their external environment – to improve their productivity.

A focus on the innovative capacity of firms is a necessary counterpart to the government’s role in developing an effective national innovation system. Without enough firms with sufficient capacity, good research will not translate to effective solutions and commercial-scale rollout.

This chapter on innovation and low emissions is very much about the absorptive capacity of firms to learn about and use clean technologies. Making the most of new technologies is a major challenge for firms. The research indicates that those firms that actively develop their capacity to adapt and learn are much better placed to benefit from the opportunities that new technologies bring. Three key dimensions of absorptive capacity in firms are “use of external knowledge”, “links with national researchers” and “international cooperation with business”. Markers associated with high levels of absorptive capacity in firms are:

- firms having overseas interests and links (eg, New Zealand multinationals);
- firms that undertake R&D;
- firms that innovate and/or export;
- larger firms; and
- firms employing greater relative numbers of professionals, managers and technicians.

The research concludes that scope exists for policy to improve the absorptive capacity of firms by assisting the firms to improve their internal capabilities. To the extent this succeeds, these firms are highly likely to innovate more, undertake more R&D, and export more – three “drivers of productivity”. Fonterra (sub. 88) notes that capability and limited “knowledge-transfer” resources hinder the widespread adoption of best practice on farms.

When these insights about the absorptive capacity of firms are applied to the challenge of adopting new clean technologies, they suggest the possibility of a double benefit: reduced emissions and improved productivity performance. However, a corollary is that simply providing external knowledge about clean technologies is unlikely to be enough for firms to adopt them – unless these firms have sufficient absorptive capacity.

F5.12

“Absorptive capacity” is the capacity of firms to learn by using knowledge from their external environment. It appears to be a key driver of a firm’s ability to accumulate knowledge assets and raise its productivity. Absorptive capacity is also likely to be important for learning about, and investing in, clean technologies. This suggests a double benefit from better absorptive capacity – reduced emissions and improved productivity.

Policy implications

This chapter emphasises six strands of policy.

- Get emissions pricing right (Chapter 4).
- Place a high priority on public support for creating and adopting clean technologies to change from the path dependence on polluting technologies to a path dependence on clean technologies.

- Strengthen the weaker parts of the national innovation system so that the various parts are aligned and work well together in the transition to a low-emissions economy.
- Help firms improve their absorptive capacity.
- Create and maintain clear and stable policy settings.
- Keep the market environment flexible to allow “creative destruction” to take place, so that resources can flow from firms that lag in adopting clean technologies to firms that lead.

The key overall message is the need for an innovation system geared to the objective of transitioning the economy to low emissions, and for the various complementary parts of that system to be in tune and working well together. Achieving that objective requires not only adequate R&D support for clean technologies, but also finance, skills, knowledge sharing, infrastructure, market conditions and regulatory regimes that are aligned to support the widespread changes needed across the economy to achieve low emissions.

These policy strands lead to the following four recommendations:

R5.2

New Zealand should establish the transition to a low-emissions economy as a high priority within its national innovation system recognising the importance of that goal and that it will require extensive economic transformation and restructuring. The Government should provide major public backing and funding support for innovation so that it can play a central role in the transition, alongside effective emissions pricing.

R5.3

The Government should take steps to:

- strengthen the national innovation system such as by clarifying its low-emissions objectives, and by improving linkages, the identification of relevant innovation opportunities, and knowledge transfer and sharing; and
- align the various complementary parts so they work well together in the transition to a low-emissions economy.

The scope should include not only science and research, but broader innovation, knowledge dissemination and learning, skills, infrastructure, regulation and finance.

R5.4

The Government should investigate and implement any cost-effective institutional models for:

- scanning new low-emissions technologies around the world to identify ones with promise for New Zealand but that may need adapting to suit local conditions; and
- helping firms to improve their absorptive capacity for external knowledge, including new low-emissions technologies.

R5.5

Policy should keep the market environment competitive and flexible to allow “creative destruction” to take place, so that resources can flow from firms that lag in adopting low-emissions technologies to firms that lead.

Lord Nicholas Stern, the author of “The Stern Review” (Stern, 2007) on the economics of climate change and a world-leading thinker in public economics, has written a more recent volume “Why are we waiting? The

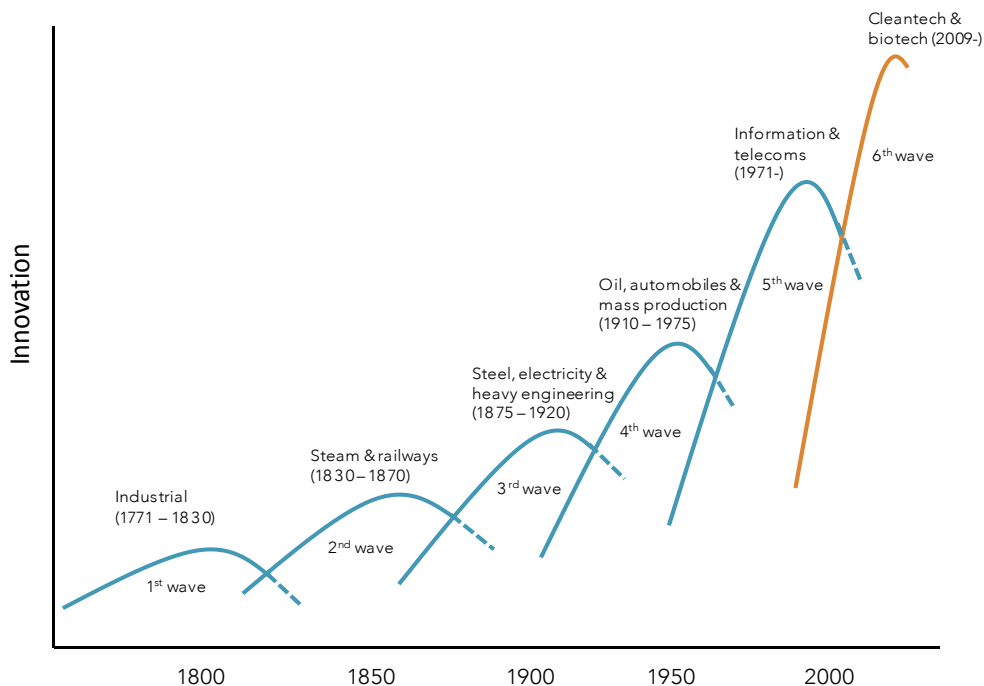
logic, urgency and promise of tackling climate change” (Stern, 2015). Stern is a technological optimist, but emphasises that countries must grasp the opportunities that lie before them.

Stern’s thesis is that the right climate policies are likely to trigger new waves of global investment, innovation, and discovery. If countries design their policies to foster learning and flexibility, then new opportunities will arise. Perhaps, he argues, the urgency of tackling climate change calls for something like the dedicated R&D that occurred to achieve major national goals such as the US Apollo Programme for landing a person on the moon, or the Manhattan Project for developing the atomic bomb partly to allay fears that Nazi Germany would develop it first. The Sustainable Business Council (sub. 31) cites the view that “climate change [is] the largest economic disruption in our lifetimes, as well as the greatest driver of innovation since World War Two” (p. 2).

However, the challenge of reducing GHG emissions also differs in important ways from these programmes. The challenge requires major economic transformation involving billions of individuals and organisations. Stern points to the need for a new Industrial Revolution with energy at its core, to achieve the required reduction in GHG emissions. Yet the transition to low-emissions growth may represent a very attractive path that could, if economic history is a guide, stimulate dynamic, innovative and creative growth. He has in mind a new economic era of innovation based on clean technologies that could be like earlier waves of innovation such as steam and railways; oil, automobiles and mass production; and ICT (Figure 5.6). The new wave is likely to see great opportunities emerge from rapid and innovative developments in, and combinations of, digital, materials, biological and energy technologies.

But, as Stern warns, opportunity is not destiny – dangers exist of lock-in to, and path dependence on, high-emissions technologies and infrastructure.

Figure 5.6 Waves of innovation



Source: A slide in a presentation that Lord Stern gave to launch Stern (2015).

5.4 Conclusion

Innovation can and should play a central role in New Zealand’s transition to a low-emissions economy. It is the closest thing to a “silver bullet” to enable humanity to meet the challenge of avoiding harmful climate change. It also holds out the opportunity for New Zealand to combine the transition to low emissions with dynamic and creative improvements in national wellbeing.

While the form, timing and impact of innovation are highly uncertain, a country’s policies and institutions significantly affect its innovation performance. They need to enable and encourage researchers and business

organisations to both create new low-emissions technologies and deploy existing low-emissions technologies.

It will be important to align all parts of the innovation system so they work well together in the transition to a low-emissions economy. Some parts are currently weak. The following parts of the system are priorities.

- The seriousness of the climate-change threat justifies all developed countries, including New Zealand, devoting serious attention and resources to it within the publicly funded parts of their national innovation systems. New Zealand can and should do more in this regard.
- The Government should take cost-effective actions to improve the absorptive capacity of firms, provide skills training to complement new technologies, and establish a mechanism to scan for emission-reducing technologies around the world that are suitable for New Zealand to adapt and deploy.
- Policy should maintain a flexible and adaptable economy to facilitate resources moving from high-emissions activities to low-emissions activities.

The upside of a transition to low emissions is that doing so may represent a very attractive path that could, if economic history is a guide, stimulate dynamic and creative economic growth. Well-designed climate policies can unleash a new wave of innovation and create an era of economic opportunity and wellbeing.

6 Investment

Key points

- Transitioning to a low-emissions economy requires a major re-orientation of public and private investment away from emissions-intensive activities and towards those that support and catalyse low-emissions energy, land use and other activities.
- Sufficient capital is available to meet low-emissions goals, but it is fundamentally about *redirecting* that capital to investments consistent with the transition. Investors will be motivated to respond to the challenge of climate change where it offers a strategy to avoid risk, to pursue profit opportunities, and as a means to achieve goals related to socially responsible investment.
- Stable and credible climate policy, underpinned by enduring institutional arrangements such as effective emissions pricing, provides a critical basis for a well-functioning investment system. This will likely be enough to enable certain types of investments, such as green bonds or commercial equity investments, to occur.
- Yet additional barriers to low-emissions investments do exist and require attention. These include information and inertia barriers, coordination failures, technology and market risks, and scale of investment barriers. Stable and credible climate policy will partly resolve these barriers, but is unlikely to be sufficient. This is because of the disconnect between standard commercial decision making and the public interest in avoiding dangerous climate change. In addition, the role of government in providing direct financial support for low-emissions investment is likely to be higher at the beginning of the transition while other policies (such as emissions pricing) take effect.
- Introducing mandatory climate-related financial disclosures is the most important action the Government can take to encourage investment that supports the transition to a low-emissions economy. These disclosures are vital as they act against investors incorrectly valuing assets or investment opportunities, resulting in misdirected finance or stranded assets. The Commission recommends that the Government should officially endorse the recommendations of the Task Force on Climate-related Financial Disclosures and work to incorporate mandatory disclosure into existing regulatory instruments.
- Other actions for Government include targeted grants and loans (which can play an important catalytic role in reducing market risk for the development and deployment of low-emissions technology), and further elaboration of the details of the proposed Green Investment Fund. Other opportunities are less clear-cut. Feedback is sought on whether the New Zealand Venture Investment Fund should identify low-emissions investments as a sector of interest.
- Finally, the Commission recommends developing a low-emissions investment strategy for New Zealand. A strategic view across public-sector interventions is important to accelerate progress in a coordinated and non-duplicative manner, as well as providing clarity about the role of government at different phases of the transition.

This chapter examines, and makes findings and recommendations about the risks and opportunities for investment supportive of the transition to a low-emissions economy. It details particular types of investment opportunities, such as equity and debt finance, government initiatives (such as government-backed investment banks and funds), and climate-related financial disclosure requirements. It also examines the role of other supportive actors for the transition (such as institutional and Māori investors). The chapter concludes with a recommendation to develop a low-emissions investment strategy for New Zealand to ensure aligned, clear, and well-targeted investment that supports the transition to a low-emissions economy.

6.1 Mobilising the investment needed for the transition

Transitioning to a low-emissions economy requires a re-orientation of public and private investment away from high-GHG intensive activities and towards those that support and catalyse low-emissions energy, land use and other activities.

Transitioning to a low-carbon and climate-resilient economy will require clear and stable climate policies, targeted public climate finance and well structured financial instruments to catalyse a major shift of private capital investment. Limited public funds need to be used efficiently to overcome barriers and to mobilise the power of market forces to support climate action. Domestic policy reform is essential to level the playing field, expand low-carbon and climate-resilient investment opportunities, and to help to manage the risks and increase the returns for investors. (OECD, 2012a, p. 1)

Financial flows can stimulate the transition by supporting investment into low-emissions activities or infrastructure (eg, electric vehicle (EV) charging networks). It can also promote innovation, and research and development (R&D), by firms into technologies that are too risky a proposition for traditional investors. The latter is particularly relevant given the core role of innovation as a driver of a low-emissions economy (Chapter 5). Box 6.1 explains what is meant by climate finance in the context of this report.

Box 6.1 Climate finance

Climate finance broadly refers to the “flow of funds used to help countries to cut their emissions and adapt to climate change” (Curran, 2016).⁴⁵ These funds may originate from public or private-sector sources, or a mix of both (also known as blended finance). Climate finance can be understood as a subset of green finance. Although “green finance” has no commonly agreed definition (Lindenberg, 2014), it also includes finance supportive of other environmental goals such as biodiversity preservation.

The Organisation for Economic Co-operation and Development (OECD) identifies two main investment challenges for the transition to a low-emissions future:

- scaling-up finance for long-term investment in infrastructure; and
- shifting investments towards low-emissions alternatives (OECD, 2015a).

The scale of the challenge

Globally, the amount of investment required to address climate change is immense. The International Energy Agency (IEA, 2016d) estimates that in order to have a 50–50 chance of limiting warming to 2°C, investments of US\$40 trillion to meet energy needs, and US\$35 trillion in energy efficiency, will be required globally by 2040. The IEA also estimates that fossil fuels will need to drop from three-quarters of the world’s energy mix to one-third by 2040. This represents a major movement of investment away from fossil fuel generation that will also have substantial flow-on implications for all other sectors of the economy.

Sufficient capital exists to achieve emissions reductions goals. It is fundamentally about *redirecting* that capital to investments consistent with the transition to a low-emissions economy.

There is no shortage of available capital. The challenge for governments is to ensure that public policies and investment conditions facilitate a re-allocation of investment from high-carbon to low-carbon and climate-resilient (LCR) options. It is only by such a re-allocation that we can get on a global emissions trajectory to meet the 2°C target. (OECD, 2015c, p. 5)

For example, Professor Geoffrey Heal (2018) calculates that the investment required to transition the entire US energy market away from fossil fuels (approximately \$US37.6 billion a year) is less than the existing capital expenditure on electricity capacity (US\$42 billion a year).

⁴⁵ Because of the focus of this inquiry on New Zealand’s domestic transition to a low-emissions economy, this chapter does not discuss international climate finance (funds from developed to developing countries, as required under Article 9 of the Paris Agreement).

Despite New Zealand's high proportion of renewable electricity and the concomitant smaller need for significant new low-emissions energy infrastructure, other types of infrastructure will be needed for the transition, such as the transport and logistics networks of a greatly expanded forestry sector (Chapter 10). Investment must also be available to enable New Zealand to respond to trends in shifting global markets, and to develop new, low-emissions goods and services to replace those that are no longer feasible as consumer preferences, costs and types of inputs change.

It is important to direct investment away from high-emissions activities

Investment contrary to the transition to a low-emissions economy is problematic because it serves to slow the transition's speed and effectiveness. While the amount of climate-aligned investment is large and growing, it is still far outpaced by fossil fuel-intensive investment (Amin et al., 2014). This is due to market forces and regulations collectively favouring such investments, though often unintentionally (OECD, 2015a). The UK's Environmental Audit Committee (2014, p. 3) notes that stock markets are "currently over-valuing companies that produce and use carbon", creating substantial risk for the transition (section 6.2).

Large investments in fossil fuel exploration, or major pieces of equipment that require fossil fuel energy (such as coal-fired boilers or diesel trains) have long lifespans and are particularly important to discourage so as to minimise the risk of high-emissions lock-in and stranded assets. These are risks facing individual companies, but they also have consequences for the whole of the economy. As former New Zealand Super Fund (NZ Super Fund) Chief Executive Adrian Orr notes, carbon is "mis-priced globally" and, by continuing to invest in emissions-intensive activities, it would expose the Fund to "undue risk" (Orr in Coughlan, 2018).

Taken together, the myriad smaller investments by individuals via channels such as pension funds are also relevant and worth considering. For example, over \$40 billion worth of assets were invested in KiwiSaver in 2017 alone (FMA, 2017). Directing even 1% of this amount away from high-emissions to low-emissions investment could make a substantial difference towards the amount of finance available for the transition.

6.2 Why are investors interested in a low-emissions economy?

The transition to a low-emissions economy requires a major shift of capital. Three main reasons explain why investors will be motivated to change their decisions: risk, opportunities, and social conscience.

Risk

For investors, and the wider finance sector as a whole, "climate-related risk is a real financial risk" (Silk, 2017). Two main risks are relevant to the relationship between investment and climate change: physical risk and transition risk (TCFD, 2017).

Physical risk

In New Zealand, as in the rest of the world, climate change will increase the costs relating to weather events (ICNZ, 2014). For example, the 20cm observed rise in sea level since 1950 directly increased losses caused by Hurricane Sandy by 30% in New York alone (Lloyds, 2014).

Physical risk can have diffuse economic impact. Insurance premiums will rise where climate change is expected to increase risk and in the future, insurance companies may no longer insure high-risk properties or activities, such as coastal property where flood risk is elevated (Storey et al., 2017). Subsequent asset devaluation related to weather-related damage, or uninsurable property, influences household wealth or firm profitability. Banks that lose such assets as loan collateral may also restrict future lending (Bank of England, 2017).

Transition risk

Transition risk refers to the risks arising from the adjustment process towards a low-emissions economy (Bank of England, 2017). Two key transition risks are apparent. First, as noted above, is the risk of stranded assets. This includes the subsequent risk to overarching financial stability objectives if large-scale asset revaluation occurs more quickly than firms or industries are able to adjust (Carney, 2016).

A key issue relating to stranded assets and transition risk is what is known as “unburnable carbon” or the “carbon bubble”. This is the amount of fossil fuel reservoirs unable to be used if countries’ emissions targets are met. Globally, between 60% and 80% of the coal, oil and gas reserves of publicly listed companies cannot be used to have an 80% chance of limiting peak warming to 2°C (Carbon Tracker, 2013). Despite its relatively high proportion of renewable electricity, this is still a substantial issue for New Zealand for two main reasons. First, many public-sector activities and investments currently include or rely upon fossil fuels. This has implications for the ability of the public sector to help to finance the transition. Second, as outlined above, fossil fuels are ubiquitous across society. Any firm or organisation whose business model relies upon fossil fuels, or products manufactured out of fossil fuels (such as all plastics), will be impacted.

The second transition risk is “liability risk”, where those suffering losses due to climate change (either from its physical effects, or decisions made about the transition to a low-emissions economy) seek financial compensation. Climate-related litigation has increased sharply in the last decade (Nachmany et al., 2017). A recent example is that of New York City which has filed a claim against several major fossil-fuel companies such as BP and Exxon Mobil. The claim argues that despite these firms having “full knowledge that fossil fuels would cause catastrophic harm”, each firm “decided to continue its conduct and commit itself to massive fossil fuel production” (*New York City v BP plc et al.*, 2018, p. 34).

Another issue relating to liability risk is disclosure of activities or assets. If an investor considers that a business or entity did not provide adequate information regarding its exposure to climate change risk, it may also make a claim (see section 6.5 for more on disclosure).

The key factors driving transition risk are the speed and scale of the transition. A stable, long-term transition is likely to reduce transition risk. This is because it allows investors to make more informed decisions that better take into account factors such as anticipated emissions price trajectories. Avoiding an abrupt transition is vital to ensuring financial stability (Bank of England, 2017).

Opportunities

Realising a low-emissions economy offers the potential to create new business opportunities. For example, the International Finance Corporation (IFC, 2016) estimates that approximately US\$23 trillion worth of climate investment opportunities are possible in emerging markets from 2016 to 2030.

Capturing competitive advantage, particularly in higher-value areas where customers may be willing to pay a price premium for climate-friendly products or services, or which will not incur emissions penalties, will likely result in substantial investment returns. This also has flow-on effects in terms of government revenue arising from a vibrant private sector supportive of a low-emissions transition. Already, businesses actively engaged with climate change show superior profitability. Research by the charity CDP (2014) found such companies achieved a 67% higher return on equity and higher shareholder dividends than non-engaged companies.

Socially responsible investment

Finally, social responsibility and altruism can drive low-emissions investment. An approach based on socially responsible investment (SRI) involves individual, firm or institutional investors, for ethical reasons, being unwilling to invest in, or divesting from, activities contributing to climate change. This is similar to avoiding investment in or to divest from tobacco or munitions, as practised by the Accident Compensation Corporation (ACC) and the NZ Super Fund (ACC, 2017; NZ Super Fund, 2017).

While divestment from fossil fuels is argued by some to be necessary (Auckland Council, sub. 97; NZ Church Climate Network, sub. 121), new types of SRI involve a more proactive approach known as environmental, social and governance (ESG) investing. This involves investors employing shareholder influence to, for example, work with firms to help them move away from reliance on fossil fuels or other high-emitting inputs. This contrasts with complete divestment, which is increasingly being seen as a less effective mechanism to encourage behaviour change. Recent research shows that firms that take account of ESG issues are more profitable and trade at a premium compared to rivals that do not (BCG, 2017). This type of SRI is increasingly seen in New Zealand. For example, the NZ Super Fund (2018) clearly states that it considers engagement as “a key tool for managing carbon emissions and risk exposure” in their passive portfolio.

6.3 A well-functioning investment system

To mobilise the investment needed to support the transition to a low-emissions economy, two elements provide a critical foundation underneath an overarching framework of climate policy settings that are “coherent, consistent and credible” (Matikainen, 2017a, p. 9):

- institutional arrangements that act as an enduring commitment device for decision-making (Chapter 7); and
- an effective emissions pricing regime (Chapter 4).

A foundation of stable and credible climate policy is vital. It enables investors to confidently expect that emissions reductions policies will actually be implemented as planned (Amin et al., 2014).

Enduring institutions help by providing clear information on the direction of travel, as well as by fostering greater awareness of, and investment into, low-emissions activities (NZ Carbon Farming, sub. 95). Long-term commitment devices are particularly important due to their role as a signalling mechanism for investment decisions. In a nutshell, “any actions that Government can take to remove instability and risk, and increase certainty about rewards will assist investors” (Environment Audit Committee, 2014, p. 8).

An effective emissions price is also needed to divert investment flows towards low-emissions activities (Guardians of NZ Superannuation, sub. 32). Without a price for the negative emissions externality, the risk-return profile is unattractive for low-emissions activities as compared to high-emissions activities (that are not facing the true cost of their actions). An effective emissions price therefore provides a strong incentive to shift towards investments that do not incur an emissions penalty, as well as clearly signalling to the investor community which activities are likely to remain viable (or not) over time. In essence, emissions pricing is necessary to provide a financial system that correctly values climate risk.

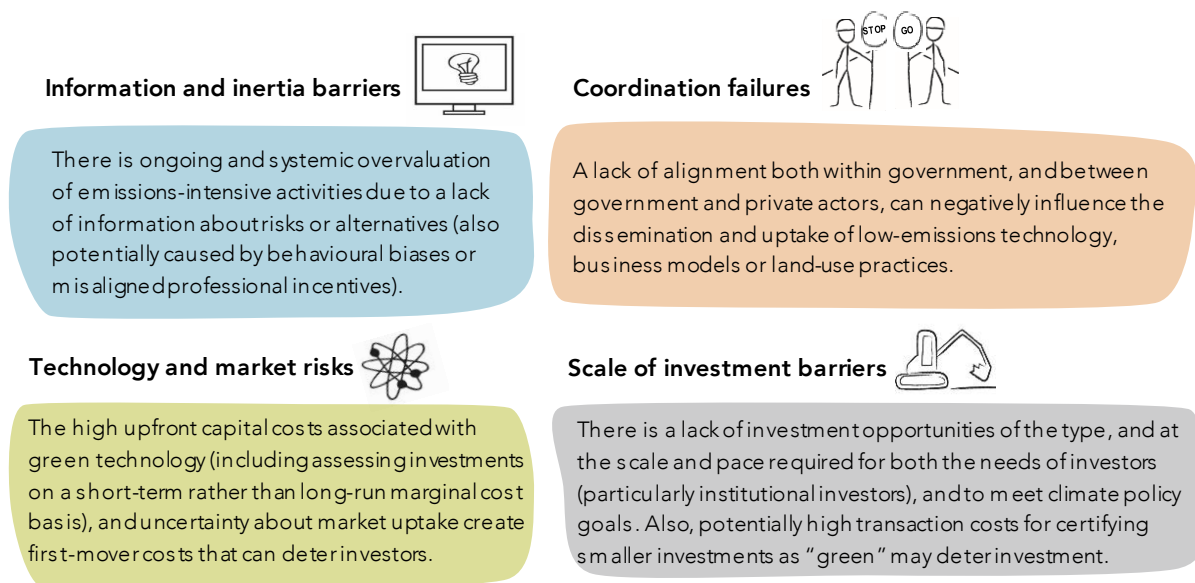
These core elements are vital to help to offset the nature of climate change as a “tragedy of the horizon” (Carney, 2016, p. 2). Capital markets have significantly shorter time horizons than necessary for the transition to a low-emissions economy. This includes the problem of the short-term focus of financial analysis not being able to shed adequate light on long-term risks, and a lack of a long-term time horizon when making corporate disclosures (2° Investing Initiative, 2017a, 2017b). Enduring commitment devices, and an effective emissions price, help to signal where investment may be most effectively directed over the longer term. They can help to create a new path dependency centred on low-emissions activities and technologies, as well as to foster investment into social and natural capital to achieve long-term goals (Te Rūnanga o Ngāi Tahu, pers. comm. 26 March 2018).

In general, New Zealand benefits from a positive macroeconomic and regulatory environment. However, historic uncertainty about climate policy settings, as well as policy decisions that have resulted in an ineffective emissions price, have not been conducive to encouraging private investment into low-emissions firms and activities at the scale required.

6.4 Additional barriers to low-emissions investments

The OECD (2015a, 2017c) argues that while coherent climate policy (including effective emissions pricing) provides a necessary foundation, it is not sufficient to effectively transition to a low-emissions economy. Figure 6.1 describes additional barriers to the investment required to support New Zealand’s transition. These do not represent a failure of business, but more that there is a disconnect between standard commercial decision-making and the public interest of avoiding dangerous climate change.

Some of these barriers are not unique to low-emissions investments. Many high-technology investments are riskier than existing technologies, and misaligned policy objectives can serve to discourage investment in numerous sectors, not just in relation to climate change. It will be important that any government intervention does not unnecessarily duplicate activities with different mandates. Thinking strategically across the economy also offers an opportunity to enable a decision-making framework that enables social, cultural, environmental and economic benefits to be quantified or comparatively assessed (Te Rūnanga o Ngāi Tahu, pers. comm. 26 March 2018).

Figure 6.1 Barriers to investment required to support New Zealand's transition

Barriers may also change over time. Investors may be hesitant to invest if they are uncertain about the durability of newly enacted climate laws or institutions. Equally, emissions prices will take time to increase to a level effective for driving significant investment change. Therefore, a stronger justification for additional government support in the short term to stimulate the required investment in certain areas is likely.

Public interventions in support of green investments should ideally be designed to plug gaps within the private sector financial market. However, whilst determining the exact size of these gaps is important it is difficult to do as the maturity and capacity of financial markets change. If levels of support are set too high, they can lead to moral hazard. If not closely managed both in terms of objectives as well as appropriate phasing out, public interventions can also lead to broader market distortions. (Amin et al., 2014, p. 22)

The key question for Government is how to respond to these barriers, given that the transition to a low-emissions economy is a priority public policy issue. The Government must also aim to focus on the additional investment gap that stable policy supported by enduring institutional arrangements and effective emissions pricing are unlikely to meet. In response, governments have two main options. They can:

- create policy to provide clearer signals or a more supportive underlying framework (eg, via regulations that encourage better understanding of climate risk); and/or
- use their own funds to directly support the transition to a low-emissions economy (Environment Audit Committee, 2014).

The following section examines four key types of financial and investment instruments relevant to the transition to a low-emissions economy, and assesses their potential in the New Zealand context.

F6.1

The fundamental role of government in ensuring adequate investment for the transition to a low-emissions economy is to provide a stable and credible climate policy underpinned by enduring institutional arrangements, and effective emissions pricing.

However, while necessary, these may not be sufficient. To enable an effective transition, these credible and consistent settings need to be complemented by other interventions specifically addressing information and inertia barriers, coordination failures, technology and market risks, and scale of investment barriers.

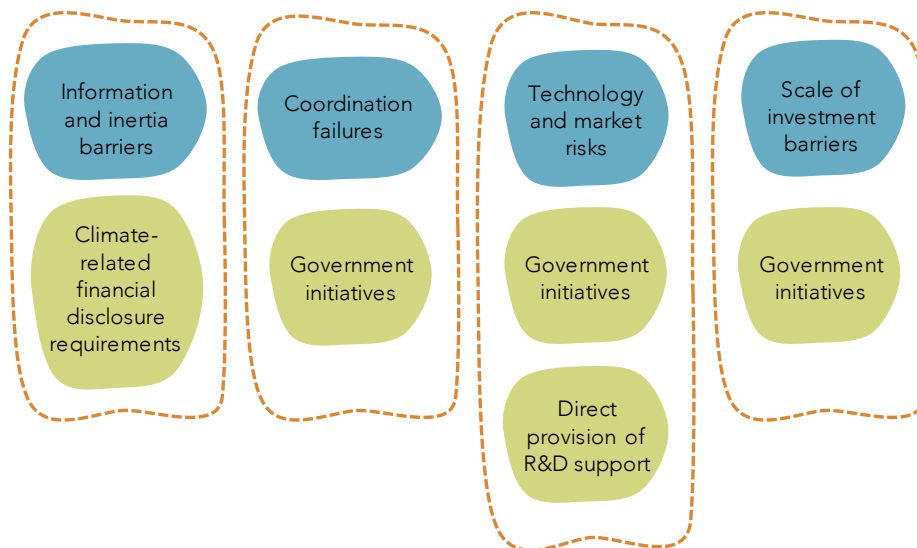
6.5 Key investment opportunities

In response to the identified barriers to low-emissions investment, complementary measures will be required to mobilise finance at the scale and speed required to stimulate New Zealand’s transition to a low-emissions economy. The international literature identifies four broad categories of financial instrument or policy as having the greatest potential to encourage low-emissions investment. The four categories are:

- equity finance;
- debt finance (including green bonds);
- government initiatives (including early-stage equity financing, green banks, guarantees, and grants and loans); and
- climate-related financial disclosure requirements.

The subsequent sub-parts of this section examine these four main categories and assess whether policy reform for each is required in the New Zealand context. Figure 6.2 provides a summary of the policy measures likely to be the most effective in catalysing necessary levels of investment in New Zealand to support the transition to a low-emissions economy (the direct provision of R&D support is examined in Chapter 5, and so is not discussed further here).

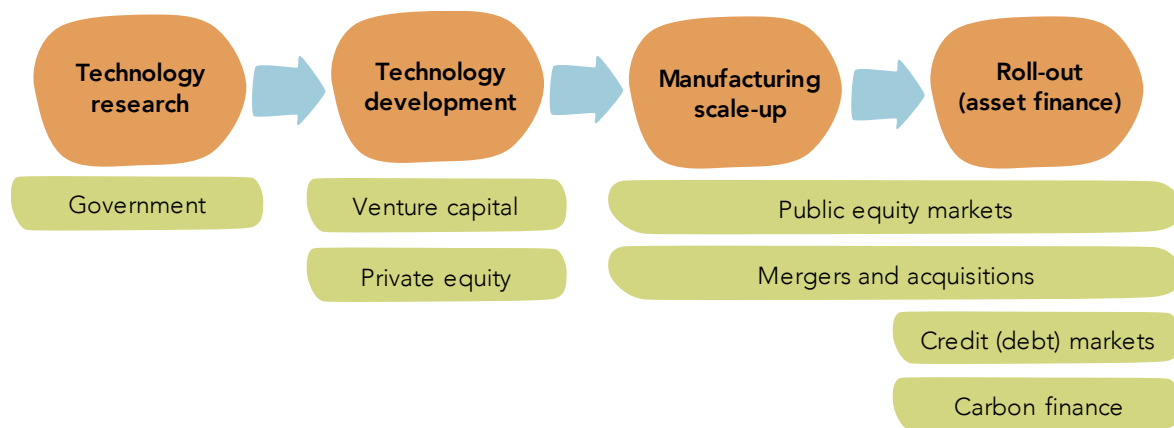
Figure 6.2 Barriers to low-emissions investment and key related domestic policy measures requiring reform



Equity finance

Equity finance is where a permanent share in the ownership of a firm or a project is offered for sale to raise funds to carry out an activity, with investors sharing in the future profits of the firm or project. Two key channels to raise equity finance are privately raised funding (such as venture or angel capital) and publicly raised funding (such as a listing on the stock market).

Climate finance often invests in what is known as junior equity, which is riskier than other types of equity because it is the last to be paid out in the event of liquidation. The intent of this choice is to lower the overall level of risk for other investors who can buy less-risky types of equity (such as preferred stock) (UNEP, 2014). Equity finance is also particularly important for developing and deploying low-emissions technologies. Figure 6.3 shows the prevalence of equity finance at nearly all stages of the technology development process (noting that this linear model of technology development is highly stylised).

Figure 6.3 Mapping sources of financing to stages of low-emissions technology development

Source: Patel (n.d.).

In New Zealand, an estimated \$88.6 billion worth of equity assets taking an ESG approach was under management by the end of 2016 (D. Hall & Lindsay, 2017). Key barriers to firms being able to secure adequate levels of equity finance for low-emissions investments throughout their lifecycle include “the scale of New Zealand’s investment community, its priorities and/or appetite for risk, or a combination of both” (D. Hall & Lindsay, 2017, p. 42). Further climate-aligned equity investment in New Zealand will be driven by:

- more climate-aligned firms emerging and seeking equity finance in response to economy-wide climate policy (ie, an effective emissions price and enduring institutional arrangements);
- banks or other entities making ESG-aligned funds invested in New Zealand equities increasingly available (largely for profit-making reasons, and again, as a result of stable climate policy settings);
- disclosure requirements, such as the reporting requirements laid out in the NZX Corporate Governance Code (see the section on climate-related financial disclosure below); and
- public-sector equity funding incorporating a low-emissions mandate into their funding decisions, particularly at the early stage of the equity financing process, to overcome both technology and market risks, and coordination failures between investors and low-emissions technology development (see the section on government initiatives below).

Debt finance

Debt financing refers to funds that a public or private sector organisation borrows to carry out an activity, and which they repay to the lender with interest. As with equity finance, different levels of risk are available if the organisation defaults (ie, is unable to pay back its creditors). For example, “senior” debt is paid out before “subordinated” debt, and climate-focused investors can target subordinated debt to lower the overall level of risk so that other investors are more likely to invest.

Similar to equity finance, debt financing may be raised via private or public channels. Privately raised debt financing generally takes the form of loans (eg, from a commercial bank); publicly raised debt financing most commonly occurs via the issuance of bonds.

Green bonds

So-called “green bonds” are an increasingly prevalent type of debt financing where proceeds go towards financing projects relating to climate change or other environmental activities (OECD, 2017d) (see Box 6.2 for a discussion of what makes a bond “green”). Green bonds are most commonly issued as a full recourse

debt security, but can take other forms – such as non-recourse revenue bonds, project bonds or securitised bonds (Russell McVeagh, 2017).⁴⁶

Box 6.2 What makes a bond “green”?

Defining a bond as green signals to investors its legitimacy in contributing towards the transition to a low-emissions future. While “green bond” has no agreed legal definition (Russell McVeagh, 2017), the investor community currently has two options to apply the label green to a bond.

- The first option is the Green Bond Principles – voluntary guidelines (developed by the banking industry) that define broad categories of eligible projects, such as renewable energy and biodiversity conservation, and also focus on transparency and disclosure (ICMA, 2017).
- The second option is the standards developed by the Climate Bonds Initiative – a charity that supports a certification scheme for green bonds. Eligible categories include renewable energy, public transport and low-carbon buildings (Climate Bonds Initiative, 2017b). These standards are considered to be more stringent than the Green Bond Principles because external review of bond eligibility is mandatory rather than voluntary. Such bonds may also be called “certified climate bonds” (D. Hall & Lindsay, 2017).

In 2017, US\$895 billion worth of bonds (representing approximately 1% of the total global bond market) were broadly categorised as “climate-aligned” (ie, financing low-carbon and climate resilient assets or projects). Of these, US\$221 billion were officially certified as green by the Climate Bonds Initiative (Climate Bonds Initiative, 2017a).

The global green bond market began in 2007 and is growing rapidly. In recent years, most green bonds have been corporate-issued, including by commercial banks. However, the majority of the total green bond amount outstanding comprises sovereign or sub-sovereign bonds (Climate Bonds Initiative, 2016, 2017c). Another new type of public-sector green bond gaining traction are environmental impact bonds operating on a “pay-for-success” model (Khalamayzer, 2017). These are public bonds that provide funding for activities such as new infrastructure, and can be understood as a “form of performance-based contracting that ensures governments limit their losses in case projects are unsuccessful, which encourages them to try novel solutions like green infrastructure” (EESI, 2017).

The nascent green bond market in New Zealand is also expected to grow despite no officially labelled green bonds or certified climate bonds yet being issued in New Zealand (Ruth, 2018). In 2017 the IFC launched a 10-year fixed-rate Green Kauri \$125 million bond sale with a yield of 3.7%. However, this bond is considered to be foreign-issued (D. Hall & Lindsay, 2017).

Other green bond-related activity in New Zealand includes 6% (approximately \$72 million) of ANZ’s green bond asset pool (ANZ, 2016). In 2017, Contact Energy launched a green borrowing programme, including wholesale and listed retail bonds to support investment in renewable energy. The programme is based on approximately \$1.8 billion of eligible geothermal assets in the Waikato and Taupō (Contact, 2017). Auckland Council also plans to establish a green bond programme and intends to issue green bonds in 2018 as part of its ongoing borrowing programme to support infrastructure development (Auckland Council, 2018).

Internationally, most green bonds support renewable energy or energy efficiency (eg, in buildings) (ANZ, 2016). It is likely New Zealand-issued green bonds will also follow this trend. Of greater relevance to New Zealand’s low-emissions transition are green bonds relating to land use. While global green bond activity in this area is minimal, an environmental impact bond based on forestry is currently being investigated in New Zealand (D. Hall & Lindsay, 2017).

⁴⁶ Full recourse means that no matter what happens, the borrower will repay the debt. Revenue bonds are backed by revenues from specific projects or sources, and non-recourse means that if the revenues cease, bondholders do not have a claim to the underlying source of the revenue. Securitised bonds are pools of financial assets created by intermediaries such as banks.

Several barriers to scaling up the green bond market have been identified at an international scale (Jun et al., 2016; OECD, 2015b). Table 6.1 assesses these barriers in the New Zealand context.

Table 6.1 Barriers to the scaling up of the green bond market in New Zealand

Barrier	New Zealand-focused assessment
General bond market challenges	The New Zealand bond market, and especially the domestic corporate bond market, is small by international comparison, and has a limited range of instruments (IMF, 2017). However, the New Zealand Stock Exchange (NZX) debt market has recently seen a large increase in capital value (mostly from the issuance of six Local Government Funding Agency bonds in 2015).
Limited awareness of green bond and existing international standards	New Zealand is experiencing an “increasing demand” for green financial products (NZX Ltd, sub. 101, p. 1). In late 2017 the NZX released updated guidance on green bonds in an effort to “support the development of green financial products” in New Zealand (NZX, 2017, p. 15). This guidance includes information on the Green Bond Principles and Climate Bond Initiative Standards. The NZX is also “currently considering options to promote listed green bonds” (NZX Ltd, sub. 101, p. 2). Market participants sharing their experience with green bonds will play an important role in fostering confidence in the nascent green bond market.
Lack of local green bond guidelines or definitions	No evidence suggests that existing international guidelines and standards are insufficient (or will likely become so) in New Zealand. However, the NZX is assessing whether it “should have a role in the certification process” for green bonds (NZX Ltd, sub. 101, p. 2). This work may uncover whether additional definitions or requirements may be needed specific to the New Zealand context.
Costs of meeting green bond requirements	The cost to obtain third-party assurance for a green bond ranges from approximately \$14 000 to \$140 000 (Jun et al., 2016). This cost may hinder smaller-scale green bond activity in New Zealand. But as green bonds become more commonplace, verification costs are likely to decrease over time.
Lack of green bond ratings, indices, and listings	No green bond ratings, indices or listings are specific to New Zealand. However, many international examples exist that include bonds issued in New Zealand dollars (eg, the Bloomberg Barclays MSCI Green Bond Index or the S&P Green Bond Index). The minimum issue size to be included in these indices is relatively large (from \$250 million), so may exclude some smaller activities.
Lack of supply of labelled green bonds	Lack of supply can often be traced to an inadequate pipeline of projects due to uncertainty about long-term governmental commitment to low-emissions development. More ambitious and stable climate policy in New Zealand would likely encourage more eligible projects seeking finance.
International investors unable to enter the market	Given the recent entry by the IFC into the New Zealand market, global green investors seem able to access the New Zealand market. This is likely due to the adoption in New Zealand of international standards for green bond definitions and disclosure requirements.
Lack of domestic green investors	Investors with capacity to analyse green investments are required to stimulate the green bond market. These are likely to be institutional investors with a preference for green assets. The shift towards low-emissions investments by large investors such as the NZ Super Fund (Guardians of NZ Superannuation, sub. 32) will reduce this barrier.

Source: Jun et al. (2016); OECD (2015b).

Based on the above analysis the two key actions required to scale up the green bond market in New Zealand are to promote the ongoing growth of the New Zealand bond market in general, and for market participants to share information about experiences with, and future availability of, green bonds. The Commission does not consider that specific government intervention into the New Zealand green bond market is required. Understanding more about the potential for green bonds in relation to land use may however be useful.

F6.2

The green bond market has the potential to accelerate the transition to a low-emissions economy. However, the market is growing independent of government assistance. So, the Commission does not consider that specific government intervention into the New Zealand green bond market is required.

Government initiatives

A potential major role for Government in the transition to a low-emissions economy is to provide support that “de-risks” projects for other, private-sector, investors, such as by providing cornerstone investments or credit enhancements (Matikainen, 2017a).⁴⁷ These interventions can crowd in further investment by reducing the cost of capital. Alternatively, they may exist as standalone instruments, or be part of blended financial offerings over different stages of a project’s lifecycle. Government involvement can also reduce the perception of risk of particular projects, even where no actual co-funding is provided.

Updating the investment policy of the New Zealand Venture Investment Fund

The New Zealand Venture Investment Fund (NZVIF) aims to help build a vibrant early stage investment market by providing start-up capital to New Zealand technology companies. It has two main funds:

- the NZVIF Venture Capital Fund invests in privately managed venture-capital funds, which then invest into New Zealand-originated technology companies; and
- the Seed Co-investment Fund directly invests into young technology companies alongside selected angel investor groups.

The NZVIF operates at the early stage of the investment market to reduce risk and help to crowd-in additional private sector finance. This makes it a suitable candidate for meeting the investment needs of low-emissions technology development. However D. Hall and Lindsay (2017) estimate that only five of the 241 companies that NZVIF has invested in since establishment might be considered as low-carbon investments.

The NZVIF excludes certain investments (such as in property development, retail, mining and hospitality), but does not have any priority investment sectors (MED, 2009). However, it is feasible that its investment policy could be “updated to identify low-emissions investments as a sector of interest in line with national interests” (D. Hall & Lindsay, 2017, p. 58). For example, this could entail identifying low-emissions investments as a priority category of investment within each of its funds, or specifying a target percentage of NZVIF investments for each investment period into climate-focused firms.

Q6.1

Should the investment policy of the New Zealand Venture Investment Fund be updated to identify low-emissions investments as a sector of interest?

Green investment banks

Government-backed investment banks or funds are well-established forms of public support for infrastructure development. More recently, institutions (such as the European Investment Bank) have identified climate change as an investment priority (EIB, 2017), and governments have also established specialist climate-related funds. These “green” investment banks or funds (referred to here as GIBs) tend to invest in the broad areas of renewable energy, energy efficiency, or low-emissions technology. A number of financing approaches exist, including equity and debt finance, as well as loans and guarantees (OECD, 2016a).

Internationally, approximately US\$93 trillion in infrastructure investment is required within the next 15 years to meet global infrastructure needs consistent with the transition to a low-emissions economy (OECD, 2015c). For developed countries such as New Zealand, this mostly comprises replacing existing ageing infrastructure with new, low-emissions infrastructure (such as for electricity generation and distribution, or related to buildings or water). The key rationale for GIBs to facilitate this type of investment is that governments can efficiently use public capital to mobilise substantially greater quantities of private capital to overcome the scale of investment barriers encountered by major infrastructure projects (Energy Management Association of New Zealand, sub. 70; Auckland Council, sub. 97; Generation Zero, sub. 119).

⁴⁷ This section focuses on the role of central government. However, cities can also play an important role in financing the transition (Billington et al., 2017).

However, governments must do this in a way that does not crowd out private investment. This specific mandate to scale up and catalyse investment that would not have happened otherwise allows GIBs to

use targeted approaches and tailored financial structuring to address the lack of suitable LCR [low-carbon and climate resilient] investments with attributes sought by private investors (e.g. through aggregation of small-scale investments like residential rooftop solar PV investments or energy efficiency retrofits in commercial buildings). (OECD, 2015c, p. 12)

GIBs can also help to:

- provide objective information, data and skills to the market to assess investment opportunities;
- increase market confidence through reducing real and perceived investment risk; for example, by virtue of their expertise and vetting processes (and doing so more effectively and quickly than traditional government programmes); and
- reduce overall financing costs (by demonstrating investment profitability to crowd in further private sector investment) (Matikainen, 2017a; OECD, 2015c).

GIBs can be tailored in many different ways. They can meet several policy goals: they can solely focus on helping to meet emissions reductions targets, or have additional mandates such as job creation. GIBs may be required to be profitable, and can also operate according to a variety of institutional structures. For example, the UK's Green Investment Group was established and capitalised by the UK Government in 2012 (as the Green Investment Bank), but was privatised in 2017. Australia's Clean Energy Finance Corporation is an independent government institution managed by a board with statutory decision-making responsibility.

GIBs may also be funded in numerous ways (such as by emissions pricing revenues, appropriations, bond issuances, or utility bill surcharges) and can pursue a "wholesale" or "retail" strategy. A wholesale strategy "aims to attract relatively large amounts of private capital to combine with public capital for on-lending or investing in funds". A retail strategy "involves delivery of funds to the project developer or individual" (OECD, 2015c, p. 12). A wholesale strategy is useful for enabling very large-scale investments; a retail strategy can help to stimulate activity in new markets.

GIBs are normally established in countries lacking national development banks or other institutions that actively encourage domestic green infrastructure or clean technology development (OECD, 2015c). At present, New Zealand has no equivalent bank or fund, and no international GIBs are operating that could provide finance of this nature to New Zealand-based projects.

However, establishing a GIB is a major policy decision. The OECD (2016a) provides a detailed checklist for policymakers on the rationale for a GIB (as opposed to, or working in conjunction with, other options to mobilise additional private finance to assist the transition to a low-emissions economy) that should be considered. The OECD also outlines numerous other factors to consider in their establishment including administrative set-up and positioning, and capitalisation and financial sustainability.

Another important question is its expected duration. Up-front clarity is required as to whether a GIB is intended to only catalyse investment while the emissions price (Chapter 4) and levels of innovation (Chapter 5) rise to a level necessary to drive the transition more directly; or whether clear market failures are visible that suggest a more enduring role is required. Intervention duration also has ramifications for its structure, particularly in terms of funding source.

In a recent report on New Zealand's climate finance landscape, D. Hall and Lindsay (2017, p. 64) contend that

[u]ltimately, there is judgement required as to whether a green investment bank is appropriate. It is an elaborate undertaking and climate finance obviously can exist without one. There are also questions as to whether New Zealand can sustain a pipeline of projects that are sufficient, or whether the transformation of existing institutions is a preferable outcome (D. Hall & Lindsay, 2017, p. 64).

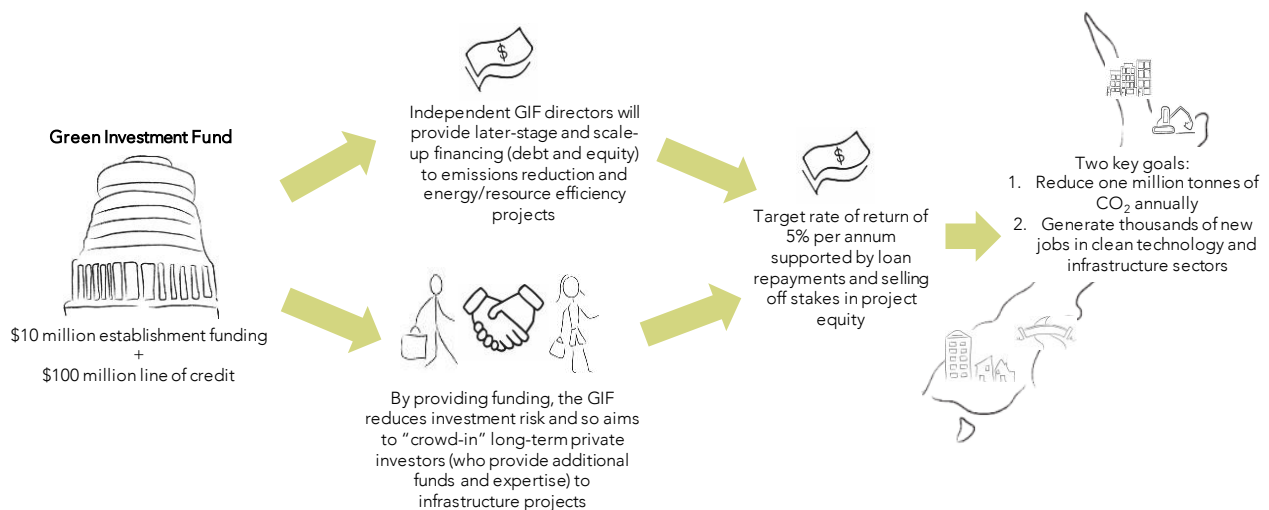
The right structure is vital to ensure an ongoing pipeline of projects necessary to maintain profitability. This includes sectoral areas of focus, minimum investment size, or the type of co-investment provided by the

Government (see also the section on government financial guarantees below). However, it is unclear what the authors mean by transformation of existing institutions, or how such a transformation could occur.

The proposed Green Investment Fund

As part of the 2017 confidence and supply agreement between the Labour and Green Parties, the Government has a goal to establish a GIB. The proposed features of the proposed \$100 million Green Investment Fund (GIF) are shown in Figure 6.4, based on plans published by the Green Party of Aotearoa New Zealand (2017). The Green Party also proposed that the \$10 million establishment funding for the GIF will be provided by “ending current fossil fuel subsidies and raising oil royalty rates from the current 46 percent to the global average of 70 percent” (Green Party of Aotearoa New Zealand, 2017, p. 9). The Treasury is currently leading the task to detail how the GIF will work in practice. Key areas of potential focus for the GIF could include process heat (Chapter 13), waste (Chapter 14) and energy efficiency and space heating in buildings (Chapter 15) (ShareChat, 2018).

Figure 6.4 Proposed Green Investment Fund



Source: Green Party of Aotearoa New Zealand (2017)

F6.3

Green investment banks can efficiently use public capital to mobilise substantially greater quantities of private capital to overcome the scale of investment barriers that low-emissions investments may encounter. These include significant funds for major infrastructure projects, or coordinating funds for more disaggregated activities. They can also stimulate investment by providing information, increasing market confidence, and reducing overall financing costs.

R6.1

The Government should clearly identify the market failure that the proposed Green Investment Fund (GIF) will address. Analysis should include, its mandate, financing approach and funding source, expected duration, institutional structure (including its degree of independence), desired minimum rate of return, relationship to existing infrastructure and clean technology funding sources, and scale of investment (wholesale or retail).

The Government should also state how the GIF would work in conjunction with any other initiatives relating to the provision of infrastructure or low-emissions technology finance.

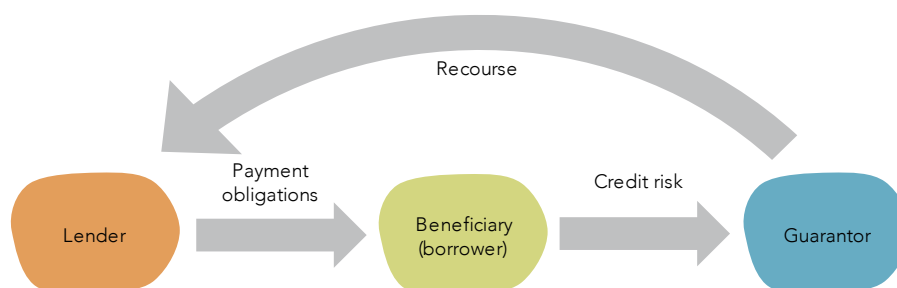
Government financial guarantees

Another option for public sector support is to provide financial guarantees that, similar to GIBs, aim to reduce risk for additional private sector investment. They do this by making lending by private investors

more attractive by sharing or reducing the greater risk and upfront cost of low-emissions infrastructure or technology projects, as well as by freeing up balance sheets (Stiglitz & Stern, 2017; UNDP, 2018). In essence, financial guarantees become a “substitute for the collateral that businesses would have otherwise needed in order to access commercial lending and thus expand available credit” (UNDP, 2018). Financial guarantees are of most interest where the risk of coordination failures or credibility issues exist (Cooper, 2005).

Financial guarantees can catalyse low-emissions investments by specifying particular priority sectors or borrower classes (eg, energy efficient equipment or other infrastructure development). They can mitigate against commercial default risks (ie, by providing direct guarantees that take on either the full or partial debt obligation of the borrower in the case of default) (Figure 6.5). Yet they can also be structured to mitigate political or regulatory risks (such as changes of laws or regulations), or foreign exchange risk. Even so, by their very nature financial guarantees can incur significant risk to taxpayers.

Figure 6.5 Sovereign financial guarantees



Source: T. Magnusson (1999).

Government financial guarantees are offered by many jurisdictions, such as the United Kingdom and France, and via many different institutional delivery models, such as standalone institutions or within government agencies. As their level of fiscal impact on government balance sheets depends on the success rates of guaranteed projects, the relative risk thresholds set by particular governments will influence total fiscal risk.

Several structural options exist for New Zealand to provide a government financial guarantee to help stimulate the transition to a low-emissions economy. A financial guarantee could be one of the mechanisms by which the proposed GIF (see above) provides funding. Alternatively, the Government could establish a guarantee scheme (such as the UK Guarantees Scheme that can issue up to £40 billion worth of guarantees for nationally significant infrastructure projects), but mandate an eligibility requirement relating to low-emissions growth. Or the Government could provide guarantees via commercial banks for loans made to low-emissions activities.

Another approach combining shadow and real emissions prices in relation to guarantees is also possible. In this model, a high shadow emissions price is established to set an asset value on the emissions saved by new investments (known as the “emissions asset”), and these assets are accepted as repayments by the Government and publicly guaranteed. Then, when the real emissions price catches up with the shadow price due to an effective emissions pricing regime, revenues are generated that allow the purchase of the emissions debt held by the Government, which, in turn, ensures fiscal neutrality (Aglietta & Espagne, 2015).

However, as with a GIB, establishing a guarantee programme, especially if it targets major infrastructure development, is a substantial undertaking. They can also be more financially intensive than a GIB, potentially requiring operational subsidies as well as initial capitalisation (UNDP, 2018). The Commission has not uncovered any evidence to suggest that establishing a standalone government financial guarantee scheme is required in New Zealand. However, an approach based on financial guarantees may be suitable as part of the proposed GIF.

F6.4

Government financial guarantees work by reducing risk for additional private sector investment by substituting the collateral businesses would have otherwise required. The Commission has not uncovered any evidence to suggest that establishing a standalone government financial guarantee scheme is required in New Zealand at present.

However, an approach based on financial guarantees may be suitable as part of the proposed GIF.

Grants and loans

Government grants or loans aim to address technology and market risks (Figure 6.2). They may be used for technical assistance (eg, R&D), capacity-building, or for start-up capital or general investment purposes. They can be deployed to reduce overall project or technology development costs that are considered to be consistent with national priorities. One example is government co-funding to fill commercially unviable gaps in the national EV charging infrastructure network (eg, to alleviate range anxiety concerns in rural areas) (Chapter 11). Direct investment can also be particularly relevant for low-emissions pilot projects “where the associated risks are very high and the economic profit uncertain” (Amin et al., 2014, p. 19).

Grants and loans may be provided separately, or used in conjunction to provide additional leverage. They may also be conditional upon private-sector involvement (ie, as part of a “blended” finance package) to ensure private-sector investment is crowded in, rather than crowded out.

Loans with concessional rates (ie, where terms are substantially lower than market rates) may also be particularly relevant for the transition to a low-emissions economy. This is because they “play a catalytic role by supporting the establishment of policy frameworks, strengthening technical capacity, lowering investment costs, and reducing investment risks for the first movers in a market” (Buchner et al., 2015, p. 7). Identifying the correct concessional rate can be complex, particularly to ensure maximum leverage from additional private-sector investment (Amin et al., 2014).

In New Zealand, a variety of publicly-provided grants and loans exist. Grants are provided by, for example, Callaghan Innovation (Chapter 5), the Afforestation Grant Scheme (Chapter 10), Low-Emission Vehicles Contestable Fund (Chapter 11) and Warm Up New Zealand (Chapter 15). Loans are provided by many organisations, such as the Energy Efficiency and Conservation Authority which distributes \$2 million worth of interest-free loans each year to energy efficiency and renewable energy projects. Auckland Council also offers energy efficiency loans at a rate of 6.6%.

Yet it is unclear how these grants and loans are working, or could be working, in tandem with other activities as part of an overall strategy to stimulate low-emissions investment in New Zealand. In their review of New Zealand’s climate finance landscape, D. Hall and Lindsay (2017, p. 34) suggest that an opportunity exists

for the New Zealand Government to build out its role as investment manager for climate change to provide a greater level of strategic direction to other grant-making participants so that they can provide future grants in a cohesive and coherent manner.

Section 6.7 focuses on the need to develop a coordinated strategy for low-emissions investment in New Zealand.

F6.5

Public grants and loans can play an important catalytic role in reducing market risk for the development and deployment of low-emissions technology. However, how grants and loans should operate in conjunction with other types of Government funding intending to support the transition to a low-emissions economy, remains unclear.

Climate-related financial disclosure requirements

Transparency about the risks and opportunities arising from climate change is fundamentally important to scaling up and redirecting the investment needed to enable the transition to a low-emissions economy. Having a clear picture of a firm or organisation’s exposure to climate risk (both physical and transition risk, section 6.2), or how its activities may respond to opportunities created by policy settings, is vital to avoiding information and inertia barriers (section 6.4).

Robust and transparent measurement and reporting of carbon is the starting point for systematic reduction. Improving the disclosure of emitted and avoided emissions at an organisational and product level will assist decision making and enable reduction targets to be set. (Vector, sub. 63, p. 5)

Without accurate information, investors may incorrectly value assets or investment opportunities, resulting in misdirected finance or stranded assets. Disclosure also helps to increase investor understanding of, and demand for, low-emissions investments. Further, if the emissions-cost of investments were more transparent, high-emitting organisations may be more unlikely to obtain finance. The inability to do so might encourage the market exit (or transition to another activity) of those organisations. Box 6.3 highlights the demand for better future-focused disclosure in New Zealand.

Box 6.3 The demand for future-focused disclosure in New Zealand

As part of the ReportingNZ project led by the McGuinness Institute in conjunction with the External Reporting Board (XRB)⁴⁸, preparers and users of reports published by for-profit entities were surveyed about extended external reporting (EER). EER comprises all information above and beyond mandatory requirements, and includes topics such as ESG strategies and impacts (including GHG emissions).

Key messages included that:

- future orientation information is an emerging key requirement because it “delivers better decision making for existing and potential investors, government and other stakeholders”;
- users in particular want to be able to “make decisions based on timely, reliable, relevant and comparable EER information”, with a focus on “reporting on goals, strategies and targets”; and
- independent assurance is critical because it “inspires trust which enables companies to build good relationships with stakeholders, including suppliers, consumers and the wider public” (McGuinness Institute & XRB, 2018, p. 3)

There is substantial demand, and recognition of the need for, future-focused disclosure in New Zealand: 85% of preparers and 96% of users indicated future orientation was an important or very important disclosure. However, only 56% of users thought it was being reported on well. Users employ this type of information to make investment decisions, to understand company strategies and future prospects, and to make judgements about the operations and wider impacts of a company.

Given the critical role of transparency in enabling the transition, a global Task Force on Climate-related Financial Disclosures (TCFD) was established by the G20’s Financial Stability Board in 2015 to “develop voluntary, consistent climate-related financial disclosures that would be useful to investors, lenders, and insurance underwriters in understanding material risks” (TCFD, 2017, p. iii). The TCFD reported in 2017, and recommended climate-related financial disclosure requirements under four key areas (see Figure 6.6 on the next page).

The TCFD identified the following as key features of these recommendations:

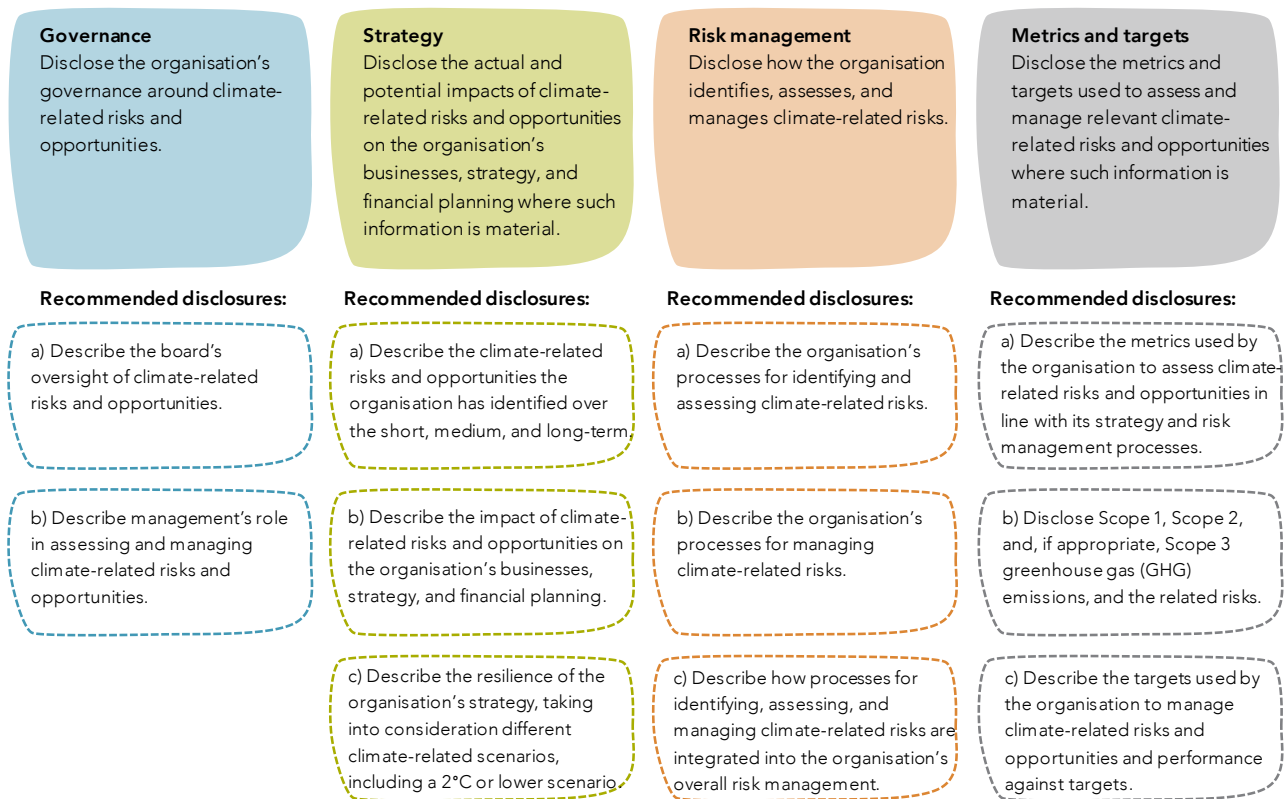
- adoptable by all organisations (including banks, insurance companies, asset managers and asset owners) to enable widespread understanding across the corporate sector;
- included in mainstream (ie, public) annual financial filings to foster shareholder engagement and broader use of climate-related financial disclosures;
- designed to solicit decision-useful, forward-looking information on financial impacts; and
- strong focus on risks and opportunities related to the transition to a lower-emissions economy.

While the TCFD’s recommendations are voluntary, global interest in how they could be implemented across different jurisdictions is substantial, particularly in terms of integrating the recommendations into existing regulation and soft law (Baker McKenzie & PRI, 2017). In particular, the TCFD’s recommendations are

⁴⁸ The XRB is an independent Crown Entity responsible for establishing a trusted accounting and assurance standards framework.

considered to enable more consistent disclosures across and within sectors, and to provide greater clarity on the scope of best-practice disclosures. This is especially relevant as investor demand for climate-related disclosures is forecast to grow over time.

Figure 6.6 Recommendations and supporting recommended disclosures from the Task Force on Climate-related Financial Disclosures



Source: TCFD (2017).

Notes:

1. Scope 1 emissions are direct emissions from sources owned or controlled by the organisation (eg, emissions from company vehicles). Scope 2 emissions are indirect emissions from sources owned or controlled by the organisation (eg, emissions resulting from generating the electricity that is then purchased by the company). Scope 3 emissions relate to all other organisational activities (eg, waste disposal, employee commuting, or upstream or downstream distribution channels) (Carbon Trust, 2018b).

As well as being adopted by the G20, many countries, institutions and individual companies have officially endorsed the TCFD's recommendations. These include:

- the Governments of the United Kingdom, France and Sweden;
- the European Union's High-Level Expert Group on Sustainable Finance, the Monetary Authority of Singapore, and the Australian Prudential Regulation Authority; and
- approximately 250 companies, including ANZ, the London Stock Exchange Group and Qantas Airways.

No formal rules define official endorsement. However, in general, official endorsement by a company means that the company commits to reporting consistent with the recommendations. To date, official endorsement by a government or a financial regulator has meant encouraging or requiring companies (or a subset of companies, such as listed companies) to comply. For example, the UK Government is consulting with industry about the best way to implement the recommendations within the UK's existing body of reporting codes and frameworks. Official endorsement of the TCFD's recommendations by the New Zealand Government would send a strong signal to the investor community that the Government considers disclosure is an important mechanism to manage climate-related risk across the economy.

F6.6

The recommendations of the Task Force on Climate-related Financial Disclosures relating to governance, strategy, risk management, and metrics and targets, offer a clear and consistent foundation for investors to assess the risks and opportunities related to climate change.

R6.2

The Government should officially endorse the recommendations of the Task Force on Climate-related Financial Disclosures.

To make an official endorsement of the TCFD's recommendations more concrete, and following from the experience of other countries, New Zealand could consider three broad options. Those options are:

- to interpret existing requirements as requiring climate risk reporting;
- to encourage TCFD-aligned voluntary reporting via industry; and
- to integrate the recommendations into existing or new government-mandated reporting requirements.

Existing reporting requirements

In New Zealand, company reporting requirements are predominantly laid out in the Companies Act 1993. For listed firms, the Financial Markets Conduct Act 2013 also applies. These then interact with the standards developed by the XRB. As they explain,

the law states which types of entities must prepare financial statements that apply XRB standards, publish financial statements and obtain assurance on them. The XRB standards themselves then state *what* and *how* entities must report (XRB, 2018).

While the Companies Act does not explicitly oblige reporting about climate change, it may be possible to interpret some of the requirements concerning the content of the annual report as covering climate risk. Specifically, Section 211(1)(a) requires that the annual report must:

describe, so far as the board believes is material for the shareholders to have an appreciation of the state of the company's affairs and will not be harmful to the business of the company or of any of its subsidiaries, any change during the accounting period in—

- (i) the nature of the business of the company or any of its subsidiaries; or
- (ii) the classes of business in which the company has an interest, whether as a shareholder of another company or otherwise.

Climate risk could be considered to be information material to shareholders (or potentially harmful to the business of the company). In an analysis of climate risk disclosure practices in Australia, Foerster et al. (2017) investigated whether such an interpretation could be made of the reporting requirements contained within Australia's Corporations Act 2001. They note that the contents of the Director's Report could be interpreted as including an analysis of climate risk, including the requirement to

contain information that members of the listed entity would reasonably require to make an informed assessment of: the operations of the entity; the financial position of the entity; and the business strategies and prospects for future financial years. (Foerster et al., 2017, p. 163)

However, the authors conclude that climate-related risks are not consistently perceived as material financial risks, even by large emissions-intensive Australian businesses. This means that expecting climate risk (particularly in the consistent and credible manner necessary for investors to make informed decisions across different investment opportunities) to be reported under standard guidance is unlikely. The Commission does not consider it likely that existing reporting requirements will adequately incentivise necessary disclosure of climate risk. As the Insurance Council of New Zealand submission contends,

[a]lthough it could be argued that such measures are not necessary because Boards already have a fiduciary duty to report to their shareholders about liability, impaired assets and bad debts, all of which can be adversely affected by climate change impacts. Even if this is the case, it is evident that few

companies do report these risks or take a sufficiently long view, and certainly there is no consistent, clear and comparable reporting. (sub. 104, p. 4)

F6.7

Existing financial reporting requirements (eg, as contained in the Companies Act 1993) will likely fail to adequately incentivise the disclosure of climate risk in a manner that is consistent and credible.

Industry-developed reporting requirements

In the absence of government-mandated requirements, industry may develop its own reporting standards. A notable example is the framework published by the Climate Disclosure Standards Board (CDSB), an international consortium of businesses and environmental non-governmental organisations (CDSB, 2015). This framework provides an approach for companies to follow when reporting environmental information and natural capital in mainstream reports (such as annual reports).

The CDSB has also developed climate change reporting requirements for adoption or support by stock exchanges (CDSB, 2014). Indeed, stock exchanges are a key mechanism by which industry-developed reporting requirements are enacted. Numerous stock exchanges reference the CDSB framework, including the Australian, London and Singaporean exchanges.

Stock exchanges can also develop their own specific reporting requirements. For example, since 2014, the Australian Stock Exchange (ASX) has, according to a “comply or explain” rule,⁴⁹ required listed entities to “disclose whether it has any material exposure to economic, environmental and social sustainability risks and, if it does, how it manages or intends to manage those risks” (ASX, 2014, p. 30).

In New Zealand, the NZX Listing Rules together with the NZX Corporate Governance Code apply for listed firms. The code specifically recommends that an issuer should

provide non financial disclosure at least annually, including considering material exposure to environmental, economic and social sustainability risks and other key risks. It should explain how it plans to manage those risks and how operational or non financial targets are measured. (NZX, 2017b, p. 19)

As with the ASX rules, this recommendation operates on a comply or explain basis. The NZX has also issued an ESG guidance note that extensively references the issue of climate change (NZX, 2017a).

The Commission considers that relying on industry-developed reporting requirements is unlikely to allow for the type of consistent and credible reporting required for investors to be able to make adequately informed decisions across different opportunities. While the NZX guidelines are positive, their coverage is such that they will not be sufficient to drive adequate investor awareness and behaviour change across the economy. At present, 161 firms operate on the NZX main board. However, this represents less than half of all New Zealand organisations with more than 500 employees and only a quarter with more than 300 employees.⁵⁰

F6.8

While the guidelines provided by the New Zealand Stock Exchange provide a positive foundation for listed firms to disclose their climate-related risks, their coverage is such that they will not be sufficient to drive adequate investor awareness and behaviour change across the New Zealand economy.

Government-mandated reporting requirements

Many jurisdictions require climate-related disclosures, particularly for large or listed firms. In Europe, Directive 2014/95/EU requires certain large public-interest companies to report on environmental matters so as to identify sustainability risks and increase investor and consumer trust. Companies must provide

⁴⁹ This means that entities must provide an explanation if they do not comply with any of the requirements.

⁵⁰ As 500 employees is the minimum size for most mandatory climate reporting regimes internationally, that minimum size is used here for comparability (even though many of the NZX firms may not have 500 employees). Firm counts are derived from the New Zealand longitudinal business database.

details of the current and foreseeable impacts of the undertaking's operations on the environment, and, as appropriate, on health and safety, the use of renewable and/or non-renewable energy, greenhouse gas emissions, water use and air pollution. (Directive 2014/95/EU, 2014, p. 2)

In the United Kingdom, listed companies not already subject to Directive 2014/95/EU must, under the Companies Act 2006, provide information about "environmental matters (including the impact of the company's business on the environment)" necessary to understand the "development, performance or position of the company's business" (UK Government, 2013, p. 3). This includes supply-chain risks relating to environmental issues, and an assessment of main trends and other factors likely to affect the company in the future. It is estimated that this reporting requirement will save 4 Mt CO₂ equivalent by 2021 (Carbon Trust, 2018a). A substantial amount of guidance supports these requirements (ICAEW, 2015; KPMG, 2015). Even so, some are calling for an improvement of the quality, standardisation and depth of information provided under this framework (which would result in reporting better aligned with the TCFD's recommendations).

In France, Article 173 of the Law on Energy Transition for Green Growth (2015) has received substantial global attention for requiring extensive and mandatory emissions reporting. Article 173 directs companies to disclose financial risks on a comply or explain basis relating to the effects of climate change and the measures adopted by the company to reduce them, and institutional investors to identify how their policies align with the national strategy for France's transition to a low-emissions economy (PRI, 2016).⁵¹

Given the arguments against solely relying on existing reporting requirements or voluntary reporting mechanisms as detailed above, the Commission considers that additional mandated climate-related disclosure requirements will be needed in New Zealand. This view was supported by submitters including the Guardians of NZ Superannuation (sub. 32), the Energy Management Association of New Zealand (sub. 70) and the NZ Institute of Forestry (sub. 73). Two options exist to require reporting consistent with the recommendations of the TCFD:

- to include disclosure requirements as part of a new piece of legislation or regulation (the approach taken by France); or
- to amend existing regulatory frameworks (the approach currently being taken by the United Kingdom).

To pursue the first option, the most likely avenue is via the inclusion of climate disclosure requirements within the proposed Zero Carbon Act. However, this is not recommended for two main reasons. First, the proposed Act (and the existing Climate Change Response Act) focus on the obligations required of Government, rather than on the obligations on companies. Given the reporting obligations for companies is part of the focus of other legislation (such as the Companies Act), these are a more suitable home for additional disclosure requirements.

Second, the timeframes are unlikely to be compatible. The Zero Carbon Act is intended to be introduced at the end of 2018 and passed in the second half of 2019. It is unlikely that adequate development of such a regulatory requirement will be possible within this timeframe. This is particularly so given the need for disclosure requirements to be developed in conjunction with industry. At present, the Commission is not aware of any other existing or proposed pieces of regulation or legislation that could suitably incorporate new climate-focused disclosure requirements.

Several options exist to implement the second option. One avenue might be to provide explicit requirements to report on climate risk in relation to section 211 of the Companies Act 1993. The Financial Reporting Act 2013 is also a possible avenue. Specifically, section 17(2) of the 2013 Act enables the Governor-General to authorise the XRB to issue financial reporting standards relating to matters including:

- (i) an entity's governance; (ii) an entity's strategic direction and targets; (iii) the social, environmental, and economic context in which an entity operates; (iv) any other matter relating to an entity's performance or position.

Before issuing a standard, the XRB carries out an extensive process of stakeholder consultation. The Commission understands that MfE, the XRB and the Ministry of Business, Innovation and Employment are

⁵¹ Despite operating on a comply or explain basis, there is "no further guidance or agreement about the expectation of what would be a satisfactory explanation for non-compliance" (PRI, 2016, p. 7) in relation to Article 173, implying that compliance will be the anticipated norm.

currently discussing how climate-related financial disclosure requirements may be enacted in New Zealand. The numerous issues to consider (such as size or type of firms required to disclose, and at what level of detail the recommended disclosures are required) will require substantial engagement with industry. Matikainen (2017b) also notes that any issued guidance should include information on common scenarios given the need for forward-looking analysis.

F6.9

Many jurisdictions have enacted mandatory climate disclosure requirements either as part of existing regulations focused on strategic reporting, or as part of new, climate-focused legislation. Government-mandated disclosure requirements are important to provide consistent, comparable and credible reporting for investor decision-making.

R6.3

The Government should incorporate mandatory climate-related financial disclosures into existing regulatory instruments as appropriate. The disclosures should be in line with the recommendations of the Task Force on Climate-related Financial Disclosures.

6.6 Other supporting actors for the low-emissions transition

Central banks and financial regulators

Central banks and financial regulators play an important role in ensuring climate-aligned financial regulation and monetary policy (Ryan-Collins & van Lerven, 2017). This is particularly so given the risks to market stability from an unpredictable or abrupt transition, and the potential opportunity for improved financial and macroeconomic stability if climate change is adequately factored into investors' decision-making (section 6.2). Monnin (2018, p. 13) explains:

Climate change is a significant risk for our societies and transitioning to a low-carbon economy a key challenge we must meet. Central banks must not stand on the sidelines in this process. They need to safeguard financial stability by taking appropriate measures to strengthen financial market resilience vis-à-vis climate-related risks, and they need to align their policies with the shift in investments that the transition to a low-carbon economy requires.

A key role for central banks or financial regulators is to assess the exposure of their domestic financial system to climate risk (Monnin, 2018). This is complementary to, but more strategic and high-level than, the assessment of climate risk required via disclosure at the firm or investor-level. Once climate stress-testing occurs, central banks and regulators can then determine whether any subsequent changes are required, such as ensuring climate-aligned financial regulation or conducting other activities such as corporate bond purchases (Campiglio et al., 2017; Matikainen et al., 2017).

Many central banks have either recently conducted, or are in the process of conducting, such reviews. For example, the Bank of England's Prudential Regulation Authority has written to local and international banks operating in the United Kingdom to ask them how they are thinking about and managing climate risk, to support an orderly transition to a low-emissions future. A report of these responses is expected in 2018 (Bank of England, pers. comm. 11 October 2017). In a review of the Dutch financial system, De Nederlandsche Bank concluded that the financial sector has considerable exposure to high-emissions sectors. In response, it intends to "embed climate-related risks more firmly in financial supervision with the aim of ensuring sustainable financial stability" (DNB, 2017, p. 4). The Swedish Financial Supervisory Authority, Finansinspektionen, also commissioned a report on "how environmental and climate change may affect financial stability in the long run, and which measures may be needed to dampen the negative effects on the financial system" (Bowen & Dietz, 2016, p. 5).

In New Zealand, there is no current whole-of-economy understanding of the level of financial exposure to climate risk. This represents a substantial information deficit in terms of systemic risk. As Monnin (2018, p. 5) contends, this "information is not only crucial for regulators, but also for financial market participants to adequately reflect climate-related risks in their investment decisions". One particularly suitable avenue to

rectify this information deficit is for an assessment of climate-related systemic risk in the New Zealand financial sector to explicitly form part of the Reserve Bank's regular stress-testing process (RBNZ, 2018).

F6.10

Central banks play an important role in assessing the exposure of financial systems to climate risk, particularly in terms of effects on financial stability.

Institutional investors

Holding over US\$55 trillion in assets worldwide, institutional investors, such as pension funds and insurance companies, represent a large potential source of finance for the transition to a low-emissions economy (OECD, 2012b, 2015d). In New Zealand, the combined ACC and NZ Super Fund portfolios alone represent nearly \$67 billion⁵² worth of invested funds (ACC, 2017; NZ Super Fund, 2017). And approximately \$10 billion of New Zealand equities are managed by New Zealand institutional investors (NZ Super Fund, 2015).

Institutional investors are increasingly moving towards diversified portfolios as a mechanism to dilute risk (OECD, 2014). As a result, infrastructure investments (as opposed to more traditional sources of institutional investment such as private equity or real estate) are becoming more prevalent (Environment Audit Committee, 2014). Low-emissions infrastructure can provide an excellent match for institutional investors, particularly due to the longer time horizons involved. However, because institutional investors have different liquidity and liability profiles (eg, life insurance funds have less scope to invest in illiquid assets because policy holders can withdraw funds at any time), there is a

need for expanded and diversified channels of financing for low-carbon infrastructure, which can cater to different investment horizons, risk appetites, liquidity needs, and capacities to invest in potentially complex and large-scale projects. (OECD, 2017c, p. 268)

New Zealand does not appear to have major barriers to institutional investors finding adequate low-emissions investments of a suitable nature. For example, via a wholly-owned US-based subsidiary, the NZ Super Fund directly owns a 45% stake in Longroad Energy Holdings, LLC, a US company developing utility-scale renewable energy facilities throughout North America.

It is also possible to require public institutional investors to prioritise low-emissions investments. For example, Christchurch City Council (sub. 13) suggested that both central and local government investments could be required to be limited to low-emissions activities. The Council also proposed that central and local government procurement of financial services could "include a weighting with regards to evaluating the providers' investments and loans in low emission activities, e.g. based on low emission indices" (p. 7). Te Rūnanga o Ngāi Tahu (sub. 83) also identified preferential purchasing policies that could be applied to institutional investors as a mechanism to incentivise low-emissions businesses and business practices.

An alternative option is to guide public institutional investors using a principle-based approach. Millar et al. (2018) propose three key principles that institutional investors could use when determining suitable investments (Figure 6.7). The Commission considers that a substantial amount of further engagement with public institutional investors is required as regards potential changes to investment mandates (see section 6.7 on the development of a climate finance strategy).

⁵² ACC: \$37.3 billion of funds under management. NZ Super Fund: \$29.6 billion invested globally.

Figure 6.7 Principles to guide investment towards a stable climate

Focus area	Principle
1: Commitment to net-zero emissions	All industries must eventually reach net-zero emissions, even if some industries do so before others. Companies should commit to a date (or a temperature increase, such as 1.5 °C or “well below 2°C”) before which the net CO ₂ emissions associated with their activities (including both supply chains and products sold) will be zero.
2: Profitable net-zero business model	Company executives should have business plans that ensure the profitability of their business, and limit supply chain risks, once emissions reach net-zero.
3: Quantitative mid-term targets	Mid-term targets (for example, for 2030) that are directly relevant to achieving a net-zero business model, such as the rate and long-term trajectory of reductions in CO ₂ emissions, are vital to properly assess compatibility with the Paris Agreement.

Source: Millar et al. (2018).

Māori investment supportive of a low-emissions transition

Iwi, particularly in the post-settlement era, are increasingly important investors in the New Zealand economy (Te Rūnanga o Ngāi Tahu, sub. 83). The size of the Māori economy is substantial, with estimates ranging up to \$50 billion (Chapman Tripp, 2017). In general however, this portion of the New Zealand economy lacks centralised data gathering and projections (Te Rūnanga o Ngāi Tahu, pers. comm. 26 March 2018).

The values of kaitiakitanga guide iwi investments with a multigenerational perspective that fits with climate change mitigation strategies. The long-term and multi-objective nature of iwi investment (ie, that goes beyond maximising financial returns) is particularly relevant (TDB Advisory, 2017). Ngāi Tahu (sub. 83, p. 5) note that “kaitiakitanga is about ensuring that future generations have a relationship with Te Ao Tūroa (the natural world) that sustains them in the way that generations before have been sustained”. They also note that, like other iwi, they are heavily invested in businesses that will be at the heart of climate change mitigation and adaptation – fisheries, farming forestry, tourism and property. Te Rūnanga o Ngāi Tahu considers that these perspectives and interests make iwi natural partners with central and local government and business in achieving transformational change in the New Zealand economy.

Outside the Treaty of Waitangi settlement framework, some Māori landowners have particular issues with raising capital because of multiple ownership of land and the nature of Māori freehold title (Chapter 10). This makes it more difficult to invest in measures to reduce agricultural GHG emissions (Insley & Meade, 2008). Barriers to afforestation are lower, as international and domestic investors are ready to work with Māori landowners under agreements covering harvesting rights and the treatment of credits and liabilities under the New Zealand Emissions Trading Scheme. Potential suggested solutions to stimulate the Māori economy include an iwi bank, and reporting on business relationships to Māori within the environmental and social spheres (Te Rūnanga o Ngāi Tahu, pers. comm. 26 March 2018).

6.7 A strategy to encourage investment supportive of a low-emissions transition

Alignment of policies and interventions to support the transition to a low-emissions economy is fundamental (OECD, 2015a). Aligning policies ensures that government initiatives do not work at cross-purposes to low-emissions goals, do not duplicate effort and waste scarce public funds, and are also directed into those areas most likely to achieve desired emissions reductions (Matikainen, 2017a).

Policy alignment is also critical between underlying regulatory settings (such as an emissions price) and additional instruments that aim to de-risk and encourage further private-sector investment (Stiglitz & Stern, 2017). Further targeted support to close funding gaps must be clearly justified to avoid crowding out potential private-sector investment that would have occurred solely due to foundation policies such as

emissions pricing. That targeted support must also be appropriate to the stage and nature of the types of infrastructure and low-emissions technology projects and firms most likely to drive New Zealand's transition.

Developing a low-emissions investment strategy for New Zealand

A key recommendation of UK's Environmental Audit Committee from their 2014 review into green finance was that developing a single overall strategy was necessary to address the green investment gap. While their recommendation encompassed issues beyond finance (such as the United Kingdom's position in international negotiations), it did identify issues that need further elaboration in New Zealand. One such issue is the role of, and interaction between, government initiatives such as green banks, public guarantees, and grants and loans in stimulating the transition.

The UK Government is currently coordinating a Green Finance Taskforce that brings together senior financial sector leaders to identify ways to accelerate the growth of green finance, and help to deliver the investments required to meet the United Kingdom's carbon reduction targets (UK Government, 2017b). Other countries, such as Chile (Holmes et al., 2016) and France (Lemmet & Ducret, 2017), have also identified the need to develop low-emissions investment and finance strategies.

The Ministry for the Environment has a specific work programme on climate finance. One of the first outputs of this work was the publication of a report on the climate finance landscape in New Zealand (D. Hall & Lindsay, 2017). The Commission considers that this work should be built upon by way of a more publicly visible, and industry-involved, strategic process.

A strategic view across public-sector interventions is important to accelerate progress in a coordinated and non-duplicative manner, as well as to visibly monitor the impact that public-sector, climate-related investment is making (which in turn helps to reduce information and inertia barriers). Incorporating the expertise of the private sector, such as the Guardians of NZ Superannuation, who have developed internal climate change strategies (sub. 32), is also vital. Other issues that the strategy could consider include the role of financial sector regulation more broadly in the transition to a low-emissions economy, the role of government at different stages of the transition, as well as defining what counts as "low-emissions investment" in the New Zealand context (Box 6.4).

Box 6.4 What should be counted as "low-emissions investment" in New Zealand?

The strategy recommended in this section should aim to shed light on what is defined as "low-emissions investment" in the New Zealand context. This is important so that progress (and particularly the additionality caused by public interventions crowding-in private finance) can be measured (EU High-Level Expert Group on Sustainable Finance, 2018). Without clarity on what is or isn't categorised as low-emissions investment, so-called "greenwashing" can occur, which is where business-as-usual lending is repackaged as climate-related lending. For example, the National Australia Bank has been criticised as labelling lending for business-as-usual residential property development to minimum mandated energy efficiency standards as "climate change financing" (Jewell, 2017).

At present, climate finance from New Zealand to developing countries is tracked by the Ministry of Foreign Affairs and Trade (MFAT). This is part of New Zealand's commitment under Article 9 of the Paris Agreement to report every two years on climate finance mobilised to developing countries. However, while substantial effort is being directed towards consistent assessment of these international finance flows (Ellis & Moarif, 2016; Vallejo et al., 2017), no assessment, or consistent definition, of similar types of domestic public investment (including how effectively it is contributing towards the low-emissions transition) exists. The OECD (2017f) also recommends that countries should explore possibilities for collecting data on private finance for climate action.

F6.11

A strategy on public sector investment is needed in New Zealand to enable aligned, clear, and well-targeted investment that is supportive of the transition to a low-emissions economy.

R6.4

The Government should develop, in conjunction with interested parties including the private sector, a low-emissions investment strategy for New Zealand. Relevant topics should include:

- the strategic alignment of direct government investment intended to support the transition to a low-emissions economy (eg, grants, loans and other initiatives such as the proposed Green Investment Fund), as well as the interaction between policies such as disclosure requirements and direct government funding;
- the investment mandates of large public institutional investors (eg, ACC or the NZ Super Fund);
- the role of financial sector regulation in supporting the low-emissions transition; and
- what constitutes low-emissions investment, with the aim of identifying a clear taxonomy of measurable investment flows.

7 Laws and institutions

Key points

- The long-term nature of climate change (literally spanning generations) and the deep uncertainty associated with the future, presents a credible commitment problem in formulating a long-term policy response. There are strong political incentives to avoid making long-term policy decisions that will have short-term cost and impacts, but benefits that manifest well into the future.
- Well-designed laws and institutions can play a critical role in providing a strong signal about future policy intentions and act as a commitment device to help drive the development and implementation of a long-term policy response to climate change. In this way, laws and institutions provide policy stability and credibility.
- New Zealand has an existing climate change regulatory framework, but it is not underpinned by a credible commitment to a domestic low-emissions transition. The current systems architecture exhibits a lack of long-term stability and predictability about the nature and pace of New Zealand's low-emissions transition, lack of a clear plan for reducing domestic emissions, and poor policy coherence.
- New Zealand needs a reformed statutory framework that requires long-term thinking, promotes policy stability and provides signalling, yet allows flexibility about the precise path to the long-term goal: essentially ensuring an eye is kept on the long-term compass while letting the tiller be adjusted along the way.
- A new architecture for New Zealand's climate change legislation should be built on principles of transparency and accountability, with a backbone based on mandatory processes. It should include the following mutually reinforcing elements:
 - legislating for long-term greenhouse gas emissions-reduction targets;
 - a system of emissions budgeting;
 - a statutory duty to prepare and publish a long-term low-emissions economy strategy;
 - clear mandatory reporting obligations, including regular reporting to Parliament; and
 - creation of an independent climate change institution to provide objective analysis and advice.
- An independent Climate Commission, set up as an independent Crown entity, would help to insulate policymaking from short-term political pressures, promote stability and predictability, expand climate policy debate, and improve transparency and accountability. Decision-rights should not be delegated to such an independent body.
- The Government should seek to achieve a high level of political consensus for any new climate change law, with an aim of enacting legislation that has a strong prospect of policy and legislative durability regardless of the make-up of the Government over time.
- A legislative target, mandatory processes and an independent Climate Commission are necessary, but not sufficient, for an effective and efficient emissions-reduction strategy. Developing the government response to meet emissions budgets and targets will be a substantive and challenging policy process. It will require leadership from the centre of government and policy alignment across government.

An important theme in this report is that a long-term perspective must be introduced into politics and policymaking, domestically and internationally. The long-term nature of climate change and deep uncertainty associated with the future requires political commitment and durability that spans many generations. For it is those future generations who will live with the consequences of policy decisions made today to reduce emissions and curb the impacts of climate change. It is therefore not surprising that in their submission to this inquiry, Generation Zero—a youth-led organisation in New Zealand—say, “We believe a Zero Carbon Act, backed by cross-party agreement, is the most urgent and important law that our next Parliament could legislate” (sub. 119, p. 3).

This chapter examines and makes findings and recommendations on:

- the role of laws and institutions in supporting a low-emissions transition;
- New Zealand’s existing emissions-reduction response, and reforms to New Zealand’s legal framework;
- the need for, and key design features of, an independent climate change institution; and
- the role of central government in leading the transition to a low-emissions economy.

7.1 The role of laws and institutions

The credible commitment problem

As outlined in Chapter 1, climate change is a long-term problem. Achieving a low-emissions economy for New Zealand requires early action and a long-term enduring response. Action is needed in the face of deep uncertainty and in the context of a global public good (with its incentives to free-ride). Yet a time inconsistency challenge exists, because optimal policy decisions for the future may be at odds with optimal policy decisions in the short-term. Further, the nature of democratic political systems (where the political executive governs based on short-term electoral cycle mandates) tends to favour short-term interests over long-term interests (Averchenkova & Bassi, 2016; Brunner et al., 2012; Hovi et al., 2009). This presents a problem for any government to credibly commit to a long-term policy response (the so-called “credible commitment problem”). The Governor of the Bank of England, Mark Carney, puts it this way, “climate change will be felt beyond the traditional horizons of most actors – imposing a cost on future generations that the current generation has no direct incentive to fix” (Carney, 2015).

Well-designed laws and institutions can play a critical role...

Well-designed laws and institutions can promote long-term stability by acting as “commitment devices” and signalling a clear, long-term policy direction.

Commitment devices help to overcome the credible commitment problem by placing political transaction costs in the path of policy change (Brunner et al., 2012). As Boston (2016, p. 23) explains:

[t]he concept of a ‘commitment device’ refers to a mechanism that is designed to change the structure of intertemporal pay-offs and/or limit future discretion by binding a person, organisation or government to a particular course of action. Commitment devices can take many different forms, from marriage vows to multi-party agreements. In the policy realm they can include constitutional or quasi-constitutional mechanisms, procedural and substantive devices, and mechanisms that are designed to insulate decisions from short-term political influence (e.g. transferring decision-rights to an independent group of experts).

New Zealand’s fiscal and monetary regulatory frameworks are examples of policy domains where “strong commitment devices have been implemented to protect future-oriented interests” (Boston, 2016, p. 21; section 7.4).

Overarching framework legislation is particularly important in providing a comprehensive, unifying basis for driving climate policy (Nachmany et al., 2015). Averchenkova and Bassi (2016, p. 14) identify that “legislation can be a powerful instrument to prevent policymakers from backtracking from policy commitments.” Domestic legislation is also “the absolutely critical, essential, linchpin between action at the national level and international agreements” (Figueres, 2013; Box 7.1). Domestic law plays an important role in the context

of the Paris Agreement's "bottom-up" framework of allowing individual countries to set their own nationally determined contributions (NDCs) to reducing emissions (Chapter 2).

Box 7.1 The relationship between international and domestic climate-change obligations

The power to enter into or withdraw from international treaties sits with the political executive. International treaty obligations are binding at international law, but the executive cannot change New Zealand's domestic law by becoming party to a treaty. So, to have effect in New Zealand, international obligations must be incorporated into New Zealand law (Costi, 2016; Legislation Advisory Committee, 2014; MFAT, 2017).

The Paris Agreement (which qualifies as an "international treaty") is unusual because it includes many provisions that are not binding. The Agreement "contains a carefully calibrated mix of hard, soft and non-obligations, the boundaries between which are blurred" (Rajamani, 2016, p. 358), and is therefore a package of both obligations and expectations (New Zealand Government, 2016). For example, individual countries must communicate their NDC every five years, but can set their own emission reduction commitments. The Paris Agreement also establishes a "good faith expectation" that countries intend to achieve their contributions, but stops short of imposing legally binding obligations to do so (Rajamani, 2016; Rive & Harker, 2017). Detailed rules to operationalise the Paris Agreement (such as arrangements for international trading and accounting rules) are still being negotiated, with the aim of having the "Paris Rulebook" finalised by the end of 2018 (Timperley, 2017).

F7.1

The long-term nature of climate change, literally spanning generations, and the deep uncertainty associated with the future, presents a credible commitment problem in formulating and implementing a long-term policy response.

Well-designed laws and institutions can play a critical role as commitment devices to help drive the development and implementation of long-term response strategies.

...but must be underpinned by political consensus

Laws and institutions can reflect, and help to hold in place, political consensus about core regulatory goals and regulatory frameworks.⁵³ Creating new laws and institutions can potentially also help political consensus to form, as the "asymmetry" of legislation (and politics) means that a successor government may find it much harder to repeal legislation once in place than to decide not to introduce it (Rutter & Knighton, 2012). While political consensus sometimes crystallises before new laws and institutions are introduced, it can develop sequentially (as occurred for example with the Fiscal Responsibility Act 1994 and the Reserve Bank Act 1989).⁵⁴

Ultimately though, laws and institutions will not endure unless underpinned by political consensus. Legal and institutional arrangements that lack substantial cross-party support will not provide the long-term stability and predictability needed for an effective low-emissions transition. For example, if the core elements of legislation (such as a long-term, emissions-reduction target) risk being repealed by successor governments, investors will not be sufficiently confident to rely on the current law when making long-term investment decisions. Support across political parties is vital; climate change is the ultimate intergenerational issue, and governments change (PCE, 2017). The United Kingdom's (UK) Climate Change Act 2008 for example (which is viewed as world-leading climate-change legislation) was enacted with overwhelming cross-party support. Political consensus about the architecture of the legislation has been key to the Act's success and political durability (BEIS, pers. comm., 13 November 2017; Weeks, 2017).

⁵³ The UK's Climate Change Act 2008, for example, has been credited with helping to preserve the political consensus on the need for climate action and the UK's long-term ambition (Fankhauser et al, 2018).

⁵⁴ The Fiscal Responsibility Act, for example, did not have cross-party support when it was passed in 1994 by a bare National-led majority.

F7.2

Long-term political commitment and durability is essential to the success of climate change laws and institutions. Substantial cross-party support for the core elements of statutory and institutional arrangements will help provide policy permanence regardless of the make-up of the Government.

7.2 A regulatory framework...but no credible commitment to a domestic low-emissions transition

New Zealand already has in place a regulatory framework for mitigating climate change that includes international commitments, domestic laws, policies and institutional arrangements. Core elements of the existing regime include:

- emissions-reduction targets for 2030 and 2050 (Chapter 2);
- a central piece of climate change legislation, the Climate Change Response Act 2002 (CCRA) that “forms the backbone” of New Zealand’s climate change policy (Grantham Research Institute, n.d.). In its current form, the CCRA has a “three-pronged” purpose: enabling New Zealand to meet its international obligations, setting up the New Zealand Emissions Trading Scheme (NZ ETS), and providing for a synthetic gas levy (section 3(1) CCRA; Rive & Harker, 2017);
- a key policy tool for reducing emissions, the NZ ETS (Chapter 4);
- institutional arrangements within government that include a Climate Change Minister, the Ministry for the Environment (MfE) as lead department and a range of other bodies with key responsibilities in areas such as energy, transport, agriculture and forestry (Chapter 2).

Despite the existing regulatory framework, New Zealand is not on track to meet its 2030 target (Chapter 2) and has “yet to begin making a real transition to a low-emissions economy” (PCE, sub. 54, p. 3).

Barriers to ‘bending the curve’ of emissions include various sector specific issues (identified in other parts of this report). At a broader level, key cross-cutting issues identified by submitters to this inquiry were:

- lack of stability and predictability in climate policy, reflecting the absence of political consensus about New Zealand’s transition to a low-emissions economy;
- no clear plan for reducing domestic emissions and meeting New Zealand’s existing targets;
- inadequate central government leadership to drive the low-emissions transition; and
- poor policy coherence, including inadequate coordination and lack of joined-up thinking.

These issues (discussed below) reflect the underlying challenges in establishing a credible commitment to making a domestic low-emissions transition, particularly in the context of a transition that will be profound and widespread, and requires long-term thinking and decision-making under uncertainty. As observed by the Parliamentary Commissioner for the Environment (PCE), “New Zealand’s policy record on climate change reads very much as one of developing sophisticated policy tools but not being prepared to deploy them in a way that will ‘bite’” (PCE, 2018, p. 10).

Lack of stability and predictability

Climate policy in New Zealand has been subject to major changes in direction, particularly following changes of government. Between 1999 and 2008, the Labour-led Government aimed for New Zealand to be ‘bold’ on climate change (Clark, 2006) and put in place the world’s first ‘all sectors, all gases’ emissions trading scheme. New Zealand’s stance changed to that of a ‘fast follower’ under the National-led Government from 2008-2017, with policy “dialled back” (PCE, 2018, p. 10), including via major reform of the NZ ETS (Chapter 4). The new Labour-led Government has signalled a strengthening of action on climate change (Office of the Minister for Climate Change, 2017).

Since October 2015, cross-party collaboration on climate policy has been fostered through GLOBE-NZ (a cross-party group of New Zealand Members of Parliament that forms a national chapter of an international association of parliamentarians, GLOBE International⁵⁵), whose work included commissioning the 2017 Vivid Economics report *Net zero in New Zealand: Scenarios to achieve domestic emissions neutrality in the second half of the century*. Even so, New Zealand currently lacks political consensus about the country's long-term low-emissions goal, including how deeply its domestic emissions need to be cut, and by when. BusinessNZ highlighted the impacts of a lack of shared political commitment around targets:

[A]greed emission reduction targets or at least targets within a narrow range are as - if not more - important as the policy pathways used to achieve them. A credible shared political commitment needs to emerge around New Zealand's emission-reduction targets. While we appreciate that targets are out of scope, they are critical to the overall conversation. One need only think about the current differences in targets across the political parties (for example, 30% below 2005 levels by 2030, net zero carbon by 2050, and net zero emissions by 2050) to realise what these might mean for how targets might vacillate over time, and the concomitant implications for policy settings and investment signals for business. (sub. 89, pp. 5–6)

Political uncertainty and policy instability was a key theme raised by submitters to this inquiry (Box 7.2).

Box 7.2 The need for stability and predictability

Submitters highlighted a variety of stability and predictability issues, including the political uncertainty associated with short-term election cycles and its resulting (negative) impacts on investment decisions.

Clarity is required regarding the dairy and wider agricultural industry long term low emissions pathway and how this interlinks with the expectation on the other sectors of New Zealand's economy... This certainty must extend beyond the current three-year political cycle, climate change is a long term issue, which requires a long term plan. Political uncertainty simply creates an environment where inaction perpetuates." (Dairy NZ, sub. 18, p. 3)

Ultimately New Zealand's response to climate change must be depoliticised. Decisions around how New Zealand responds to climate change, and how we move to a lower carbon emissions economy, cannot be at the mercy of our three-yearly MMP election cycle. (Contact Energy, sub. 29, p. 8)

The Investor Group on Climate Change Australia-NZ survey of institutional investors found that 55% of respondents were already allocating capital to green investments and 100% were intending to increase their allocation in the future. Yet, the two main barriers to allocating capital to low carbon solutions were policy or regulatory uncertainty and lack of investable deals. (Guardians of NZ Superannuation, sub. 32, p. 5)

The major uncertainty facing Ballance in considering investments relevant to a low-emissions future is the ongoing political uncertainty regarding the pace of change required and the policy instruments to be applied." (Ballance Agri-Nutrients, sub. 34, p. 4)

During the investigation into the UK Climate Change Act, members of my staff met with a number of private sector companies. They found a general frustration with the lack of stability in climate change policy... Without a measure of predictability, companies cannot manage the risks of moving to a low-carbon economy. Nor can they invest with confidence in low carbon technologies. (PCE, sub. 54, p. 4)

Transitioning to a low-emissions economy is an intergenerational effort which will span many decades. To provide long-term stability it is important to shield actions and initiatives from political interference arising from short-term political cycles. (NZ Carbon Farming, sub. 95, p. 19)

Businesses need long-term certainty, beyond the election cycle, to make the right investments and changes to their business operations. (Sustainable Business Council, sub. 131, p. 3)

⁵⁵ GLOBE International is an association of legislators that seeks to work across party political divisions to develop legislative responses to major global sustainable development challenges: see <https://globelegislators.org/about-globe>.

No clear plan to meet targets

Submitters were critical that New Zealand has no plan to reduce domestic emissions and to meet existing targets. For example:

I have read the published speeches of successive Ministers for Climate Change over the past five years and I see no evidence of a genuine intent to reduce emissions. For example, most recently Paula Bennett has said, “Large parts of our [climate change] plan are already underway, and our target will be met through a combination of domestic emissions reductions, removals of greenhouse gas emissions in the atmosphere by forests, and international carbon markets.” In fact, there is no detailed domestic emission reduction plan (e.g. including reductions per year by sector), MfE has no published reports on the matter, and domestic emissions are not, in fact reducing. (Robert McLachlan, sub. 9, p. 2)

We have a target for 2030 but no integrated plan for achieving this. (Vision Kerikeri, sub. 116, p. 4)

There is a lack of clarity and certainty on what New Zealand’s transition to a low carbon economy looks like and what each sectors role in achieving this is under the current policy framework. (Dairy NZ, sub. 18, p. 2)

The absence of an integrated approach to developing a strategy and set of actions to address how New Zealand’s should meet it’s 2030 climate change emissions reduction target or to agreeing a target date and actions to achieve a net zero position has been a concern for the Association. While a number of separate initiatives have been announced by Government there is currently no defined transition pathway to a low carbon economy. (NZ Wind Energy Association, sub. 40, p. 1)

PCE’s 2017 report highlighted the lack of direct link between New Zealand climate policy and reaching emission reduction targets:

[I]t is not shown how policies contribute to meeting targets. For instance, one of the priorities in the New Zealand Energy Efficiency and Conservation Strategy is that electric vehicles are to form 2% of the fleet by 2021. But how far will this go towards helping us achieve our Paris target?

Overall, there is no systematic quantification of reductions in greenhouse gases from climate change initiatives in New Zealand. A United Nations expert review has criticised New Zealand for this omission. The new funding for “costed, tested and consulted policy options for reducing emissions domestically” in the 2017 Budget should go some way to remedying this. (PCE, 2017, p. 20)

Inadequate central government leadership

Various stakeholders, including business and local government, have called for more central government leadership to help drive the low-emissions transition. Local Government New Zealand (LGNZ)’s submission for example highlighted the “growing frustration at the current lack of action on climate change by central government” (LGNZ, sub. 36, p. 11) and Auckland Council identified that “strong messaging from central government on the prioritisation of climate change action” would help to embed support for emissions reduction (sub. 97, p. 59). The Sustainable Business Council emphasised the importance of leadership, including from government (sub. 131, pp. 16-17).

Since submissions were made on the Productivity Commission’s *Low-Emissions Economy Issues Paper*, the country has seen a change of government. The current Labour-led Government has signalled that it sees climate change as a priority issue and “is committed to taking decisive action on climate change and transition to a net zero target by 2050” (Office of the Minister for Climate Change, 2017, p. 1).

Poor coherence

New Zealand’s response to reducing emissions also lacks coherence. The NZ ETS is the key policy tool, but the wider regulatory framework relevant to a low-emissions economy transition does not form a coherent and consistent suite of measures. As observed by PCE:

New Zealand’s laws, regulations and policies have been developed over many decades, but the conviction that, along with the rest of the world, we must reduce carbon emissions is relatively recent. It is inevitable that there will be long-standing inadvertent barriers to reducing emissions. (PCE, sub. 54, p. 9)

Palmer argues that New Zealand’s domestic law on climate change “exhibits the characteristic weaknesses of the New Zealand law-making system”, with incoherence in statutory schemes arising from legislation

being frequently and substantially amended without sufficient care and scrutiny. Palmer (2015, p. 126) notes that the “statute book speaks with many voices in New Zealand on climate change”, citing, for example, provisions that incentivise fossil fuel exploration. Although the CCRA is New Zealand’s primary climate change law, a range of other laws are also relevant to a low-emissions economy yet many do not expressly refer to climate change (such as the Energy Efficiency and Conservation Act 2000, Waste Minimisation Act 2008 and Land Transport Management Act 2003). Specific sectoral regulatory gaps and barriers are discussed in Part 4 of this report.

Submitters identified problems with coordination and a lack of joined-up thinking across government (Box 7.3).

The OECD’s 2015 report *Aligning policies for a low-carbon economy* highlights that policy misalignments in an economy can significantly undermine the effectiveness of climate policy efforts. Misalignments between overall policy and regulatory frameworks and climate goals can send contradictory signals and hinder the low-emissions transition (OECD, 2015a).

Box 7.3 **Lack of coordination and joined up thinking**

Stakeholders were critical of lack of coordination and joined up thinking.

[T]here is no mutual interaction between the Minister, the MfE policy advisers, the public, and our non-governmental experts. (Robert McLachlan, sub. 9, p. 3)

In New Zealand, the development of climate policy is distributed across different government agencies, and can be crowded out by other priorities. (PCE, 2017, p. 20)

Delivering a sustainable transition to a low-emissions economy within the extraordinarily tight timeframes (20–30 years to 2050) requires a coordinated and joined-up approach to climate change and its implications, through identifying opportunities to both reduce emissions and embed resilience. (ADLS, sub. 7, p. 4)

[T]here needs to be a holistic approach to successfully transition towards a low-emissions economy. The statutory framework should not just be focused on a particular act to deal with climate change, but needs to be integrated into all sectors (such as transport, resource management, and primary production). (Rangitikei District Council, sub. 35, p. 3)

[W]e have observed a lack of ‘joined-up thinking’...We believe that these decisions have suffered from a lack of coordination and alignment across the national and local government agencies around New Zealand, which each apply different policy and regulations, and give different weighting to energy, water, and environmental concerns. (Trustpower, sub. 59 (supplementary submission), p. 1)

N.Z. has a number of government departments operating in silos and their own agendas. (Vision Kerikeri, sub. 116, p. 4)

The CCRA is not designed to address the credible commitment problem

The existing CCRA performs valuable functions, but the CCRA is not based on political pre-commitment to a long-term low-emissions goal. Nor is its architecture geared towards promoting long-term stability in climate change policy. Rather, the purpose of the CCRA is focused on:

- machinery needed to comply with New Zealand’s international obligations (eg, powers for the Minister of Finance to manage and trade emission units, setting up a registry to record the holding and transfer of emission units, and establishing a national inventory agency to record and report information about New Zealand’s greenhouse gas (GHG) emissions by sources and removals by sinks); and
- specific policy instruments (the NZ ETS and synthetic gas levy).⁵⁶

⁵⁶ The CCRA comprises seven parts and four schedules: Part 1 – preliminary provisions, Part 2 – institutional arrangements, Part 3 – inventory agency, Part 4 – NZ greenhouse gas emissions trading scheme, Part 5 – sector specific provisions, Part 6 – targets, and Part 7 – synthetic greenhouse gas levy. Schedules 1

While the CCRA does provide for the setting of “targets” either via gazette notice or in regulations, the political executive has broad discretion regarding how, when and what targets are set (or changed) (section 7.5).

The CCRA has also not yet been updated to reflect the Paris Agreement. Amendments to the CCRA were not considered to be legally required for New Zealand to ratify the Paris Agreement, but “substantial amendments to implement and to comply with the [Paris] Agreement” will likely be needed (Office of the Minister for Climate Change Issues, 2016, p. 11).

F7.3

New Zealand’s current emission reduction response is not “fit-for-purpose” for transitioning to a low-emissions economy. A number of deficiencies exist, such as:

- a lack of stability and predictability in climate change policy, reflecting the absence of political consensus about New Zealand’s transition to a low-emissions economy;
- lack of a clear plan for reducing domestic emissions and meeting existing emission reduction targets;
- inadequate central government leadership to drive the low-emissions transition; and
- poor policy coherence for supporting a low-emissions transition.

New Zealand’s emissions are not yet declining; nor are current policy settings likely to lead to adequate emission reductions in the future, let alone do so in a way that achieves the greatest net benefit to New Zealand.

7.3 Calls for a new ‘UK-style’ law

Strong support for a UK-style climate change law for New Zealand

Support for new climate change legislation has been building. In July 2017, the (now former) PCE, Dr Jan Wright, released a report titled *Stepping stones to Paris and beyond: Climate change, progress, and predictability* (PCE, 2017). The PCE report recommended that the Minister for Climate Change Issues develop a Climate Change Transition Bill that contains the key features of the UK’s Climate Change Act 2008. In relation to mitigation, the PCE recommended emissions targets, carbon budgets, policies to ensure carbon budgets are met, and an independent Climate Change Commission. The new PCE has endorsed his predecessor’s recommendation for a UK-style law (PCE, 2018).

A broad range of stakeholders are advocating for New Zealand to adopt a climate change law modelled on the UK Act (Box 7.4).

The current Labour-led Government has announced its intention to introduce a Zero Carbon Bill in 2018, which will set a more ambitious target for emissions reductions by 2050 and establish an independent Climate Change Commission (Office of the Minister for Climate Change, 2017).

Box 7.4 Public support for a new ‘UK-style’ climate change law

Since 2016, Generation Zero has campaigned for its own version of a Zero Carbon Act, and submitted that “a Zero Carbon Act, backed by cross-party agreement, is the most urgent and important law our next Parliament could legislate” (sub. 119, p. 3). Generation Zero’s blueprint is for legislation that commits New Zealand to zero carbon by 2050 or sooner and includes legally binding long-term targets, five-yearly carbon budgets, and an independent Climate Commission. Generation Zero proposes a ‘firewall’ between domestic action and international carbon trading, with the targets in the Act applying

and 2 set out the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Schedules 3 and 4 relate to the NZ ETS (respectively, Activities with respect to which persons must be participants, and Activities with respect to which persons may be participants).

to New Zealand's domestic emissions only. It also proposes a two-baskets approach, where long-lived gases must reach net zero by 2050 or sooner, and short-lived gases must be significantly reduced to sustainable levels, but not zero (Generation Zero, 2017).

Stakeholders show wide support for the PCE's recommendation to implement a UK-style Act in New Zealand, including from the private sector (eg, Z Energy, Meridian, Dairy NZ, Westpac, Contact Energy), local government and non-governmental organisations (eg, the NZ Church Climate Network, Environmental Defence Society). For example:

[W]e support the PCE's recommendation that New Zealand develops a Climate Change Transition Bill which sets emissions targets in legislation, sets carbon budgets, requires policy to be developed that meets those budgets and that we have a Climate Change Commission – an expert body to provide objective analysis and advice. This would provide predictability, reduce New Zealand's risk of an abrupt transition and ensure co-ordination between corporates and government agencies to achieve those targets. (Contact Energy, sub. 29, p. 1)

ARPHS and the DHBs recommend a similar framework [to the UK Climate Change Act] be implemented in New Zealand, one that recognises the different dynamics of our emissions profile, and enables consistent and long-term planning across multiple terms of government in how best to meet our emission targets. (Auckland Regional Public Health Service, sub. 105, pp. 14–15)

The Parliamentary Commissioner highlights the importance of having an independent expert commission on climate change, setting emissions targets or carbon budgets in law that reduce over time to meet our Paris commitments; with the additional requirement for the Government of the day to then develop policies that enable the budgets to be met within a context of rigorous monitoring. The UK's approach provides an example of safeguarding the independence needed to insulate the policy system from short term political pressures...The Committee supports such an approach. (ADLS, sub. 7, p. 4)

The PCE recommended a new Climate Change Act and to put emissions targets into law in recognition that a long term cross party approach is required [for] what most regard as the ultimate intergenerational issue. NZWEA shares the PCE's view that we need to look decades ahead and supports the Report's recommendations. (NZ Wind Energy Association, sub. 40, p. 7)

Meridian strongly supports the recent report and recommendations from the Parliamentary Commissioner for the Environment (PCE), *Stepping stones to Paris and beyond: Climate change, progress, and predictability*. The report outlines opportunities to strengthen New Zealand's action on climate change and provides a set of ideas that would assist in embedding support for reductions in domestic greenhouse gas emissions. In particular the report advocates for the country's Paris Agreement targets to be passed into law, and the establishment of interim carbon budgets to transparently track progress towards the targets over time and provide long-term certainty to business. (Meridian Energy Limited, sub. 55, p. 15)

The United Kingdom's Climate Change Act 2008

The United Kingdom's Climate Change Act 2008 (the UK Act) sought to provide a "clear, credible and long-term framework that will provide greater clarity and confidence for businesses and individuals to plan and invest in delivering the changes needed to move to a low carbon economy" and demonstrate leadership through example (Miliband, 2007). The UK Act is viewed as world-leading and has acted as a model for legislation in a number of other jurisdictions.

Despite its ambitious nature, the UK Act had overwhelming support during its passage through Parliament. A series of events had seen climate change rise rapidly up the UK policy agenda after the 2005 election, and by the end of 2006 the idea of a Climate Change Bill had cross-party support.

The UK Act sets up a framework for the United Kingdom to achieve its long-term GHG emission reduction goals, as well as to ensure steps are taken to adapt to climate change impacts. The core pillars of the UK Act for emissions reduction are:

- the setting of statutory long-term emission reduction targets, with accompanying five-yearly carbon budget ‘stepping stones’ to the long-term target;
- the establishment of an independent body (the Committee on Climate Change) to advise on achieving emissions targets and budgets;
- a requirement for the Government to prepare proposals and policies to meet carbon budgets; and
- a suite of monitoring and reporting obligations, based around mandatory reporting to Parliament.

The key features of the UK Act (in the context of climate change mitigation) are summarised in Table 7.1.⁵⁷ Further detail about the provisions in the UK Act is set out in the Commission’s research note titled *Examining the UK Climate Change Act 2008* (Weeks, 2017).

Table 7.1 Key elements of the United Kingdom’s Climate Change Act 2008

Core element	Details
Long-term target	<p>GHG emissions-reduction target for 2050 set in primary legislation, with a corresponding duty on the Secretary of State to ensure the target is met.</p> <p>The Act limits when and how the long-term target can be amended.</p>
Carbon budgets	<p>Secretary of State must set five-year carbon budgets (limits on the amount of net GHG emissions during the budget period) that are consistent with meeting the 2050 target (as well as a medium-term 2020 target).</p> <p>The Act requires that certain matters are considered when setting carbon budgets, and prescribes the process for setting budgets (which includes considering advice from the Committee on Climate Change, and explaining any deviation from that advice).</p> <p>The Act limits when and how carbon budgets can be amended.</p>
Planning to meet carbon budgets	<p>After each carbon budget is set, the Secretary of State must prepare proposals and policies to enable existing (current and future) carbon budgets to be met.</p>
Committee on Climate Change (CCC)	<p>The Act creates the CCC as a new independent non-departmental public body.</p> <p>The CCC has two key roles:</p> <ul style="list-style-type: none"> • to advise (including in particular on carbon budgets); and • to report (on the United Kingdom’s progress towards meeting its climate change targets).
Monitoring and reporting obligations	<p>Mandatory direct reporting to Parliament by both the Government and the CCC. For example:</p> <ul style="list-style-type: none"> • the Government must report once a year on the United Kingdom’s GHG emissions; • the CCC must report once a year on progress towards budgets and targets; • the Government must respond to the CCC’s progress reports; and • the Government must report on its proposals and policies for meeting current and future carbon budgets.

The UK Act remains highly regarded. The legislation has driven action, including the setting of five carbon budgets that collectively cover the period 2008–2032 and the preparation of proposals and policies for meeting carbon budgets (including the latest Clean Growth Strategy, released in October 2017). Regular reporting to Parliament has enhanced transparency and accountability, and the independent CCC has built an excellent reputation and high credibility. During the course of this inquiry, the Productivity Commission has engaged with a range of UK stakeholders (including from the CCC, Parliament, government

⁵⁷ The UK Act also contains provisions dealing with adaptation. This report does not address the adaption provisions given this inquiry’s limited terms of reference in relation to adaptation.

departments, industry organisations and NGOs) about their experience with the UK Act. The consistent overall message was very positive about the UK Act and its achievements, with a general consensus that the United Kingdom would not have made the same level of progress without the Act.

A number of other countries have modelled their laws on the UK Act. Core elements of the UK Act (long-term targets, carbon budgets, an independent body, mandatory strategies and/or reporting obligations) are found in legislation in other jurisdictions. Those jurisdictions include, for example, Denmark's Climate Change Act (2014), Finland's Climate Change Act (2015), France's Energy Transition for Green Growth law (2015), Mexico's General Law on Climate Change (2012), Philippines' Climate Change Act (2009), Sweden's Climate Act (2017), and Victoria's (Australia) Climate Change Act (2017). Yet each country's laws are different, and the detail of the legislation in each country would need to be carefully examined to understand how far it replicates the UK Act, and the rationale for any departures from the UK model (including relevant cultural, political and constitutional contexts).

Despite the UK Act's successes, implementing the Act is likely to become increasingly challenging; indeed, some commentators have argued that the Act's ongoing political durability is at risk (Gillard, 2016; Lockwood, 2013). Although the United Kingdom met its first carbon budget (2008–2012) and is expected to outperform against its 2013–2022 budgets, a 'policy gap' currently exists for meeting the subsequent budgets (the fourth and fifth budgets that cover 2023–2032). In its 2017 report to Parliament, the CCC warned:

UK emissions have fallen while the economy has grown, but progress will not continue without new policies. It would be wrong to assume that the UK has permanently shifted to a path of falling emissions. Three-quarters of the decline in emissions from 2012 to 2016 has come from the reduction in the use of coal for power generation, which is now at low levels. Eliminating the remaining coal-fired generation would deliver less than two years' worth of the required progress to 2030. In stark contrast, emissions from transport (which make up 26% of total emissions) were higher in 2016 than in any year since 2009. (Committee on Climate Change, 2017, p. 8)

Legislation must be carefully tailored to fit the New Zealand context

There is no "one-size-fits-all" model for good climate-change legislation. International approaches (including the design of the UK Act), as well as New Zealand's own experience in other policy domains, can provide useful insights about frameworks and principles. Ultimately however, New Zealand's climate-change legislation must be carefully designed to fit the particular New Zealand context. The relevant context for New Zealand's transition to a low-emissions economy (which is materially different from the context in which the UK Act was enacted) includes:

- the relatively small size of New Zealand's economy (where, for example, a single business operation may constitute an entire industry, and there are limits to the country's research and analytic resources);
- New Zealand's unusual emissions profile (Chapter 2), which has implications for the nature of its low-emissions transition (Chapter 3);
- the NZ ETS as New Zealand's key policy tool for reducing emissions;
- the current lack of political consensus about the nature and pace of New Zealand's transition to a low-emissions economy; and
- New Zealand's constitutional environment and political economy (including for example Te Tiriti o Waitangi, how government operates, and parliamentary procedures).⁵⁸

⁵⁸ For example, legislation needs to be tailored to reflect New Zealand's parliamentary procedures and practices. As identified by PCE, differences exist in both how governments operate, and in the parliamentary rules and practices between the two countries. PCE notes:

"One such difference is the use of the affirmative resolution procedure for enacting secondary legislation. This procedure is commonly used in the UK Parliament, but in New Zealand is generally reserved for decisions about Offices of Parliament and parliamentary agencies. (See Regulations Review Committee, May 2007, *Inquiry into the Affirmative Resolution Procedure*, and the Government Response). In the UK Climate Change Act, the affirmative resolution procedure is used for amending targets and baseline years, setting and altering carbon budgets, adding new targeted greenhouse gases, and setting regulations on international aviation and shipping." (PCE, 2017, p. 25).

As identified by the PCE (2018), differences between the United Kingdom and New Zealand contexts mean that New Zealand’s legislation cannot simply be a “carbon copy” of the UK Act.

The international framework for addressing climate change has also changed since the inception of the UK Act.⁵⁹ New domestic legislation in New Zealand needs to take account of the Paris Agreement and ensure that it complies with international obligations (Legislation Advisory Committee, 2014; New Zealand Government, 2016). Not all aspects of the Paris Agreement are legally binding at international law and the Agreement gives countries a high degree of sovereign discretion (Box 7.1). So decisions about precisely how the Paris Agreement is reflected in domestic law must be made.

Political durability is key

As discussed in section 7.1, laws and institutions will not endure unless underpinned by political consensus.

The importance of achieving political consensus was a strong theme in submissions (Box 7.2). BusinessNZ and others cautioned that “[n]ew Acts, institutions and mechanisms, regardless of how stable or independent they are claimed to be, are only independent (if they are that at all) and provide predictability while a political consensus exists” (BusinessNZ sub. 89, p. 5; Motor Industry Association, sub. 51, p. 3; Export NZ, sub. 91, p. 7). Submitters also expressed concern about creating an independent climate change body unless it is backed by cross-party support (Ballance Agri-Nutrients, sub. 34; Evonik Industries, sub. 46; Straterra, sub. 69; NZ Institute of Forestry, sub. 73). NZ Carbon Farming emphasised the need for cross-party agreement to ensure any arrangement remains in place regardless of the make-up of government. It noted “[w]e are encouraged by the collaborative cross-party effort made by GLOBE New Zealand and believe this indicates the current political environment would endorse such an approach” (sub. 95, p. 19).

The importance of achieving political consensus should therefore be given high priority when developing any new statutory and institutional arrangements, with an aim of enacting legislation that has a strong prospect of being politically durable. The GLOBE-NZ initiative fostered cross-party collaboration on climate policy between 2015 and 2017, and is a valuable forum for helping to build political consensus in the current Parliament. The Minister for Climate Change Issues has indicated that he will be seeking to build cross-party support for the proposed Zero Carbon Bill (Edwards, 2018; Office of the Minister for Climate Change, 2017).

Some political compromise is likely to be needed to create durable laws and institutions. Yet it is neither necessary nor realistic for consensus to extend to all policy details about how the low-emissions transition should be achieved. The key is to have consensus about New Zealand’s long-term, low-emissions goal and the core legal and institutional architecture supporting that goal.

F7.4

Inquiry participants and others showed strong support for implementing a UK-style Climate Change Act in New Zealand.

R7.1

The broad principles and framework of the United Kingdom’s Climate Change Act should be used as a basis for designing a new architecture for New Zealand’s climate change legislation. Yet such a legislative framework should be carefully tailored to fit the New Zealand context.

R7.2

The Government should seek to achieve a high level of political support and consensus for new climate change legislation, with an aim of enacting legislation that has a strong prospect of policy and legislative durability regardless of the make-up of the government.

⁵⁹ The UK will, for example, be reviewing its long-term emissions-reduction targets in light of the Paris Agreement (Darby, 2018; Harvey, 2018).

7.4 Designing a Climate Change Act

Common threads for statutory frameworks dealing with long-term policy problems

Although the architecture of the UK Act is not mirrored in the current CCRA, some design elements are common to both the UK Act and New Zealand's statutory frameworks for regulating fiscal and monetary policy (Box 7.5). The regulatory regimes are all based on a political pre-commitment, seek to promote policy stability and require long-term thinking.

Box 7.5 New Zealand's regulatory frameworks for both fiscal policy and monetary policy

Fiscal policy

Fiscal regulation (as originally introduced by the Fiscal Responsibility Act 1994) aimed to establish a stable fiscal operating environment. The legislation "was intended to require transparent reporting of a government's fiscal intentions and to encourage governments to consider the long-term consequences of policy decisions" (The Treasury, 2005, p. 33). The statutory framework is founded on increased transparency and greater accountability, which is achieved by requiring governments:

- to be explicit about their long-term fiscal objectives and short-term fiscal intentions, and to assess them against principles of responsible fiscal management, and
- to report on a wide range of economic and fiscal information.

Monetary policy

The regulatory framework for monetary policy (under the Reserve Bank of New Zealand Act 1989) includes:

- specifying one macroeconomic objective for monetary policy (price stability);
- creating an independent central bank, the Reserve Bank of New Zealand (Reserve Bank), with autonomy to implement monetary policy directed to the price-stability objective;
- setting specific policy targets (under a Policy Targets Agreement between the Governor of the Reserve Bank and the Minister of Finance);
- accountability and reporting provisions, such as a duty on the Governor of the Reserve Bank to ensure the actions of the Reserve Bank in implementing monetary policy are consistent with the set policy targets, and requirements for the Reserve Bank to publish regular monetary policy statements.

Source: Lloyd (1992); State Services Commission (1996); The Treasury (2005).

While the specific design details differ, the statutory frameworks share:

- pre-commitment to clear and explicit high-level, long-term goals and a focus on progress towards those goals;
- core principles of transparency and accountability;
- mechanisms that seek to promote stability but retain a degree of flexibility; and
- mandatory procedural requirements, including transparency via reporting obligations.

These features are important elements of statutory frameworks designed to encourage long-term commitment and policy stability.

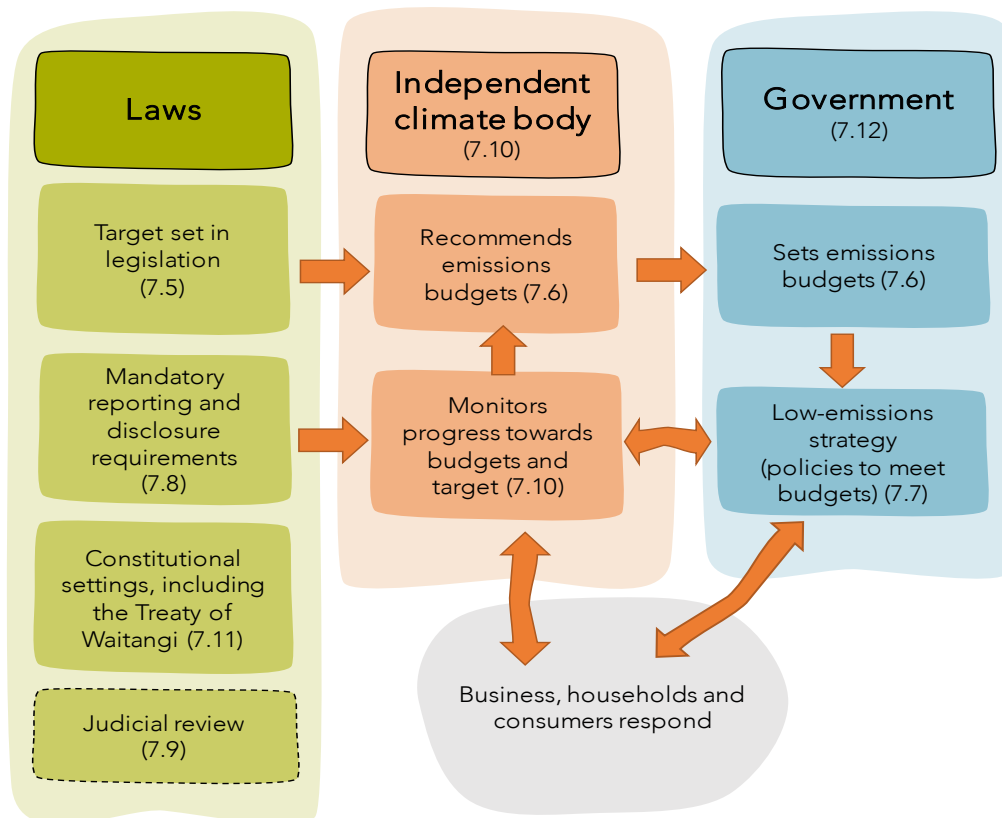
F7.5

Key elements of statutory frameworks that promote policy stability and require long-term thinking include:

- clear and explicit high-level, long-term goals and a focus on progress towards those goals;
- core principles of transparency and accountability;
- mechanisms that seek to promote stability but retain a degree of flexibility; and
- mandatory procedural requirements, including reporting obligations.

The rest of this chapter explores key elements of, and design issues for, a new Climate Change Act. Specific issues discussed are legislating emission-reduction targets (section 7.5), emissions budgets (section 7.6), a low-emissions economy strategy (section 7.7), the power of strong process (section 7.8), and achieving compliance (section 7.9). The role and design of a new Climate Commission is analysed (section 7.10), along with the need to recognise the Treaty of Waitangi (section 7.11) and for central government leadership (section 7.12).

Figure 7.1 Laws and institutions to support the low-emissions transition



7.5 Legislating emission reduction targets

A new Climate Change Act needs clear and explicit objectives, and a focus on progress towards achieving long-term goals. This section examines whether it is appropriate to legislate a (quantitative) emissions-reduction target, and discusses key design issues for such a target.

Should a (quantitative) emissions-reduction target be set in law?

Legislated targets function as a commitment device. Essentially, “the effect of legislated targets is to try to bind the hand of successor governments” (Rutter & Knighton, 2012, p. 5).

The UK Act enshrines a legislated target as a key regulatory goal: it is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline.⁶⁰ By contrast, New Zealand's regulatory framework for fiscal policy does not set quantitative fiscal targets in legislation. Instead, legislating *principles* was considered preferable to legislating fiscal *targets* (Janssen, 2001; Scott, 1995; The Treasury, 2015a). The reasons why mandatory targets were rejected included:

- lack of a solid theoretical justification for any particular fiscal target that can be maintained;
- other countries' experience of legislated targets suggesting that substantial risks are attached to their use, particularly that rigid adherence can seriously distort decision making and, unless carefully handled, minor variations from targets can result in significant yet unnecessary damage to credibility;
- the inherent inflexibility of targets that makes it difficult for fiscal policy to respond appropriately to the inevitable volatility of economic circumstances; and
- fiscal targets can be effectively and often comprehensively evaded, and without the political will to achieve targets, ways are inevitably found to avoid them.

Setting targets in legislation has advantages and disadvantages, as shown in Table 7.2.

Table 7.2 Examples of potential advantages and potential disadvantages of legislating targets

Potential advantages	Potential disadvantages
Well specified legislated policy targets can help give clarity about policy objectives.	Is a low-cost way for the government to give the appearance of vigorous action without actually having to commit to take measures in the short term
Provides an internal signal to the rest of government about the priority the Government attaches to an issue. Likely to create a stronger influence on civil service (and ministerial) behaviour than more weakly articulated priorities or statements of principles (reflecting that governments are institutionally disposed to obey the law)	Has the potential to be used as an alternative to winning the political argument and establishing a new political consensus
Provides an external signal of the seriousness of government intent	Risks a target being set without clarity on the measures required to meet it and therefore without adequate analysis of costs and benefits of trying to meet the target
Is a way to influence decision making on a continuing basis	Poorly specified targets can drive the wrong policy, produce perverse outcomes and distort spending priorities
Can make government action more resilient and less sensitive to tides of popular opinion	Introduces an element of legal uncertainty, particularly about how a target is enforced and the role of the judiciary

Source: Adapted from Rutter & Knighton (2012).

On balance, the Productivity Commission considers that setting a quantitative long-term emissions-reduction target in law is appropriate, provided the target is well designed. In particular:

- There is an environmental imperative for setting a quantitative emissions-reduction target. The transition to a low-emissions economy is fundamentally driven by the global need to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (Article 2, UNFCCC, 1992). This core objective is reflected in the Paris Agreement's aims of reaching net-zero global GHG emissions in the second half of this century and limiting temperature rise to well below 2°C (Chapter 2). Because the amount of GHGs released to the atmosphere directly relates to temperature (Chapters 2 and 8), a science-based justification for emission reduction targets exists (although target setting is not a purely scientific exercise because the global nature of climate change

⁶⁰ In addition to setting the 2050 target in primary legislation, the UK Act also provides for a system of five-yearly carbon budgets that must be set consistently with the 2050 target.

creates political debate about each country's 'fair' share of mitigating emissions). Legislating domestic emission reduction targets aligns with the international architecture for climate change mitigation. New Zealand has committed to setting (progressively more ambitious) NDCs, and the Paris Agreement expressly provides that developed countries should "continue taking the lead by undertaking economy wide absolute emission reduction targets" (Article 4.4).

- Mitigating climate change involves long time horizons. A legislated target can function as a commitment device to require governments to take a long-term view and promote policy stability. Setting a target in law elevates its status. Given the long-term nature of climate change and time inconsistency challenge, the internal and external signalling and ongoing influence on decision making that a legislated emissions-reduction target can provide is important. The implications of legislated targets would, for example, need to be recognised in government fiscal and economic reports and risk analyses.

Even so, legislated targets must be "constructed carefully". Characteristics of good target design include:

- a focus on the desired high-level outcome, without being overly prescriptive about how the goal is reached;
- realistic targets, which requires an assessment of the measures needed to achieve the target and an awareness of the policy tools that the government has at its disposal; and
- built-in flexibility to adjust targets in the light of major changes in circumstance, but without undermining the purpose or credibility of the target (Rutter & Knighton, 2012).

Targets should not be set in law without close scrutiny of the implications of doing so, which requires (among other things) an understanding of what sort of measures might be needed to meet the target. As Rutter and Knighton (2012) highlight:

Parliament should recognise the constitutional implications of one government seeking to bind its successors and making policy more justiciable, and therefore should subject such bills to (even) more rigorous scrutiny than normal legislation. Not just the formulation of the target but also the measures that might be required to deliver it should be subject to scrutiny as well as the compliance regime. (p. 12)

[A] target should be seen as a means, not an end, for policy and setting a target is not a substitute for putting in place the measures needed to achieve the objective. It is too easy to applaud the government's willingness to set a heroic goal – without testing the feasibility and desirability of doing what it takes to meet that objective. (p. 13)

To provide long-term stability, a legislated long-term emissions-reduction target needs to be durable. The process for setting a statutory target must therefore be robust and inclusive (including rigorous analysis and debate, and broad stakeholder engagement). Achieving substantial cross-party support for a statutory target is key (section 7.1). As the Morgan Foundation (sub. 127) observed:

In our view there needs to be a fairly high degree of rigidity around the 'what' – in particular getting strong buy-in to the emissions outcomes. This is central to the successful functioning of a UK-style law. Adaptability is mainly needed in the 'how'. (p. 23)

Key design issues for a long-term target

It is critical to carefully consider the details of any proposed statutory target. As identified by Rutter and Knighton (2012, p. 7), "[f]orm matters. Once a decision has been taken to put a target into law, the formulation becomes very important." Key design issues to address include:

- the nature of a statutory target or targets (including the target year, which GHGs are covered by the target, whether the target is expressed as a point-in-time emissions target or as a limit on the total quantity of allowable emissions by the target date, whether the target is for gross emissions or net emissions after carbon sink removals, and whether the target is based only on domestic emissions or allows the use of international credits);
- whether, when and how the statutory target(s) can be amended;

- the nature of the obligation to meet the target (the UK Act for example puts an unqualified duty on the Secretary of State to ensure that the long-term target is met); and
- whether the target(s) is set in primary or delegated legislation.

An important issue is whether (and if so, how) separate targets for long-lived and short-lived gases should be set in law (to reflect the need to give greater relative priority to reducing emissions of long-lived gases, as well as drive substantial and sustained emissions reductions of short-lived gases). The issue of treating gases differently is discussed in Chapter 8.

A legislated target must be unambiguous and should not be easy to amend. The Productivity Commission agrees with the PCE that a transparent process for amending a target requiring the disclosure of clear reasons and seeking parliamentary assent “would instil a discipline that would discourage arbitrary changes of ambition in response to short-term considerations” (PCE, 2018, p. 20).

The current target-setting provisions in the CCRA are not a good model for legislating a target in a new Climate Change Act. While the CCRA does provide for the setting of “targets” either via gazette notice or in regulations, the political executive has broad discretion about how, when and what targets are set (or changed). In practice, use of the CCRA’s target-setting provisions has been *ad hoc*, and only non-binding targets have been set (via gazette notice): Box 7.6.

Legislation should be designed to help deliver greater clarity about the nature and pace of New Zealand’s **domestic** low-emissions transition. There are different ways a legal framework could achieve this, for example framing a long-term target in relation to domestic emissions, or (as with the UK Act) requiring the Government to set limits on any use of international credits at specified times in the future.

Box 7.6 Target setting under the Climate Change Response Act

Part 6 of the CCRA provides for two target-setting processes: gazetting of targets via publication in the New Zealand Gazette (section 224), and making regulations that set a target (section 225). These target-setting provisions did not form part of the CCRA as originally enacted in 2002, but were added later (section 224 in 2008, followed by section 225 in 2009).⁶¹

The CCRA does not define the term “target”. A target must be set, but this can be done either by gazette notice or by regulation. Any number of targets may be set, and there are few constraints on when targets can be set, amended or revoked.

To date, two targets have been gazetted: various sectoral targets adopted by the Labour-led Government in 2008, and New Zealand’s 2050 target (set in 2011). Gazetted targets are not binding on the Government or other entities (Harker et al., 2017; Rive, 2011).

The extent of the executive’s target-setting discretion is evidenced by:

- the Government’s decision to simply gazette the new 2050 target, without revoking the existing 2008 sectoral targets (despite those sectoral targets no longer appearing to remain government policy when the 2050 target was set);
- New Zealand’s 2020 and 2030 targets having been adopted as commitments under the international UNFCCC framework, but not formally set as targets under the CCRA; and
- no targets having yet been set by regulation, despite the original intention that the 2050 target be set using the new regulation-making process (Rive, 2011; Rive & Harker, 2017).

⁶¹ Section 224 was introduced in 2008 following a late Supplementary Order Paper addition to the bill amending the CCRA, and section 225 followed in 2009 as part of further changes to the CCRA.

Should targets be set in primary or delegated legislation?

The United Kingdom's long-term target is set in primary legislation. By contrast, the CCRA provides for targets to be set via gazette notice or by regulation (Box 7.6).

Commonly accepted principles guide what material is suited to primary or delegated legislation. The accepted general rule is that matters of substantive policy should be included in primary legislation, while delegated legislation is suitable for matters of detail or implementation, of a technical nature or those likely to require frequent alteration or updating (Cabinet Office, 2017; Legislation Advisory Committee, 2014). The Productivity Commission has however previously identified that there is scope for greater use of delegated legislation in New Zealand (NZPC, 2014).

The Productivity Commission considers that the nature and role of a long-term emission reduction target means it should be set in primary legislation. Emission reduction targets are a matter of substantive policy, and would function as a core statutory objective under a new Climate Change Act. A statutory target also needs to be durable, so it is not a matter for frequent amendment. Setting a target in primary legislation also elevates the status of the target, signalling Parliament's commitment to the emissions-reduction goal. As Macrory (2014, p. 264) explains, setting a long-term target in primary legislation "gives it a moral dimension and permanence", and while the target could be removed by a future government this would have to be done by new legislation, subject to public and parliamentary scrutiny.

F7.6

Legislated emissions-reduction targets are important commitment devices that act to bind the political executive to govern in line with the long-term commitment of a low-emissions economy. Such targets would have authority and durability. Well-designed legislative targets are:

- focused on the desired high-level outcome, without being overly prescriptive about how the goal is reached;
- determined through a robust public policy process and achieve broad buy-in from those affected;
- realistic, and require an assessment of the measures needed to achieve the target and an awareness of the policy tools that the government has at its disposal;
- directly related to the underlying climate change problem;
- stable over time, yet have some built-in flexibility to be adjusted in the light of major changes in circumstance, but without undermining their purpose or credibility; and
- clear about the nature of the obligation to meet them.

R7.3

A long-term greenhouse gas (GHG) emissions-reduction target should be set in primary legislation. Legislative emissions targets require careful design and should be formulated following a robust public policy process seeking broad agreement.

7.6 Emissions budgets

In addition to setting a long-term target, the UK Act also provides for a system of carbon budgets. Each budget covers a five-year budget period. The first three carbon budgets were set shortly after the legislation was enacted, with subsequent budgets then set approximately 12 years in advance. Carbon budgets operate to set a limit on the total amount of allowed emissions during the budget period, but allow flexibility as to how the overall budget is met.

Given the different types of GHGs (not just carbon dioxide), the Productivity Commission considers that "carbon budgets" are better termed "emissions budgets".

Benefits of emissions budgets

Emissions budgets function as a mechanism to help achieve (and monitor progress towards) a long-term target; they are “stepping stones” that provide a clear yet flexible pathway to the long-term target (Fankhauser et al., 2018; PCE, 2017). Setting emissions budgets a number of years in advance provides valuable early signalling about the pace of a low-emissions transition, as well as protecting the budget-setting process from short-term political calculations (Fankhauser et al., 2018). A system of emissions budgets can reduce the risk of abrupt transitions, therefore helping to maximise the benefits and reduce the costs of reaching a long-term target (OECD, 2017c; PCE, 2017; RSNZ, 2016; Stern, 2007; World Bank, 2015). This is particularly so given that the lowest cost path to a long-term target “is likely to involve steady action, avoid stop-start investment and ensure sufficient lead time for making more difficult changes” (Thompson, 2016).

Importantly, emissions budgets can function as more than just “stepping stones” to help achieve an ultimate longer-term target. By setting limits on the amount of emissions allowed in each budget period (ie, the level of the carbon budget), budgets control the total volume (or “stock”) of GHG emissions released to the atmosphere in the period leading up to the long-term target date. By comparison, long-term targets are typically expressed as emission “flow” targets for a particular year. That is, they require X% reduction in GHG emissions at a particular point-in-time (for example, New Zealand’s current 2050 target is for a 50% reduction in New Zealand’s net GHG emissions from 1990 levels by 2050), but do not limit the total “stock” of GHG emissions that can be emitted leading up to the target date. A long-term, point-in-time target could therefore be met by initially allowing emissions to rise unabated, but then making late, deep cuts in emissions. In contrast, fewer emissions would be released to the atmosphere if the same target is instead met through a system of progressively tighter emissions budgets (Figure 2.1 in Chapter 2).

In the New Zealand context, an emissions budget system would also help to guide the setting of NZ ETS caps (as recommended in Chapter 4).

Designing an emissions budget system

Legislating for emissions budgets raises similar design issues to those discussed in relation to legislating for a long-term target. The detail matters. Design issues for emissions budgets include (1) the budget period; (2) what the budget covers and how it can be met; (3) the process and timing for setting budgets; and (4) whether, when and how budgets can be amended.

The basis on which emissions budgets are set, and the process for setting them, is critical. Legislation should specify key matters that must be considered when setting budgets. Those key matters should include climate science and technology, but also wider factors such as economic and social impacts and Treaty of Waitangi considerations.⁶² Emissions budgets need to be based on robust and transparent analysis that demonstrates the budget level is consistent with achieving the ultimate emissions-reduction targets while imposing least cost on the economy and society. Government should set emissions budgets, but only after considering independent expert advice (section 7.10).

An emissions budget system needs to carefully balance predictability and flexibility. To provide signalling and predictability about the low-emissions transition, budgets should be authorised by Parliament and set a number of years in advance. Once set, emissions budgets should only be able to be amended in very limited circumstances and with Parliament’s approval.⁶³ To be credible and durable, a budget system also needs to be flexible enough to accommodate uncertainty about future pathways (Chapter 3). The nature of the flexibility mechanisms to be built into New Zealand’s emissions budget system should be carefully considered. The UK Act, for example, provides flexibility through the use of multi-year budget periods (which allows smoothing of factors such as the impact of yearly weather fluctuations on emissions and short-term economic events). The Act also sets budgets on a “net carbon account” basis (so the budget does not just cover gross UK emissions, but also takes into account removals from UK carbon sinks and emission units

⁶² The UK Act sets out the matters that must be considered when setting carbon budgets. Those matters include scientific knowledge about climate change, technology relevant to climate change, economic circumstances, fiscal circumstances, social circumstances, energy policy and international circumstances (section 10).

⁶³ Under the UK Act, carbon budgets are set, or amended, by order of the Secretary of State, but subject to the affirmative resolution procedure (that is, both Houses of Parliament must approve the order).

that are traded internationally⁶⁴), and allows “banking” of any budget surpluses to the next budget period and limited “borrowing” (1% maximum) from the next budget. It also allows budgets to be amended if there have been significant changes in the factors that formed the basis on which a budget was set.

The detail of an emissions budgets system will need to be tailored for New Zealand, including to ensure that NZ ETS caps (as recommended in Chapter 4) are set at a level consistent with emissions budgets. Statutory emissions budgets should drive the level of ambition in New Zealand’s NDCs under the Paris Agreement (rather than the other way around). Even so, how a domestic emissions budget system fits with the Paris Agreement’s NDC framework and timing cycle (eg, the requirement to submit a new or updated NDC by 2020 and every five years after that) needs to be carefully considered.

F7.7

Emissions budgets help to translate long-term targets into clear and specific short-term actions. They provide visible “stepping stones” to achieving a long-term target and help reinforce steady action on, and accountability for, achieving a long-term target. By setting limits on the “stock” of GHG emissions, emissions budgets can also helpfully restrict the total quantity of GHGs released to the atmosphere on the path to a long-term target.

R7.4

A new architecture for New Zealand’s climate change legislation should provide for a system of emissions budgeting, whereby short-term limits on emissions are periodically set by government, and progress toward their achievement is reported publicly. To be credible and durable, an emissions budgeting system must carefully balance predictability and flexibility, and budgets should be set at a level consistent with achieving the long-term target while imposing least cost on the economy and society.

7.7 A low-emissions economy strategy

A legislated long-term target and system of emissions budgets would set emission reduction goals, but would leave open how those targets and budgets are to be met – particularly given that setting of budgets and implementing policy measures to meet them would be “decoupled in time” (PCE, 2018, p. 14). Statutory targets and budgets therefore need to be supported by mechanisms to promote transparency about the policies that government intends to implement to meet emissions budgets and long-term targets.

A statutory requirement for the Government to prepare and publish its low-emissions strategy would provide valuable signalling to stakeholders about the Government’s proposed policy settings, as well as promoting government accountability for meeting emissions budgets.

What sort of strategy?

A low-emissions strategy should set out the Government’s short-term policy plans, but should also look to the longer term. That is, it should set out a strategy for meeting both current and future emissions budgets, and with a view to meeting the ultimate long-term target. A long-term strategy would be consistent with the Paris Agreement, which provides that Parties “should strive to formulate and communicate long-term low greenhouse gas emission development strategies” (Article 4.19), with countries invited to communicate these strategies to the UNFCCC by 2020 (UNFCCC, 2018a).

The 2050 Pathways Platform (a multi-stakeholder initiative launched at the 2016 UN climate conference that aims to support the development of long-term deep decarbonisation strategies) recognises that “having a good plan is never a sufficient condition for success, but not having one is always a recipe for failure”

⁶⁴ International trading in the UK context includes trading by some sectors within the European Union Emissions Trading Scheme, as well as the ability for the United Kingdom to acquire other international emissions units (within set limits) to help meet carbon budgets.

(UNFCCC, 2016). Long-term, low-emission strategies can help to place short-term actions in the context of the long-term structural changes required to transition to a low-emissions economy (Waisman et al., 2016).

A low-emissions strategy should be a broad and far-reaching economy-wide document that deals with all sectors of the economy and all relevant policy and regulatory instruments (including emissions pricing, as well as complementary policies, investments and regulations). It should set out detailed policy proposals for the shorter term, particularly how the Government intends to ensure that the country meets the current emissions budget and, if the start of a new budget period is imminent, then the intended approach for meeting the forthcoming budget. But it is not realistic to expect a strategy to be as definitive about how emission budgets for periods some way into the future will be met, particularly where budgets are set 10 years or more in advance. A statutory duty to prepare a low-emissions strategy therefore needs to consider the practical and political reality that policy will unfold over decades. Strategies for the long term will inevitably be less certain and well-defined than those for the short term (as illustrated for example in the fiscal policy context by the different character and content of the Government's long-term fiscal statement compared with three-year forecasts).

A smart strategy needs to take account of deep uncertainties about different potential pathways to a low-emissions economy (such as the impact of technological change) and allow an appropriate degree of responsiveness to new information (Chapter 3). A low-emissions strategy therefore cannot be a "set-and-forget" document; rather, it will need to be updated to take account of new emissions budgets once set, and also adjusted in light of changing circumstances. It is a strategy, not a blueprint (BEIS, pers. comm., 13 November 2017).

A low-emissions strategy should not be solely focused on achieving the required emission reductions (eg, policies to meet carbon budgets, such as setting NZ ETS caps to limit emissions from ETS sectors). The strategy should also reflect the need to maximise the benefits and minimise the costs of the transition, which may require additional measures such as policies directed at reducing abatement costs and managing distributional effects of the transition.

The UK's Clean Growth Strategy provides a useful example of the sort of content that a low-emissions strategy might include, such as priority policies and proposals (including intended timeframes for implementing particular policies or making policy decisions, and areas for future policy development), key opportunities and challenges, and modelling of potential pathways for meeting future budgets (including estimated projections of emissions by sector).

R7.5

Government should have a statutory duty to prepare and publish a long-term economy-wide low-emissions strategy. The strategy should set out the Government's policies and proposals for meeting both current and future emissions budgets (and with a view to meeting the long-term target), and should be updated after each new emissions budget is set.

F7.8

Matters to consider when formulating a requirement to prepare a low-emissions strategy include the need for:

- flexibility and responsiveness;
- recognition that strategies for the long term will inevitably be less certain and well-defined than those for the short term; and
- a strategy to not only address policies that achieve the required emission reductions, but also how to maximise benefits and minimise the costs of the transition.

7.8 The power of process

Clear, mandatory process forms the backbone of statutory frameworks designed to promote policy stability and require long-term thinking.⁶⁵ Statutory procedural requirements are powerful; they act as a “legal metronome that keeps ticking” (Baroness Worthington, pers. comm., 7 September 2017). Procedures can enhance transparency and help to maintain momentum for, and scrutiny of, government action on long-term policy issues. Statutory requirements (with clear deadlines) are particularly important given the time inconsistency challenge posed by climate change, as they force government to address key low-emissions transition issues rather than “kick them down the road” (BEIS, pers. comm., 13 November 2017).

Procedural requirements can also help to improve the quality of decision making by influencing the information available to decision makers at the time the relevant decision is made. For example, the UK Act’s requirement that the Government consider the CCC’s advice when setting budgets (and publicly explain any departure from the CCC’s advice) changes the “choice architecture” for government decision-making (Boston, 2017).

Statutory processes also play an important role in promoting compliance, as discussed in section 7.9.

Setting an appropriate procedural metronome

The monitoring and reporting framework in the UK Act was designed to “enhance the overall transparency and accountability of UK action on climate change” (HM Government, 2007, p. 10). It requires direct reporting to Parliament by both the Government and the CCC on a range of matters such as annual reports on GHG emissions, reporting on progress towards meeting budgets and targets, and reporting on the Government’s proposals and policies for meeting budgets.⁶⁶ New Zealand’s domestic climate change statutory framework should similarly require regular reporting to Parliament on key aspects of New Zealand’s transition to a low-emissions economy.

Legislation needs to set a procedural metronome that provides for regular review and reporting, but without over-engineering procedural obligations. An appropriate balance needs to be struck between “doing” and “reviewing”. Statutory processes also need to function as a coherent package.

In the United Kingdom, the procedural metronome is based around the five-year carbon budget cycle, plus a system of annual reporting. For example, the UK Government must publish its policy proposals every five years (“as soon as is reasonably practicable” after each new carbon budget is set). The CCC reports each year on progress towards meeting budgets and targets, with the government required to respond. To better align with New Zealand’s three-year electoral cycle and provide a more frequent update of policies, the PCE has recommended that New Zealand adopt a six-year emissions budget period with government policies published after each new budget is set, followed by an interim update of policies three years later (PCE, 2018).

The chosen statutory timeframes need to ensure that the low-emissions strategy is kept reasonably up-to-date, but also recognise that, in practice, policy will continually evolve and that formally updating a major economy-wide strategy (that addresses both short- and long- term time horizons) is likely to be a substantial undertaking. The UK’s Clean Growth Strategy for example runs to 165 pages. Updates of the low-emissions strategy should be synchronised with the emissions budget period (the duration of which needs to be carefully considered, including taking into account the practicalities of how the budget system fits with the Paris Agreement’s NDC timeframes: section 7.6), and also consider other reporting processes and timeframes, such as regular reporting on progress towards meeting budgets and targets. The Productivity Commission considers that annual progress reporting (by the Climate Commission: section 7.10) is appropriate, but does not see the case for requiring a formal annual response from the government. Updating the low-emissions strategy could serve as the government’s formal response, coupled with less formal interim responses (such as via policy announcements and responses to Parliamentary questions).

⁶⁵ For example, Fankhauser et al. (2018, p. 32) identify that “[a] striking feature of the [UK Act] is the clear timetable it mandates for key milestones and processes”.

⁶⁶ The UK Act’s reporting details are outlined in more detail in Weeks (2017).

Legislation should clearly identify *who* needs to report, on *what* and by *when*. The Productivity Commission heard suggestions from UK stakeholders about areas for potential improvement in the UK Act’s procedural requirements. In particular, setting a specific deadline for the Government to publish its proposals and policies (instead of the “as soon as is reasonably practicable” requirement),⁶⁷ and ensuring timeframes are realistic.⁶⁸ Reporting obligations should be clear and achievable. Legislation should set a specific timeframe for publication of the Government’s strategy (as recommended by, for example, the PCE (2018) and Fankhauser et al (2018)). Even so, legislation should provide an element of flexibility to allow for exceptional situations where publication of the updated low-emissions strategy may need to be delayed (such as following a snap election for example).

R7.6

Mandatory processes should underpin a Climate Change Act. Legislation should include clear reporting obligations, including requiring regular reporting to Parliament on key aspects of New Zealand’s transition to a low-emissions economy (such as GHG emissions, progress towards budgets and targets, and the Government’s low-emissions strategy). Timeframes for the suite of processes should be set so as ensure regular review and reporting, but avoid over-engineering procedural obligations.

7.9 Achieving compliance with a Climate Change Act

In practice, political accountability will be a key driver for compliance with obligations in a climate change law, including meeting emissions budgets and targets. This relies on notions of transparency, which has become a widespread nostrum of “good governance” in many different contexts today (Hood & Heald, 2006). Fixed and published policy goals and measures whose operation and achievement are open to public scrutiny can be a prevailing influence in promoting compliance.

Transparency mechanisms, including requiring the Government to prepare and report on its low-emissions strategy and regular reporting on progress towards meeting emissions budgets, play a critical role in enhancing political accountability and promoting compliance. The UK Act also contains specific reporting obligations that are triggered if budgets or the 2050 target are not met, including a duty to report on proposals and policies to compensate in future periods for budget excesses.⁶⁹ Central government leadership will be essential for meeting emissions budgets and targets (section 7.12).

Compliance with a Climate Change Act could also be subject to scrutiny by the courts via judicial review, but constitutional and practical limits to how far that role would extend are likely – particularly in relation to enforcing emissions budgets and targets. One reason is that meeting emissions budgets and targets involves complex and polycentric policy priorities and resource allocation decisions over time, and legal remedies for non-compliance are arguably ineffective and/or inappropriate (Church, 2015; Macrory, 2014; McHarg, 2011; McMaster, 2008; Reid, 2012; see also *Thomson v The Minister for Climate Change Issues*, 2017).⁷⁰

Importantly, the value of setting emissions budgets and targets in law goes beyond the ability to legally enforce those budgets and targets. As observed by Lord Rooker (2007) during the passage of the UK Climate Change Bill:

Putting a duty such as this into law is important in itself. It is not just about the punishment in the event of failure; it is about trying to change institutional behaviour through a change in the law...By putting these duties into law, we are giving them a constitutional significance which will permeate down to every level of decision making. There is no other way of achieving an equivalent effect without using the law.

⁶⁷ The UK’s fifth carbon budget (for 2028–2032) was set in June 2016, but the Government’s policy proposals (the Clean Growth Strategy) were not published until October 2017, leading to mounting criticism of the delay and threats of legal action (CCC, 2017; Johnston, 2017).

⁶⁸ For example, the three-month deadline (which falls over the summer period) for the Government’s response to the CCC’s yearly progress report is arguably too short.

⁶⁹ If the carbon budget for a budgetary period is exceeded, the Government must report to Parliament on proposals and policies to compensate in future periods for the excess emissions. If the 2050 target is not met, the Government’s final statement to Parliament on 2050 emissions must explain why the target has not been met: sections 19 and 20 of the UK Act.

⁷⁰ See Weeks (2017) for further discussion of potential obstacles to judicial enforcement of emissions budgets and targets.

The duty should be looked at in this broader constitutional sense, rather than just in terms of what happens in court.

F7.9

Political accountability will be a key driver for compliance with obligations in a climate change law, including meeting emissions budgets and targets. Limits to the legal enforceability of emissions budgets and targets would not negate the status and constitutional significance of putting them in law.

7.10 An independent climate change institution

Independent institutions act as a form of commitment device designed to help “insulate” policymaking from short-term political pressures. Such devices are particularly relevant in policy domains where desirable long-term policy outcomes require: 1) a capacity for long-term planning; 2) credible, consistent, stable, and predictable policy settings; and 3) periodic non-simultaneous exchanges (ie, the imposition of near-term costs to secure net long-term gains) (Boston, 2017). Climate change policy is archetypical of such requirements.

In its 2014 report *Regulatory institutions and practices*, the Productivity Commission identified a range of features that indicate more or less of a need for regulatory independence. Those on the side of more regulatory independence and which reflect the nature of climate change as a policy problem include:

- decisions where costs are long term, and are undervalued due to a focus on electoral cycles;
- decisions weighing a politically powerful private interest against a dispersed public interest;
- decisions requiring a substantial degree of technical expertise, or expert judgement of expert analysis;
- decisions where the causal relationship between the policy instrument and the desired outcomes is complex and uncertain;
- regulatory regimes where a consistent approach over a long period of time is needed to create a stable environment;
- where decisions need to be taken urgently; and
- where public confidence that the regulator is impartial is important.

Internationally, various countries have set up independent climate change institutions as part of their national climate change mitigation frameworks, with both similar and different roles and functions, governance, organisational form and capabilities. The UK’s statutory framework for example includes the CCC, which is an independent non-departmental public body made up of experts in fields such as climate science, economics, behavioural science and business. The two core functions of the CCC are to advise (including in particular on carbon budgets), and to report (on the United Kingdom’s progress towards meeting its climate change targets). Examples of other independent climate change institutions include the Danish Council on Climate Change, the Finnish Climate Panel, the Swedish Climate Policy Council and Australia’s Climate Change Authority.

Support in New Zealand has been growing for the creation of an independent body in the context of New Zealand’s transition to a low-emissions economy, especially as a mechanism to promote stability, clarity and accountability.

The creation of an independent body was expressly supported by numerous submitters to this inquiry, including for example: industry bodies (eg, Dairy NZ, Fertiliser Association of NZ, New Zealand Institute of Forestry, Beef and Lamb NZ), the energy sector (eg, Vector, Contact Energy, Meridian), local government (eg, Auckland Council, Bay of Plenty Regional Council, Christchurch City Council, LGNZ), NGOs (eg, Generation Zero, Wise Society) and individuals (eg, Graham Townsend) (Box 7.7).

The current Labour-led Government has announced its intention to establish an independent Climate Change Commission, along with an Interim Climate Change Committee, as a precursor to establishing the Commission (Office of the Minister for Climate Change, 2017).

Box 7.7 **Benefits of an independent body identified by inquiry participants**

Inquiry participants showed strong support for establishing an independent body that would advise on climate change matters.

An independent body to oversee climate change commitments would carry the obvious advantage of being able to plan with a longer time horizon and be free of shorter term, political influence. (Energy Management Association of New Zealand, sub. 70, p. 32)

Establishing an independent commission who oversees New Zealand's domestic and international climate change commitments and develops carbon budgets outlining how the country will meet these will provide businesses the certainty they need in factoring in climate change mitigation into their strategies and therefore support the transition to a low-emissions economy. (Dairy NZ, sub. 18, p. 15)

Strong stable policy settings and quality public education are drivers for public and private action on climate change, but require cross-party support. To this end, an independent body may be useful. (Guardians of NZ Superannuation, sub. 32, p. 3)

Currently there is significant risk for the sector due to the potential for changes in policy with changing governments. An independent Climate Change Committee / Commission, with a similar role to that described for the UK legislative process, which provides independent advice and reporting, could smooth the fluctuations in direction introduced by successive governments and help provide consistency in approach. (Fertiliser Association, sub. 61, p. 8)

New Zealand needs an independent body to provide accountability and advice on New Zealand's climate change commitments...Given the gravity of climate change in human and economic terms, the communities and businesses of Aotearoa New Zealand should be able to find out from an independent and impartial source whether we are likely to meet the targets that are set, and whether existing emission reduction policies require change. (Generation Zero, sub. 119, p. 8)

Some submitters questioned the need for an independent body, instead emphasising that what is required is "a properly funded body with a serious mandate to develop and implement a plan for how the Paris targets are to be achieved" (Bioenergy Association, sub. 37, p. 14; Hitachi Zosen Inova, sub. 68, p. 14; Oji Fibre Solutions, sub. 71, p. 11), and that could also advise on the appropriate targets that could be achieved. Concern was also raised about creating an independent body in the absence of political consensus, to the extent that any independent institution can be dismantled or have its mandate politicised (Box 7.8):

Box 7.8 **Political consensus important to the success of an independent institution**

A number of submitters highlighted that political consensus is important to the success of an independent institution.

[Policy] consensus and 'independent' institutions can be undone...The presumption that independence will provide policy durability is a chimera. New Acts, institutions and mechanisms, regardless of how stable or independent they are claimed to be, are only independent (if they are that at all) and provide predictability while a political consensus exists. (BusinessNZ, sub. 89, pp. 5–6; similar submissions made by Motor Industry Association, sub. 51, p. 3; Export NZ, sub. 91, p. 7)

The ongoing absence of political consensus means that putting in place an independent body now would be too soon as its appointments and terms of reference will in turn be viewed to be politicised. There is also the risk that an independent body such as a Climate Commission may enable politicians to disassociate themselves from the difficult decisions to be made, potentially negating the role of parliament's checks and balances. (Ballance Agri Nutrients, sub. 34, p. 10)

At present the absence of political consensus on stringency of NZ’s domestic policy and targets means that putting in place an independent body now would be too soon. (Evonik Industries, sub. 46, p. 9)

There has been discussion about an independent climate commission established by an Act of Parliament, as if this entrenches climate policy. In reality, we would suggest this only has merit if there is bilateral political support for such an Act and the goals it would espouse – otherwise a future Government could simply repeal the legislation. (Straterra, sub. 69, p. 3)

[A]n independent agency may struggle for traction in the absence of a bipartisan approach to this area of policy. (NZ Institute of Forestry, sub. 73, p. 9)

F7.10

Given the long-term nature and time-inconsistency problem associated with climate change policy, an independent institution, at “arm’s length” from government, can play an important role as a commitment device to help insulate policymaking from short-term political pressures, expand climate policy debate, promote stability and predictability, and improve transparency and accountability. Such an institution will be more enduring if established through broad political consensus.

R7.7

The regulatory framework to support New Zealand’s transition to a low-emissions economy should include an independent climate change institution (a Climate Commission) that operates at “arm’s length” from government.

Independence is multi-faceted and more than just designating an agency as at “arm’s length” from government

It is important to recognise that independence is not a binary condition: institutions can be more or less independent in a range of ways. In its 2014 report *Regulatory institutions and practices*, the Productivity Commission identified that “independence” is multi-faceted and is more than a matter of legally designating an agency as “independent” or at “arms-length” (NZPC, 2014). The dimensions of independence include:

- the ability to adjust the regulatory settings and rules (regulation independence);
- the ability to undertake functions without interference (operational independence);
- funding arrangements that protect the regulator from external pressure (budgetary independence); and
- formal distance from the Executive and security of tenure for governors and senior management (institutional independence).

New Zealand’s state sector includes a wide variety of independent institutions that undertake a range of roles in different policy domains and take different types of institutional form (Table 7.3). The design of each institution differs in terms of the various dimensions of independence.

Table 7.3 Examples of independent institutions in New Zealand

Institution	Type	Role
Parliamentary Commissioner for the Environment	Officer of Parliament	Investigates environmental concerns independently of the Government of the day. The Commissioner reports to Parliament through the Speaker of the House and the Officers of Parliament Committee.

Institution	Type	Role
Environmental Protection Authority	Crown agent	Regulates activities that affect New Zealand's environment: administers applications for major infrastructure projects, regulates new organisms (plants, animals, genetically modified organisms) and hazardous substances and chemicals, helps industries work safely with hazardous substances, administers the NZ ETS and New Zealand Emission Unit Register, manages the environmental impact of activities in New Zealand's Exclusive Economic Zone.
Electricity Authority	Independent Crown entity	Electricity market regulator responsible for the efficient operation of the New Zealand electricity market.
Law Commission	Independent Crown entity	Reviews, reforms and develops New Zealand law, and makes recommendations to Government to improve the law.
New Zealand Productivity Commission	Independent Crown entity	Provides advice to the Government on improving productivity, primarily by undertaking in-depth inquiries on topics referred to the Commission by the Government. The Commission also carries out productivity-related research that assists improvement in productivity over time; and promotes understanding of productivity issues.
Reserve Bank of New Zealand	State services (unique organisation form)	New Zealand's central bank. The Reserve Bank's role includes: operating monetary policy to achieve and maintain price stability, helping to keep the banking, finance company and insurance sectors running smoothly and supplying New Zealand's currency. The Governor of the Reserve Bank in most areas has statutory independence about how outcomes are achieved, but performance is monitored by the board (under review).

The institutional design of a Climate Commission (such as its function and form) needs to consider a range of matters, including the different dimensions of independence and the need for role clarity. Yet a well-designed statutory framework is not sufficient. Ultimately, the success of a Climate Commission will also depend on how it operates in practice (for example, its culture and leadership).

F7.11

"Independence" is multifaceted, and includes regulation independence, operational independence, budgetary independence and institutional independence. No single "blueprint" for an independent body exists: successful design and operation relies on a whole suite of elements.

The rest of this section examines (1) the role of a Climate Commission; (2) its institutional form; (3) its membership; and (4) how it operates in practice.

Role of a Climate Commission

It is critical that regulatory bodies have a clear mandate – that is, clarity about what they are authorised or tasked to do. A clear mandate can help promote accountability, compliance, focus, legitimacy and predictability (NZPC, 2014). Legislation establishing a Climate Commission therefore must clearly specify the role of the Commission.

Two key (interrelated) questions arise about the role of a Climate Commission:

- Should a Climate Commission be a decision maker or an advisor?
- What issues should fall within the Climate Commission's remit?

Should a Climate Commission be a decision maker or an advisor?

In designing the role of the proposed Climate Change Commission, a fundamental issue is whether decision-making powers should be delegated to the Commission, or whether the Commission should provide non-binding advice.

Boston identifies that, in democracies,

virtually all the decision-rights in the critical area of fiscal policy – whether in relation to taxation, expenditure, the fiscal balance, or levels of public debt – are held by elected officials or representative institutions; they have not been transferred to politically independent bodies. Much the same applies to major decision-rights in most other policy domains, not least those where long-term policy investments are often required and hence intertemporal trade-offs arise. (Boston, 2017, p. 296)

A key exception is in relation to monetary policy, where (in New Zealand and various other jurisdictions) independent central banks have been vested with decision-making powers over the implementation of monetary policy. In New Zealand, while the Reserve Bank has short-term, tactical decision-making powers, it still operates within the context of a target set by Government. The rationale for delegating certain decision-making powers in the context of monetary policy but not delegating fiscal decisions is explained by Scott:

New Zealand’s record of complete political control of day-to-day monetary policy was associated with high and unstable rates of inflation and very large costs to the taxpayers from underwriting exchange rates. Against this background it was thought wise to create a central bank that was insulated substantially from short-term political pressure and free to exercise its discretion about short-term interest rates while targeting a medium-term inflation rate that is set by government. Fiscal decision-making, in contrast, goes to the very heart of a government’s development strategy and political priorities, and cannot be delegated in the same way. Only the implementation of detailed fiscal decisions can be delegated. (Scott, 1995, p. 15)

In the United Kingdom, the question of whether the CCC should be more involved in policymaking was expressly considered during the pre-legislative scrutiny process. The Government’s clear view (supported by Parliamentary committees) was that the CCC’s role should be advisory only:

We continue to believe that the Committee’s role should be to provide advice on budgets but that the Government should be responsible for setting them: as the Joint Committee argued, giving the responsibility for setting budgets to the Committee would probably be unworkable and would mean devolving significant policy decisions to an unelected body. (HM Government, 2007, p. 25)

The Productivity Commission agrees that it is not appropriate for a Climate Commission to have decision-making powers. New Zealand’s transition to a low-emissions economy will have profound and widespread impacts, and require the weighing of a range of economic, environmental, social and foreign policy considerations. Decisions about emissions reduction targets and economy-wide budgets (and policies to meet them) are highly political. Like fiscal policy, they go “to the very heart of a government’s development strategy and political priorities” (Scott, 1995, p. 15). Boston (2017) identifies that no government has so far been willing, or deemed it prudent, to transfer decision-rights on climate change mitigation matters to an independent body.

Even without decision-making powers, advisory institutions can still be highly influential and play a valuable role as an “insulating device” to protect against short-term political pressures impeding a long-term climate change response strategy. The United Kingdom’s CCC, for example, is an advisory body that is highly influential – to the extent that the government is very unlikely to depart from the CCC’s advice (BEIS, pers. comm., 13 November 2017).

How a Climate Commission fits within the wider regulatory framework is critical. As identified by Generation Zero, there is no point in the Commission providing advice in a vacuum; rather, the Commission’s functions should be woven into the systems architecture, with legislation providing a clear mandate for the Commission’s work to feed into the policymaking process (sub. 119, pp. 8–9). The PCE’s submission noted that the UK’s CCC is one element of the comprehensive system set up in the UK Act, and stressed that “[a]n independent advisory body set up on its own without the other elements would be far less effective” (sub. 54, p. 4). The Productivity Commission agrees that an independent climate change institution should be a statutory body (with its role clearly specified in legislation) that forms an integrated part of the wider

legal framework. Influence is also determined by other factors that affect the credibility of institutions, including culture and leadership (as discussed below).

The statutory framework should include:

- requirements for the Government to consider⁷¹ and respond to the Climate Commission’s recommendations, and to give reasons for any material departure from the Commission’s advice;
- mechanisms to promote transparency and accountability in the Climate Commission’s work, including, for example, by requiring the Commission’s advice to be published.

F7.12

Decisions about New Zealand’s transition to a low-emissions economy (including the setting of emissions budgets) are highly political and go to the heart of a Government’s development strategy and political priorities.

Independent institutions can be highly influential and play a valuable role without having decision-making powers.

R7.8

A Climate Commission should take an advisory role. Decision rights should not be delegated to such a Commission.

What issues should fall within the Climate Commission’s remit?

To help insulate key policy decisions about New Zealand’s low-emissions transition from short-term political pressures and provide a robust information base for decision making, the Climate Commission should:

- advise the government (with a corresponding statutory duty for the government to have regard to the advice) on:
 - setting and reviewing statutory targets;
 - emissions budgets, and the setting of NZ ETS caps consistent with the overarching budgets;
 - other matters materially relevant to New Zealand’s low-emissions transition (and should, for example, be consulted on any proposed NZ ETS reforms).
- undertake and publish research about the opportunities, costs and risks relating to New Zealand’s transition to a low-emissions economy (to help deepen New Zealand’s knowledge base and stimulate debate about specific opportunities, costs and risks relating to New Zealand’s transition to a lower domestic emissions future);⁷²
- assess and report to Parliament each year on New Zealand’s progress towards meeting emissions budgets and the long-term target, including assessing the performance of policy instruments (including, but not limited to, the NZ ETS) and identifying emerging risks; and
- in carrying out its role, to engage in outreach and public communications (including having the power to invite and publish submissions, and consult with stakeholders as it sees fit).

Legislation should provide clear parameters for the Climate Commission’s advice, including in relation to guiding principles and any hierarchy of objectives (NZPC, 2014). In particular, the Commission must have a clear mandate for its advice on emissions budgets. For example, the UK Act sets out what advice the CCC

⁷¹ There are various options for the precise wording of the statutory obligation to consider the Climate Commission’s advice, such as “take into account” or “have particular regard to”. The appropriate language should be carefully considered during the legislative process.

⁷² This proposed function is similar to the Productivity Commission’s statutory functions, which comprises “core” inquiry work as directed by the government but also includes “on its own initiative, to— (i) undertake and publish research about productivity-related matters; and (ii) promote public understanding of productivity-related matters” (s 9(1)(b) New Zealand Productivity Commission Act 2010).

must give in relation to carbon budgets (including the level of carbon budget, the extent to which the carbon budget should be met by domestic reductions versus use of international credits, and sectoral contributions and opportunities). The CCC's recommendations are "derived from detailed economic, engineering and science modelling, long-term scenario planning and a deep understanding of the long-term technological, economic and behavioural transformations that are required" (Fankhauser et al., 2018, p. 13). What factors the Commission must consider when recommending emissions budgets is critical, and should include climate science and technology, as well as broader factors such as economic and social impacts (section 7.6). Ultimately, the Climate Commission should be charged with recommending emissions budgets that, based on robust and transparent analysis, it considers are achievable (even if ambitious) and consistent with achieving the long-term emissions reduction target while imposing least cost on the economy and society.

The Government (rather than the Climate Commission) should formally develop the low-emissions strategy for meeting emissions budgets and long-term targets (section 7.7). The Government is best placed to make detailed economy-wide policy design and prioritisation choices that require cross-government coordination and allocation of funds, and the particular choice of policy measures "sit[s] squarely with elected representatives" (PCE, 2018, p. 29). Even so, without needing to be formally tasked with recommending a low-emissions strategy, the Climate Commission will over time input into (and review) the Government's strategy and policy choices. In proposing emissions budgets that it considers are achievable, the Climate Commission would need to have an idea of how the budgets might be met, and that analysis would feed into the policymaking process. The Government's policy choices would also be subject to scrutiny via the Climate Commission's regular progress reports. UK Government officials noted that the CCC carries out "deep dives" into areas it sees as particularly problematic and makes specific policy recommendations but, while that advice influences the policy process, the Government does not feel beholden in the same way as it does with the CCC's advice on setting budgets (BEIS, pers. comm., 13 November 2017).

R7.9

The Climate Commission should be responsible for:

- providing advice on emissions budgets, targets and New Zealand Emissions Trading Scheme (NZ ETS) caps (based on clear statutory parameters for that advice), and other matters materially relevant to New Zealand's low-emissions transition;
- reporting on progress towards emissions budgets and targets, including assessing the performance of policy instruments and identifying emerging risks;
- undertaking and publishing relevant research into transitioning to a low-emissions future; and
- (in carrying out its role) engaging in outreach and public communications.

Legislation should oblige the government to have particular regard to the Climate Commission's advice when making decisions on emissions budgets, targets and NZ ETS caps, and give clear reasons for any material departure from that advice.

Choosing an appropriate institutional form

State sector organisations have many forms – from government departments and departmental agencies (both legally part of the Crown), to various forms of Crown entity (standalone agencies governed by a board and not legally part of the Crown), and Officers of Parliament.

So what institutional form should a new independent climate change body take? The choice of institutional form is important as much in terms of what it signals around expected levels of agency independence, as for the legal protections associated with particular agency forms (NZPC, 2014). To properly perform its role, retain credibility over the longer term, and be viewed as independent to maintain public confidence, an independent climate change body should have a high degree of operational and institutional independence. Therefore, it should have:

- broad discretion to exercise functions at “arm’s length” from the executive and legislative branches of government or industry; and
- formal distance, and security of tenure for governors and senior management.

Some have suggested that New Zealand’s independent climate change body should be an Officer of Parliament (Taylor, 2017; Christchurch City Council, sub. 13), but others favour creating the body as an independent Crown entity (PCE, 2017). Both are institutional forms that signal greater levels of operational and institutional independence.

Officers of Parliament are associated with the oversight of executive authority and perform functions that the House of Representatives might perform. They should be subject to the conditions applying to an arm of the legislative branch of government (such as being outside the public service and not being subject to control of its actions by the executive). As such, they must be seen to act impartially to retain the integrity and confidence of the whole House of Representatives (McGee, 2017).

Box 7.9 **Officers of Parliament**

New Zealand currently has three Officers of Parliament: the Controller and Auditor-General, the Ombudsman, and the Parliamentary Commissioner for the Environment. The position of Officer of Parliament is not defined under statute. Criteria for the position are also not defined. Rather, the status of Officer of Parliament is attached on an individual basis to particular positions, with the main powers, duties and functions of the officers determined by the individual statutory provisions applying to each. The accepted criteria for considering whether it is appropriate to make a particular position an Officer of Parliament are that:

- an Officer of Parliament must only be created to provide a check on the arbitrary use of power by the executive;
- an Officer of Parliament must only discharge functions that the House of Representatives itself, if it so wished, might carry out;
- an Officer of Parliament should be created only rarely;
- the House of Representatives should, from time to time, review the appropriateness of each Officer of Parliament’s status as an Officer of Parliament; and
- each Officer of Parliament should be created in separate legislation.

Source: Legislation Advisory Committee (2014); McGee (2017).

By contrast, Crown entities are standalone corporate bodies that are not legally part of the Crown, but are still ultimately managed (though from a distance) by Ministers (NZPC, 2014; State Services Commission, 2014). Crown entities can take three different institutional forms: Crown agent, autonomous Crown entity, and independent Crown entity. Each form displays different levels of operational and institutional independence.

- Crown agents, where there is a high degree of Ministerial oversight (eg, Maritime New Zealand, Environmental Protection Agency, New Zealand Transport Agency, Tertiary Education Commission). They are governed by a board, which can be appointed and removed at the responsible minister’s discretion. They are operationally independent, but must give effect to government policy when directed.
- Autonomous Crown entities, which have an intermediate degree of Ministerial oversight and independence in decision making (eg, New Zealand Teachers Council, Commission for Financial Literacy and Retirement Income). They are governed by a board, which can be appointed and removed for just

cause by the responsible minister. They are operationally independent, but must have regard to government policy when directed.

- Independent Crown entities, where there is a high degree of independence from Ministerial influence (eg, Commerce Commission). They are governed by a board, which can be appointed and removed for just cause by the Governor-General on advice of the responsible minister given after consulting the Attorney-General. There are no ministerial powers of direction. Typically, legislation expressly requires independent Crown entities to act independently when performing their functions and duties, and exercising their powers.⁷³

Overall, the Productivity Commission considers that a Crown entity model is a more appropriate institutional form for an independent climate change body than an Officer of Parliament model. A key differentiating factor is that, as part of the executive branch of government, Crown entities are more readily able to develop working relationships within government. A positive strategic working relationship with government is capable of being managed in a way that does not undermine the Climate Commission's independence, and would enable valuable sharing of information – for example, the ability to draw on the resources of other government agencies (PCE, sub. 54, p. 4), as well as develop a good mutual understanding of both parties' work programmes and viewpoints. The ability to share resources between public sector agencies is particularly important given that, due to its small size, New Zealand has limited research and analytic resources compared with other jurisdictions.

The UK's CCC (a non-departmental public body), for example, operates under a Memorandum of Understanding with government and interacts regularly with key government departments. Importantly, the CCC remains a "highly independent voice" with "immense authority" and "high credibility" (Department of Energy and Climate Change (UK), 2014; Macrory, 2014; BEIS, pers. comm., 13 November 2017).

More specifically, of the three different Crown entity models identified above, an independent Crown entity model is the most appropriate institutional form for an independent body focused on climate change. An independent Crown entity has a high degree of operational and institutional independence to properly perform its role and retain the necessary credibility.

R7.10

To properly perform its role, retain credibility over the longer term, and be viewed as independent, the Climate Commission should have a high degree of operational and institutional independence.

The Climate Commission should have:

- broad discretion to exercise functions at "arm's length" from the executive and legislative branches of government or industry; and
- formal distance, and security of tenure for governors and senior management.

The Climate Commission should be set up as an independent Crown entity.

Membership

Design of the Climate Commission needs to address important issues relating to the Commission's membership, including the composition of the Commission and how members should be appointed (and dismissed).

Submitters expressed strong (though not universal) support for the creation of an independent **expert** body, rather than a committee of stakeholders. Proposed relevant areas of expertise for an independent body include climate science, business and economics, energy and agricultural technology, finance and

⁷³ For example, the Productivity Commission is an independent Crown entity, and section 9 of the New Zealand Productivity Commission Act 2010 provides that "[e]xcept as expressly provided in this or any other Act, the Commission must act independently in performing its functions and duties and exercising its powers".

investment, the Treaty of Waitangi and tikanga Māori, Māori interests, and social transformation (eg, Generation Zero, sub. 119; LGNZ, sub. 36; Ora Taiao, sub. 72; PCE, 2017; 2018).

To tackle the complex and economy-wide issues involved with the transition to a low-emissions economy, the Climate Commission needs to be a multidisciplinary expert body (not a committee of special interest or advocacy representatives). More specifically, the Climate Commission should comprise Commissioners and staff (a high-quality secretariat) with a governing board that has responsibility for output. If capacity gaps occur within New Zealand, the Climate Commission should be able to appoint overseas experts to its ranks. Relevant economic expertise will not be limited to economic forecasting, as the profound nature of the low-emissions transition will require broad and deep economic understanding and policy wisdom.

The appointment process is an important dimension of institutional independence (NZPC, 2014). To help maintain institutional independence, Climate Commission members should not be appointed directly by the responsible minister. Rather, members should be appointed by the Governor-General on the recommendation of Cabinet, following (as proposed by the PCE) consultation with other political parties.

The success of a Climate Commission will also depend on how it operates in practice

The success of an independent body will depend not only on its statutory design, but on a range of other factors that affect how the institution operates in practice (such as culture and leadership, and funding).

Culture and leadership

The leadership and culture of organisations is critically important to organisational success and how success is achieved (NZPC, 2014). Culture relates to the norms, values and beliefs of an organisation which are, in turn, profoundly shaped by the actions of organisational leaders. Organisational leaders set the tone, behaviour and aspirations of a new organisation, drawing on their own experiences, values and assumptions about how to interact with stakeholders, identifying organisational priorities, and how best to achieve their statutory purpose (Schein, 2010).

The Productivity Commission heard from a range of UK stakeholders that the chairs of the CCC (Lord Turner followed by Lord Deben) have played an invaluable role in building the credibility and strong reputation of the CCC. Different leadership strengths (such as bipartisanship and consensus building skills versus deep technical knowledge) may best suit different stages in the lifecycle of the Climate Commission. How the Climate Commission builds its public profile and reputation (so it cannot be easily shut down if government dislikes its advice) is also important (CCC, pers. comm., 11 October 2017; BEIS, pers. comm., 13 November 2017).

The quality of the relationship between the Climate Commission and the Government will be vital. There will be tensions and vigorous debates, and a Climate Commission needs to have institutional robustness to confront conflict. It also needs to manage its role and relationships in a manner that helps to build a credible commitment, recognising that the Commission and the government are both engaged in a process of discovering over time how to meet long-term emissions targets.

The nature and extent of the climate change challenge also calls for thought leadership. As Gruen (2018) argues, while independence is prized in our public culture, most independent public sector agencies are tethered to the career public service and “think like bureaucrats”; yet what is needed is independent bodies that are bolder and show intellectual leadership. Gruen points to the Bank of England as an institution that is prepared to lead the process of intellectual search – as evidenced by, for example, its blog that explores a range of interesting and important questions. Thought leadership can be supported by giving an organisation a clear mission and focus, valuing professionalism and technical capacity, and judging personnel performance on that basis.

Funding

A Climate Commission should be funded via its own budget line(s) (non-departmental appropriations) as part of the Government’s annual budget process. This is the usual funding basis for independent Crown entities. The level of funding affects the capacity of agencies to perform their role (NZPC, 2014). So that the

Climate Commission can provide robust advice, its funding needs to be adequate to properly resource an appropriately sized secretariat and enable the Commission to attract (and retain) high calibre personnel. Under-funding would hinder the Commission’s ability to perform its role, and therefore undermine its value.

F7.13

Independence is earned as much as granted. The success of an independent body will therefore depend not only on its statutory design, but also on how the institution operates in practice (including the quality of appointments, its culture and leadership, and adequacy of ongoing funding).

7.11 Recognising the Treaty of Waitangi

The Treaty of Waitangi/Te Tiriti o Waitangi is the foundation of the Māori–Crown partnership. The fundamental elements of the relationship are understood now, but questions remain about how iwi and hapū would work with the Crown in developing the country’s future (Constitutional Advisory Panel, 2013).

Te Rūnanga o Ngāi Tahu submitted that “there is greater potential to get things right when viewing economic benefits, and associated co-benefits, from an indigenous perspective, through the lens of Treaty partnership”. (sub. 83, p. 7)

This section is about the Treaty of Waitangi and the legislative framework for a low-emissions economy. It discusses how the Treaty is typically referenced in legislation, current developments and the opportunities for a partnership approach in achieving the goal of a low-emissions economy.

References to the Treaty or to the principles of the Treaty are found in statutes that govern physical resources and the environment where Māori have strong iwi and hapū relationships, often involving kaitiaki relationships – including land, water, important sites, wāhi tapu and other taonga. Most statutes that contain “Treaty clauses” contain regulatory provisions or confer regulatory powers and responsibilities, and they often create obligations on a range of parties (NZPC, 2014).

A Treaty clause in the legislative framework for a low-emissions economy would be consistent with current practice. It would acknowledge both the importance of the kaitiakitanga role of mana whenua and the stability and longevity of the fundamental constitutional arrangements on which a low-emissions future would be achieved.

The inclusion of Treaty clauses in previous legislation has focused on how the Crown or its agents should “have regard to”, “give recognition to”, “take into account” or “give effect to” the principles of the Treaty of Waitangi. Māori have advocated the Treaty clauses as a means to protect their rights. Many statutes have focused on consultation requirements in satisfying Treaty principles, but often with little specificity or conviction.

A particular example is the current CCRA, which requires under various sections that “the Minister must consult, or be satisfied that the chief executive has consulted, representatives of iwi and Māori that appear to the Minister or chief executive likely to have an interest in” the pre-1990 forest land allocation plan, the fishing allocation plan, regulation-making powers in relation to eligible agricultural activities, regulations relating to unique emissions factors, the gazetting of targets, and regulations relating to targets.

However, in recent years the trend is towards both more specificity around consultation and greater Māori participation. For example:

- The Resource Management Act is specific about the ways in which local authorities are deemed to have consulted iwi. Consultation includes fostering iwi capacity to respond to an invitation to consult, establishing processes for the opportunity to consult, and indicating how to address issues identified by iwi as a concern to them (Schedule 1, 3B).
- To recognise and respect the Crown’s responsibility to take account of the Treaty of Waitangi, the Environmental Protection Authority Act 2011 established a Māori Advisory Committee to advise the Authority on policy, process, and decisions.

- Recent changes to the Resource Management Act are intended to facilitate and enhance Māori participation in resource management processes through Mana Whakahono a Rohe (iwi participation arrangements) (MfE, 2017n; NZPC, 2017a) (Box 7.10).

Box 7.10 Principles in initiating, developing, and implementing a Mana Whakahono a Rohe

The participating authorities must use their best endeavours—

- (a) to achieve the purpose of the Mana Whakahono a Rohe in an enduring manner:
- (b) to enhance the opportunities for collaboration amongst the participating authorities, including by promoting—
 - (i) the use of integrated processes:
 - (ii) co-ordination of the resources required to undertake the obligations and responsibilities of the parties to the Mana Whakahono a Rohe:
- (c) in determining whether to proceed to negotiate a joint or multi-party Mana Whakahono a Rohe, to achieve the most effective and efficient means of meeting the statutory obligations of the participating authorities:
- (d) to work together in good faith and in a spirit of co-operation:
- (e) to communicate with each other in an open, transparent, and honest manner:
- (f) to recognise and acknowledge the benefit of working together by sharing their respective vision and expertise:
- (g) to commit to meeting statutory time frames and minimise delays and costs associated with the statutory processes:
- (h) to recognise that a Mana Whakahono a Rohe under this subpart does not limit the requirements of any relevant iwi participation legislation or the agreements associated with that legislation.

Source: Section 58N: inserted, on 19 April 2017, by section 51 of the Resource Legislation Amendment Act 2017 (2017 No 15)

More meaningful consultation and enhanced participation (and developing Māori capacity and capability to do so), should be considered when reflecting the Treaty partnership in the legislative framework for a low-emissions economy. The Commission considers that it would be appropriate for the legislative framework for a low-emissions economy to provide for mechanisms for Māori to advise the Government on policy, process, and decisions relating to emissions budgets and the Government’s strategy to achieve them.

The Commission has previously noted however, that good practice in upholding Treaty principles of partnership, mutual respect and good faith cannot be legislated for. It crucially depends on the quality of leadership (NZPC, 2014).

In a submission to the *Regulatory institutions and practices* inquiry from Environment Canterbury, Dame Margaret Bazley offers insight on effective approaches to working in partnership with Māori, and also points to the weaknesses of simply relying on legislative requirements:

Environment Canterbury has experience and insight to offer on effective approaches to working in partnership with Māori... in terms of its *Tuia* partnership with Ngai Tāhu. This partnership has been built from the ground up, and has been progressed from identifying and respecting past issues and grievances to working shoulder to shoulder to set in place new ways of working focussed on solutions and practical outcomes. *Tuia* is premised on mutual good faith and commitment to do what is right and in the best interest of the iwi and the region, not on narrow legislative requirements. (NZPC, 2014, p. 172)

The submission’s focus on “working shoulder to shoulder to set in place new ways of working focused on solutions and practical outcomes” seems entirely consistent with the goal of working towards a low-emissions economy.

F7.14

Inclusion of a Treaty of Waitangi clause in the legislation would acknowledge both the importance of the kaitiakitanga role of mana whenua and the stability and longevity of the fundamental constitutional arrangements on which a low-emissions future would be achieved.

R7.11

The legislative framework for a low-emissions economy should provide for mechanisms for Māori to advise the Government on policy, process, and decisions relating to emissions budgets and the Government's strategy to achieve them.

F7.15

The legislative framework could strongly signal a partnership approach between Māori and the Crown in achieving the goal of a low-emissions economy. However, relying on legislative provisions alone will not be sufficient to uphold Treaty principles of partnership, mutual respect and good faith. Much will depend on the quality of leadership.

7.12 Leadership from the centre

The change to legislation and institutional settings proposed above can be expected to significantly ease some of the problems outlined in section 7.2 – namely, the lack of policy stability and clarity about the nature and pace of the transition to a low-emissions economy. Further changes are needed within the executive to resolve the outstanding issue of poor policy coherence across government and to deliver actual progress towards lower national emissions. This section discusses options for improving that coherence.

Institutional change outside the executive is necessary but not sufficient

A legislative target and independent advisory body are necessary, but not sufficient, conditions for an effective and efficient emissions-reduction strategy. The legislative targets and independent advice from a Climate Commission will need to be responded to by the Government. UK experience suggests that this process can be fraught. While the first three carbon budgets recommended by the CCC were accepted by the UK Government, the fourth and fifth budgets required much larger reductions in emissions and have proven more controversial.

- The Cabinet split over whether to accept the CCC's advice on the fourth budget, and only accepted the advice following the intervention of the Prime Minister. However, the finalised government budget differed from CCC advice, in particular rejecting the recommendation that all emissions reduction should be achieved by domestic action. A number of scholars have argued that the initial cross-party consensus that led to the passing of the Act has weakened, especially as the likely costs of the transition become clearer and closer (Benson & Lorenzoni, 2014; Carter, 2014; Gillard, 2016; Lockwood, 2013; Rollinson, 2010).
- A government response to the fifth carbon budget was scheduled for release in 2016, rescheduled to early 2017, and then delayed further.
- Although the UK Government did ultimately publish its response to the fifth carbon budget in the form of a "Clean Growth Strategy" in October 2017, the CCC has argued that the Strategy "does not go far enough" (Committee on Climate Change, 2018). The CCC concluded that even "if delivered in full, existing and new policies, including those set out in the Clean Growth Strategy, miss the fourth and fifth carbon budgets by about 10-65 MtCO₂e – a significant margin" and called on the UK Government to "urgently firm up policies and proposals in the Clean Growth Strategy", "develop and implement new policies to close the remaining 'emissions gap'" and "address the risks of under-delivery" (Committee on Climate Change, 2018).

Leading the government response to the Climate Commission's advice

Developing the government response to the Climate Commission's advice will be a substantive policy process, with agencies assessing the Commission's proposals, selecting alternative priorities or pathways, identifying the impacts on affected sectors and communities, and designing suitable policy, regulatory and fiscal responses. Processes must also be in place to monitor compliance with Cabinet's final decisions.

Crafting a response will require close Cabinet involvement and oversight, and specific skills and capabilities on the part of the agency or agencies leading the policy development process. In particular, the organisation(s) responsible for providing advice on the Commission's recommendations and monitoring compliance with emissions budgets will need to:

- have the capability and knowledge to understand and robustly assess the Commission's recommended actions in each sector;
- have the ability to take an economy-wide, strategic view and to consider the full range of benefits and costs;
- be linked to the fiscal budget process, to ensure that Cabinet decisions are suitably resourced; and
- have the mana to bring together the range of portfolio agencies, work through any differences of view to develop a coherent and robust set of policy proposals, and monitor the government's progress against Cabinet decisions.

The Productivity Commission was not able to identify any one agency within the current public sector with the full range of capabilities and attributes. In assigning responsibility for leading the response to the Climate Commission's advice, the Government should get an assurance from the relevant chief executive(s) that the agency or agencies have, or will quickly obtain, the necessary skills and knowledge.

F7.16

Developing the government response to the Climate Commission's advice will be a substantive and challenging policy process and will present major coordination issues. The organisation(s) responsible for providing advice on the Climate Commission's recommendations will need to:

- have the capability and knowledge to understand and robustly assess the Climate Commission's recommended actions in each sector;
- have the ability to take an economy-wide, strategic view and to consider the full range of benefits and costs;
- be linked to the fiscal budget process, to ensure that Cabinet decisions are suitably resourced; and
- have the mana to bring together the range of portfolio agencies, work through any differences of view to develop a coherent and robust set of policy proposals, and monitor the Government's progress against Cabinet decisions.

No single agency within the current public sector has this full range of necessary capabilities and attributes. New arrangements will be required to deliver these capabilities.

Ministerial influence will be important

Regardless of which agency is responsible for leading the response to meet emissions budgets and targets, achieving alignment across government will require ongoing efforts to ensure that new regulatory, policy or fiscal proposals do not undermine progress towards the goal of moving to a low-emissions economy. The transparency and disclosure requirements recommended below will help reveal the climate impacts of new

regulatory proposals, but not other policy and fiscal initiatives. Keeping sight of these other proposals will depend on constant vigilance at the Cabinet level.

Under current government arrangements, the Minister for Climate Change sits outside Cabinet. This could limit the Minister's ability to have sight of the full range of new initiatives and to assess their compatibility with national emissions reductions objectives.

The Productivity Commission has commented on similar arrangements in its inquiry into *Regulatory institutions and practices*, noting that the regulatory reform portfolio had originally sat outside Cabinet and that assigning this responsibility to a senior Cabinet minister has significant advantages, as seniority provides:

- the ability to take a whole-of-government perspective;
- the capacity to maintain the Government's focus in improving the system;
- the authority to ensure that initiatives are implemented; and
- access to the information required to develop and implement policy (NZPC, 2014, p. 421).

Similar considerations would appear to apply to climate change policy.

F7.17

Developing a robust and enduring cross-government emissions reduction strategy will require coordination across both departments and Ministers.

Would wider legislative obligations on Ministers or the public service be beneficial?

As discussed earlier, the legislative target and reporting obligations, and the independent Climate Commission, are examples of "commitment devices" that provide some assurance that decision makers will act in a certain way or pursue specified goals. Other types of commitment devices are possible, such as legislative obligations on decision makers to take into account certain climate change related factors.

Obligations on decision makers

Ministers could be required by law to take into account specific climate change-related factors when making decisions. For example, the Victorian Climate Change Act 2017 requires that "a person making a decision or taking an action" in specific statutory circumstances "must have regard to:

- (a) the potential impacts of climate change relevant to the decision or action; and
- (b) the potential contribution to the State's greenhouse gas emissions of the decision or action; and
- (c) any guidelines issued by the Minister...[section 17(2)]

In having regard to these climate change impacts, decision makers must in particular consider:

- (a) potential biophysical impacts; and
- (b) potential long and short term economic, environmental, health and other social impacts; and
- (c) potential beneficial and detrimental impacts; and
- (d) potential direct and indirect impacts; and
- (e) potential cumulative impacts. [section 17(3)]

Further, the Act lays down "guiding principles" that the Minister may "have regard to" when issuing guidelines under the law, namely "informed decision making", "integrated decision making", "risk management", "equity", "community engagement" and "compatibility."

Assessment obligations

Alternatively, more general obligations could be placed on Ministers and agencies to conduct climate-change assessments of decisions, in a similar manner to the Cabinet Office's current requirements to conduct impact analysis on proposals for regulatory change (DPMC, 2017). A Private Member's Bill was introduced to Parliament in 2015 proposing that all government Bills "have a Climate Impact Disclosure Statement – a report, prepared by the Ministry for the Environment, that outlines the likely impact of the legislation on the climate" (Green Party of Aotearoa New Zealand, 2015). The Labour–Greens Confidence and Supply Agreement includes the goal that all "new legislation will have a climate impact assessment analysis" (New Zealand Labour Party & Green Party of Aotearoa New Zealand, 2017, p. 3).

Transparency is preferable

Given the need to ensure that any new climate change legislation and institutions are durable and provide sufficient flexibility for future Governments, the Productivity Commission does not favour adding process-based decision-making principles in legislation along the lines of those used in Victoria. Such principles are inevitably cast at a high level and open to wide variations in interpretation. In addition, the proposed combination of a legislated long-term target and regular emissions budgets already provides significant constraints within which government decisions will have to be made. Adding more constraints in the form of principles risks creating uncertainty around how those principles will or should be applied, judicial challenge, and potentially reduced flexibility for future Ministers. The Commission is not persuaded that the possible benefits of such principles outweigh these costs.

Even so, some form of assessment and disclosure regime around climate change impacts would be valuable for Ministers, Parliamentarians and the wider public, and could help ensure that individual policy decisions make a cumulatively positive contribution to national emissions-reduction goals. To avoid creating unnecessary process burdens or duplications, climate change assessment requirements should be built into the existing Regulatory Impact Analysis (RIA) system, with a corresponding obligation on agencies to consult with the organisation responsible for developing advice on the Climate Commission's recommendations when considering any climate change impacts and ensure the agency's comments are fairly and accurately reflected in any final assessment. Embedding these assessments into the RIA process would also ensure that a wider array of legislative instruments (ie, not just new primary legislation) were subject to climate impact analysis.

R7.12

Treasury should update the Regulatory Impact Analysis requirements to explicitly include consideration of climate change impacts, where relevant.

The Cabinet Office should update its circular to require agencies making proposals for regulatory changes with climate change implications to consult with the organisation responsible for developing advice on the Climate Commission's recommendations and ensure that the agency's comments are fairly and accurately reflected in any final assessment.

Local government will play an important role in the national response, and should be appropriately included and consulted

Changes to land use and land transport will be critical contributors to any national emissions-reduction strategy, given that agriculture and transport are New Zealand's two largest sources of GHG emissions. Local government plays a key role in shaping land use and transport activities, through its regulatory roles (eg, land use regulation through the Resource Management Act 1991), funding and investment activities (eg, management of public transport services and local roading under the Land Transport Management Act) and waste management obligations. Local government will therefore need to be appropriately included in any national climate change strategies.

The Productivity Commission has previously explored the regulatory roles of local government, and commented on the need for an improved relationship between local and central government. Among other things, the Commission found limited analysis by central government of local government's capability or

capacity to implement regulations before new regulatory roles were allocated, little understanding by central government of the local government sector, and an “uneasy relationship” and “generally poor engagement” between the two levels of government (NZPC, 2013). Instead, the Commission recommended that local and central government should find new arrangements for working together, with clearly defined roles, appropriate representation, and processes to work through issues of common interest. Developing the government response to the Climate Commission’s recommendations would be a good opportunity to set up these new arrangements.

F7.18

Local government will play an important role in any national emissions-reduction strategy, given the responsibilities it has for regulating land use and managing land transport. The development of a government response to the Climate Commission recommendations would be a convenient opportunity to establish new, more effective arrangements for local and central government to work together on issues of common interest.

7.13 Conclusion

There are strong political incentives to avoid making long-term policy decisions that have benefits that manifest well into the future, but will have short term costs and impacts. Well-designed laws and institutions can play a critical role in acting to bind the political executive (across policy cycles and parliaments) to govern, within flexible limits, in line with the long-term commitment of a low-emissions economy. Crucially, they can entrench disciplined processes for promoting transparency and accountability, and signal policy intentions.

The design of laws and institutions needs to recognise that the underlying policy objective is not simply to transition to a low-emissions economy; reducing emissions is key, but the nature of the transition matters too. Laws and institutions should support a low-emissions transition that maximises benefits to New Zealand, and seeks to maintain and build natural, human, economic and social capital.

Getting a new Climate Change Act on the statute books and establishing an independent Climate Commission are important steps towards supporting New Zealand’s low-emissions transition. But the success of laws and institutions depends on much more than statutory design. To endure, they need cross-party support and ongoing leadership to help navigate the long and uncertain journey to a profoundly different low-emissions economy.

A key strength of a “UK-style” Act is that it operates at an overarching framework level; it provides core legal and institutional architecture to guide the low-emissions transition, but does not prescribe particular policies for reducing emissions. This allows flexibility about precisely how the transition is achieved. Helpfully, it means consensus on overarching laws and institutions can co-exist with ongoing political debate about specific policy measures. Indeed, in reflecting on 10 years of the UK Act, Fankhauser et al. (2018) credit the Act with transforming the political debate on climate change (by keeping climate change on the political agenda via regular reporting procedures, and by helping build a credible independent evidence base to enlarge and support the political debate). But the authors also rightly caution that a “good framework law does not guarantee automatic policy delivery. Climate action requires strong leadership” (Fankhauser et al., 2018, p. 5).

8 Short-lived and long-lived gases

Key points

- Greenhouse gases (GHGs) have different atmospheric lifetimes. Some, such as carbon dioxide (CO₂), are long-lived. They accumulate in the atmosphere and so are the dominant driver of temperature. Others, such as methane (CH₄), are short-lived and only influence temperature in relation to their flows in and out of the atmosphere.
- The total atmospheric stock of both short- and long-lived GHGs is important in relation to the Paris Agreement goal of limiting warming to well below 2°C. However, the sooner long-lived gases reach net-zero, the more likely it is the planet will remain within this limit. Conversely, while emissions reductions of short-lived gases are also needed in the context of the 2°C goal, they do not need to reach net-zero to stabilise temperature.
- The relative proportion of short- to long-lived gases has implications for countries' low-emissions trajectories, including choices about mitigation targets and policy frameworks. In thinking about these trajectories, various factors such as the abatement costs of different GHGs, or the flexibility to adjust policy over time, must be considered.
- Most other developed countries' emissions profiles are dominated by CO₂, meaning that, by default, long-lived gases are the main focus of mitigation attention. In comparison, New Zealand has a high proportion of short-lived gases (mainly CH₄ from livestock production). This distinctive emissions profile means that the question of how best to prioritise between emissions reductions from short- and long-lived gases is of special interest.
- While the priority must be to reduce emissions of long-lived gases to net-zero, there are benefits to also mitigating short-lived gases over the coming decades. These include to allow for a (slightly) greater budget for long-lived gas emissions, to reduce short- and medium-term temperature change, to achieve health co-benefits, and to signal the need to transition.
- Much of the scientific and policy discussion relating to short- and long-lived gases refers to the emissions metric used to calculate carbon dioxide equivalence (CO₂e). Emissions metrics show how powerful different GHGs are in terms of their cumulative effect on warming and their atmospheric lifetime, and are used to help make mitigation trade-offs between different GHGs. Yet, no single metric is perfect, and all have limitations and uncertainties.
- The standard metric to calculate CO₂e is global warming potential over 100 years (GWP₁₀₀). While amending or moving away from GWP₁₀₀ is possible, it risks New Zealand falling out of step with international emissions reduction frameworks under the United Nations Framework Convention on Climate Change.
- The Commission considers that the following elements comprise the minimum necessary components required to provide greater relative priority towards emissions reductions of long-lived gases in the New Zealand context:
 - separate long-term domestic targets law for short- and long-lived gases (where the long-term target is net-zero by a specified end date, and the short-term target is a stabilisation level within a specified temperature limit);
 - an overarching single all-gases mitigation target; and
 - a regular series of reviews of progress against these targets.

This chapter:

- explains the physical differences between short- and long-lived greenhouse gases (GHGs), and why ensuring relatively greater priority towards emissions reductions of long-lived gases is important (while also continuing to mitigate short-lived gas emissions in the short- and medium-terms);
- describes New Zealand's short- and long-lived gases, and associated policy mechanisms;
- outlines the experience of New Zealand and other countries in targeting different GHGs; and
- explores different options involving separate targets and policies for New Zealand to give greater relative priority towards emissions reductions of long-lived gases.

8.1 Short- and long-lived gases

GHGs have different atmospheric lifetimes.⁷⁴ Some are long-lived, such as carbon dioxide (CO₂) which can stay in the atmosphere for centuries to millennia, or nitrous oxide (N₂O) which has a lifetime of around 120 years. Others are short-lived, which means they stay in the atmosphere for less than 20 years.⁷⁵ These include CH₄ which has a lifetime of 12 years, and some hydrofluorocarbons (HFCs) with a lifetime of only a few days.

A stock of atmospheric greenhouse gases consistent with 2°C

Emission flows of both short- and long-lived GHGs contribute to the overall stock of atmospheric GHGs (Stern, 2015). This stock of GHGs is important because it directly relates to temperature, and specifically, the peak warming limit of 2°C as specified in the Paris Agreement (Box 8.1).

Box 8.1 The Paris Agreement and the goal of limiting peak warming to well below 2°C

Peak warming is the maximum temperature arising from human-induced climate change. The central aim of the Paris Agreement is to ensure peak warming does not exceed 2°C above pre-industrial levels (UNFCCC, 2015b), and ideally does not exceed 1.5°C. However, this lower target is now considered to be very unlikely (less than a 5% chance) (Raftery et al., 2017). The Paris Agreement also states an aim of achieving net-zero GHG emissions⁷⁶ by a specific date (the second half of this century). But, the overriding goal is to achieve the lowest possible level of peak warming.

Long-lived gases accumulate in the atmosphere and so are the dominant driver of temperature change (IPCC, 2014a). CO₂ is particularly important because of its persistence in the atmosphere “well beyond the timescale of human experience” (Matthews & Caldeira, 2008, p. 4). Because the stock of long-lived gases is a function of all previous emissions, essentially, the only way for long-lived gases to achieve a steady-state is for emissions to cease (ie, get to absolute or net-zero).

Because of their shorter lifetime, at any point in time, the stock of short-lived gases can be understood as a function of emission inflows into the atmosphere minus emission outflows. A steady-state stock of short-lived gases is achieved when inflow equals outflow. A qualifying point is that, to achieve a stable *temperature*, the stock of atmospheric short-lived gases must continue to decrease very slightly over time. This is because recent research shows that a very minor ongoing warming effect occurs after atmospheric concentrations of CH₄ have stabilised (Andy Reisinger, pers. comm. 27 January 2018).

In summary, the overall policy goal for both short- and long-lived gases is a stock of GHGs consistent with keeping global temperatures well below 2°C. To achieve this goal, three factors must be taken into account:

⁷⁴ An atmospheric lifetime is the “average time that a molecule resides in the atmosphere before it is removed by chemical reaction or deposition” (US EPA, 2018b). Specifically, it refers to the length of time it takes for a single pulse emission of a GHG to be reduced to 37% of its initial amount (Hollis et al., 2016).

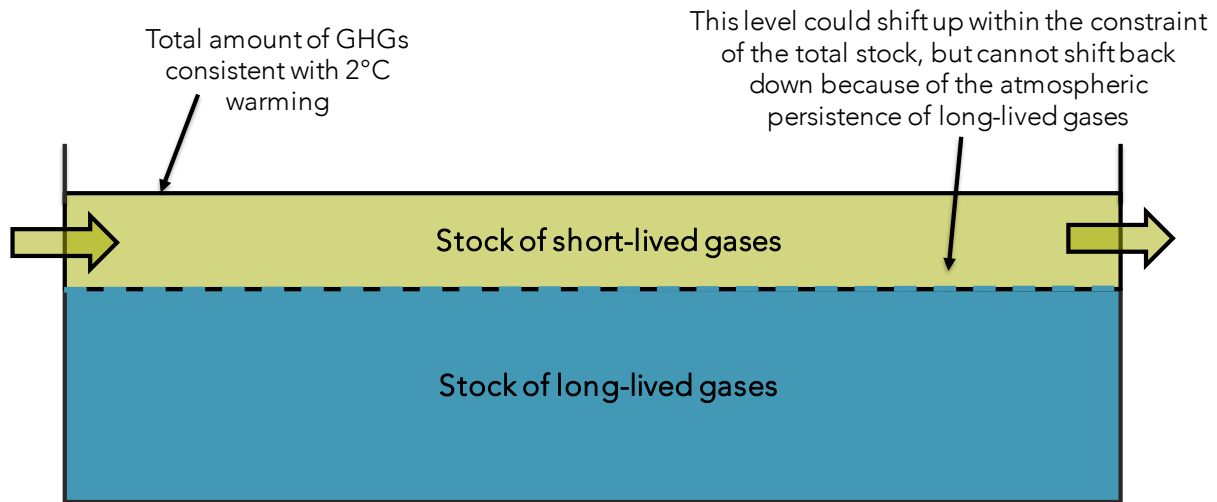
⁷⁵ 20 years or less is the standard atmospheric lifetime for a GHG to be considered short-lived.

⁷⁶ Net-zero emissions describes a situation whereby the amount of greenhouse gases emitted into the atmosphere is equal to the amount sequestered or offset (eg, by forestry).

the current stock of long-lived gases (ie, those already emitted and which have accumulated in the atmosphere); future inflows of long-lived gases; and, future inflows and outflows of short-lived gases.

Figure 8.1 illustrates what this stock could look like. It shows that the flow of short-lived gases influences peak warming *in relation* to the committed stock of long-lived gases already in the atmosphere. In other words, flows of short-lived gases only have a significant impact on peak warming at the point when the stock of long-lived gases is either stable or falling (Bowerman et al., 2013; Pierrehumbert, 2014).

Figure 8.1 Atmospheric stocks of short- and long-lived gases



The long-lived gas steady state requires that inflows are net-zero. The short-lived gas steady state requires inflow = outflow (with a consistent, minor decrease in emissions to achieve a stable temperature)

While the warming related to short-lived gases can alter relatively quickly (by changing the rate of inflow versus outflow), the warming related to long-lived gases is permanent. It is not possible to change the warming caused by long-lived gases, especially CO₂, on any meaningful timescale.⁷⁷

F8.1

The contribution of greenhouse gases (GHGs) to warming is a function of their stock in the atmosphere. The stock of both short- and long-lived greenhouse gases is relevant to the likelihood of successfully limiting peak-warming to 2°C or less (as required by the Paris Agreement).

Because of their atmospheric persistence, net-emissions of long-lived gases must reach zero. Emissions of short-lived gases must stabilise by inflows equalling outflows (with a consistent, minor decrease in emissions to achieve a stable temperature).

Net-zero long-lived gases

Clear scientific agreement exists that long-lived gases, and especially CO₂ due to its abundance and atmospheric persistence, must be reduced to net-zero, at a minimum, to stabilise the climate well below 2°C (Figueres et al., 2017; Hollis et al., 2016; Millar et al., 2017). It is the speed at which long-lived gases are reduced to net-zero that determines the likelihood of staying within the 2°C limit (Vivid Economics, 2017a).

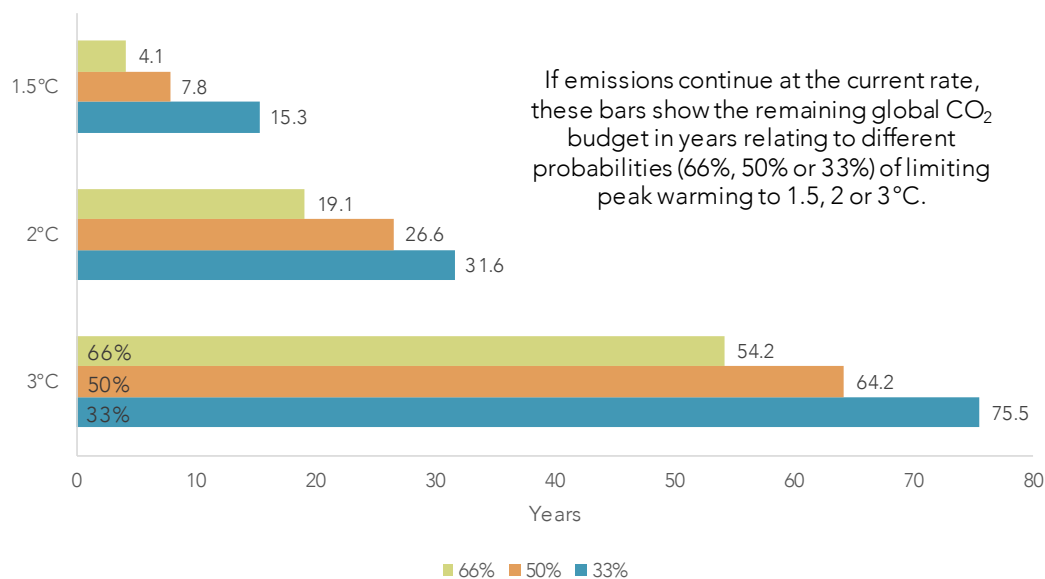
The Paris Agreement states that parties must “aim to reach global peaking of greenhouse gas emissions as soon as possible” (UNFCCC, 2015b, p. 4). However, different estimates of the date at which long-lived gases must reach net-zero exist. For example, at a global scale, to

⁷⁷ This does not preclude the potential for negative emissions technologies, such as direct air capture and storage for CO₂. These may be necessary given increasing evidence that net-zero will be insufficient at a global level to meet the 2°C target given likely international emission reduction trajectories (Sanderson et al., 2016).

meet the 2°C target of the Agreement with 50–66 per cent probability at least cost, and taking into account the current commitments made by countries in the period to 2030, modelling suggests that carbon dioxide emissions will need to reach net zero by 2060–80s, and that total GHG emissions would have to reach net zero between 2080 and 2100. (Vivid Economics, 2017a, p. 7)

As Chapter 2 explains, another common method is to express remaining emissions as a carbon budget. This refers to the amount of CO₂ the world can emit while still having a likely chance of limiting temperature rise to a particular level. At the current rate of emissions, the remaining carbon budget for a 2°C limit is approximately 1 000 billion tonnes. This is expected to be used up in 19 years (Figure 8.2). How this budget is translated into a target is a function of factors such as expected technological change, or the capacity for economies to make emissions reductions that reflect their national circumstances (UNEP, 2017).

Figure 8.2 Remaining global carbon budget



Source: Carbon Brief (2017).

Much of the international literature focuses on CO₂ because it represents two-thirds of global emissions (IPCC, 2014b). The question that arises is should the focus be solely on CO₂ or must all long-lived gases reach net-zero (Box 8.2)?

Box 8.2 Do all long-lived gases need to reach net-zero?

Most research comparing the climate impact of short- and long-lived gases focuses on the expected temperature impacts of CO₂ versus short-lived gases, as opposed to comparing all long-lived gases (ie, including GHGs such as N₂O) to short-lived gases.

Because CO₂ is so dominant and persistent in the atmosphere, the broad consensus is that CO₂ “must always be the “central” focus of mitigation efforts in the short, medium and long term” (Hollis et al., 2016, p. 1). However, because other long-lived gases accumulate in the atmosphere, prioritising their mitigation is also important (Bowerman et al., 2013). Kerr (2016b, p. 8) summarises, “in order to stabilise the climate, ever and at any temperature, net CO₂ plus N₂O emissions must be reduced to net zero levels because both CO₂ and N₂O accumulate in the atmosphere”.

Emissions reductions of N₂O are particularly important for New Zealand (Andy Reisinger, sub. 28; Generation Zero, sub. 119). This is because of the relative abundance of N₂O as a proportion of total emissions (Chapter 2), and the ability to achieve desirable co-benefits from emissions reductions such as improved water quality (Dairy NZ, sub. 18).

Policy is needed to guide the pathways of both short- and long-lived gases to reach a combined stock within the 2°C peak warming constraint. For long-lived gases, this means achieving net-zero. Given that the sooner that net-zero long-lived gases can be achieved, the more likely warming will not exceed 2°C, this means giving greater relative priority to emissions reductions of long-lived gases. In other words, the mitigation trajectory of long-lived gases matters. If long-lived gases are reduced to net-zero quickly, then the chance of limiting peak warming to 2°C, and the remaining budget for short-lived gases, are both higher.

Stabilisation of short-lived gases

Scientific evidence shows that reducing emissions of short-lived gases will also be required to stabilise peak warming at 2°C or less (Allen et al., 2016; Shindell et al., 2017; Xu & Ramanathan, 2017). However, the actual amount of emissions reductions required, and the date at which they should occur, is less certain (Rogelj et al., 2014). In part, this is due to corresponding uncertainty around the level at which the absolute stock of long-lived gases, and especially CO₂, will peak (R. B. Jackson et al., 2017). Even so, warming to which the planet has already effectively committed to, thanks to previous and current actions, means that much breathing room is unlikely for a substantial stock of short-lived gas emissions under a 2°C limit (Mauritsen & Pincus, 2017).

The stabilisation level for short-lived gases can be explained using the following examples at a global level. If, by the time long-lived gases reach net-zero, the stock of long-lived gases commits the planet to 1.5°C of warming, that allows for a stock of short-lived gases consistent with an additional 0.5°C warming to stay within the maximum 2°C limit. However, if the stock of long-lived gases is such that the planet is committed to 1.95°C warming, then the allowable stock of short-lived gas emissions is substantially reduced.⁷⁸ As S. M. Smith et al. (2012, p. 537) explain, “there is a trade-off to be made between the two: higher emission rates of shorter-lived GHGs will require lower cumulative emissions of long-lived GHGs, and vice versa”.

F8.2

Current scientific evidence shows that global emissions of all long-lived gases must be reduced to net-zero at a minimum to stabilise the climate well below 2°C. The sooner that net-zero long-lived gases can be achieved, the more likely warming will not exceed 2°C. This means giving greater relative priority to mitigation of long-lived gases.

Reductions in short-lived gas emissions will also be required in the context of limiting peak warming to 2°C. Yet because the allowable stock of short-lived gases is a function of the stock of long-lived gases, the level of short-lived gas emissions reductions needed in the context of the 2°C goal is less certain.

8.2 Should short-lived gases also be mitigated in the short and medium term?

While the priority must be to reduce emissions of long-lived gases to net-zero, there are benefits to also mitigating short-lived gases over the coming decades. It is a question of relative emphasis – to limit peak warming to well below 2°C, long-lived gases must be the core focus. But if short-lived gases can *also* be cost-effectively abated in the short and medium term, further benefit may occur as a result.

Allowing a (slightly) greater budget for long-lived gas emissions

Substantial and sustained reductions in short-lived gas emissions could enable a larger amount of long-lived gases to be emitted, while still reaching the same level of peak warming (Reisinger & Stroombergen, 2011):

Even though emissions of CH₄ do not need to go to zero to be consistent with long-term climate goals, there is a clear and quantifiable benefit from reducing CH₄ emissions as much as possible. This is because a lower (sustained) flow of CH₄ emissions allows a (slightly) greater carbon budget to reach the same peak warming level. As a result, lower CH₄ emissions would allow slightly later peaking of long-

⁷⁸ If the planet is committed to more than 2°C warming due to long-lived gases, then negative emissions technologies will be necessary to create room within the overall GHG budget for short-lived gases.

lived GHG emissions and slightly later point at which long-lived emissions have to reach net zero. This would allow deferral of some of the considerable costs associated with a rapid reduction of CO₂ emissions (or to make the actual achievement of temperature goals more likely). (Andy Reisinger, sub. 28, pp. 4–5)

If, concurrent with significant long-lived gas abatement, substantial and sustained CH₄ emissions reductions can also occur, Reisinger et al. (2013) calculate that long-lived GHG emissions may have an additional 10 to 15 years in which to peak. Reisinger (2017a) also estimates that without effective mitigation of non-CO₂ gases (including N₂O), active atmospheric removal of CO₂ will be required before 2050 to remain well below 2°C.

However, while sustained short-lived gas mitigation can create *room* for additional long-lived gas emissions (ie, to provide for a slightly more gradual transition away from fossil fuels), it does *not* mean that long-lived gas mitigation should be deferred. Hollis et al. (2016, p. 20) clearly state, “methane mitigation is not a reason to delay CO₂ mitigation”.

Short-lived gas mitigation can help to slow the moment at which peak warming occurs – it does not mean that short-lived gas mitigation can *replace* that of long-lived gases and still hope to limit peak warming to 2°C (Bowerman et al., 2013; Pierrehumbert, 2014; Rogelj et al., 2014). In other words, no amount of short-lived gas abatement can avoid the warming due to long-lived gases. And if mitigation consistent with net-zero (or negative) long-lived gas emissions does not occur, there is little point abating short-lived gases in the context of limiting peak warming (Reisinger, 2017b). Even so, if substantial reductions of long- and short-lived gases are able to be achieved concurrently, nothing is lost in terms of peak warming.

Reducing short- and medium-term temperature change

Emissions reductions of short-lived gases could avoid up to 0.6°C of warming by 2050 (UNEP, 2017). This means they could help to delay potential tipping points in the global atmospheric system (Tauranga Carbon Reduction Group, sub. 77; New Zealand Church Climate Network, sub. 121). Tipping points are critical thresholds where a major or irreversible change in the state of the climate occurs, such as melting of Arctic permafrost, or the collapse of the Gulf Stream (Lenton et al., 2008). Even so, substantial emissions reductions of short-lived gases on their own can merely delay tipping points being met – only reductions of long-lived gases can avoid them (Hollis et al., 2016).

Reductions in short- and medium-term temperature change could help to “ensure that ecosystems, food production and the economy can adapt” (Clare St Pierre, sub. 115 p. 11). Essentially, short-lived gas mitigation that contributes to avoided short- and medium-term warming is valuable because it limits the rate of climate change to a level that enables adjustment by societies and ecosystems (Bowerman et al., 2013).

The relative weight given to temperature change experienced over the next 20 or 30 years, as opposed to that experienced by generations many decades into the future, also implies an ethical judgement relating to intertemporal trade-offs about wellbeing. This question has no right or wrong answer, but it is important to recognise that these policy choices incorporate decision-making related to values, not just science.

Health co-benefits

Co-benefits to human health can arise from abating what are known as short-lived climate pollutants (SLCP). This umbrella term encompasses short-lived GHGs such as CH₄, as well as what are known as “climate forcing agents”, such as soot. SLCP emissions reductions of varying stringency in the present could avoid up to 5 million deaths from air pollution each year (Shindell et al., 2012). Many SLCP can effectively be mitigated as a co-benefit of efforts to reduce CO₂. This is because moving away from many high-CO₂ activities such as coal-fired power plants or diesel engines has the corollary of also reducing SLCP emissions.

Signalling the need to transition

Finally, short- and medium-term short-lived gas mitigation that helps to slow the speed at which temperature rises may help to soften the transition to a low-emissions economy and avoid stranded assets.

To make large changes in CH₄ in the long term, New Zealand would need to act now (not only through research and development but also development of policies and early adoption of new land uses, practices and technologies), in order to be ready to act fast later. Early action on CH₄ and clear signals of

a future transition to low-CH₄ would avoid New Zealand being locked into a high-CH₄ pathway – and facing high levels of stranded assets if required to reduce CH₄ rapidly in future. (Kerr, 2016, p. 10)

F8.3

While the priority must be to reduce emissions of long-lived gases to net-zero, there are benefits to also mitigating short-lived gases over the coming decades. These include to allow a slightly greater carbon budget, to help delay dangerous tipping points in the earth's climate system, to provide further time for adaptation to temperature change, and to help stimulate innovation or land-use change that provides for a more gradual transition to a low-emissions economy.

However, this does not mean that short-lived gas mitigation can *replace* that of long-lived gases and still hope to limit peak warming to 2°C.

8.3 Using emissions metrics to direct mitigation efforts

Under the nationally determined contribution (NDC) structure of the Paris Agreement, countries determine the contribution they consider it appropriate for them to make towards the global effort to limiting peak warming to well below 2°C. However, emissions reductions of different GHGs have different costs and benefits. One way for countries to be able to make trade-offs that recognise the considerable variation in marginal abatement costs for emissions of different GHGs is to use an exchange rate called an emissions metric (Forster et al., 2007). The relative weighting that emissions metrics give to different GHGs has significant consequences for how different gases are prioritised in terms of mitigation action.

Emissions metrics help to show how powerful GHGs are in terms of their cumulative effect on warming and their atmospheric lifetime (NIWA, 2017). They do this by converting emissions of one GHG into equivalent emissions of another GHG, based on their relative climate impacts (MIT, 2014). This concept of equivalence is then represented in a measure called carbon dioxide equivalent (CO₂e). It allows for a one-tonne reduction of CO₂ to be substituted for an equivalent emission reduction of another GHG, such as CH₄.

The primary emissions metric used for calculating CO₂e is global warming potential over 100 years (GWP₁₀₀). GWP₁₀₀ figures are determined by the Intergovernmental Panel on Climate Change (IPCC). GWP₁₀₀ is a relative measure of radiative forcing⁷⁹ over 100 years, and is expressed as a factor of CO₂ (where the GWP₁₀₀ of CO₂ is one). For example, the GWP₁₀₀ of CH₄ is 28. This figure of 28 represents the net effect of its shorter lifetime but higher energy absorption (US EPA, 2018d). In other words, compared to CO₂, the warming effect of CH₄ is powerful but short.

Alternative emissions metrics

Emissions metrics provide information and flexibility on likely relative damage (and the associated benefit of avoiding that damage) which is useful when making decisions about mitigation opportunities. However, because of their different atmospheric properties, “the notion of treating those two gases as completely interchangeable via CO₂ equivalence is rather problematic” (Reisinger, 2017a).

GWP₁₀₀ has been criticised for under-valuing the atmospheric lifetime of long-lived gases, and over-valuing short-lived gases, in the context of peak warming (Forster et al., 2007; Shine et al., 2007; S. M. Smith et al., 2012). It has also been criticised for under-valuing short-lived gases, and over-valuing long-lived gases, in the context of short- and medium-term temperature change (Ocko et al., 2017). Others, such as Allen et al. (2016), argue that GWP₁₀₀ can be considered appropriate if the Paris Agreement goal of limiting warming to well below 2°C is taken seriously by country signatories.

GWP was never originally intended to be used in policy – it was only mentioned in the first report by the IPCC to illustrate the difficulties inherent to the idea of emissions metrics (Tanaka et al., 2010). In light of problems with GWP, other emissions metrics have been developed, such as global temperature potential

⁷⁹ Radiative forcing is the key driver of climate change and is the difference between incoming solar radiation and outgoing infrared radiation. All GHG emissions absorb infrared radiation and re-emit it back to the surface of the Earth. GWP is a way of expressing the different rates at which GHGs absorb infrared radiation and therefore contribute to warming.

(GTP) (Forster et al., 2007; Shine et al., 2005). In contrast to GWP which measures cumulative radiative forcing, GTP is an end-point metric which represents the impact of the emission of one tonne of gas on global average surface temperatures at a specified point in the future. Further alternatives include GTP on a time-dynamic basis (ie, values would be updated over time due to how quickly the world was approaching peak warming) (Persson et al., 2015), or hybrids of GWP and GTP.

It is also possible to measure GWP or GTP over different time scales, such as 20 or even 500 years (Allen et al., 2016; Shine et al., 2007). Because New Zealand's emissions profile comprises a relatively high proportion of short-lived gases, these time scale changes can make a considerable difference. For example:

- changing from GWP₂₀ to GWP₅₀₀ reduces New Zealand's total emissions (in 1990 terms) by 70% (Skodvin & Fuglestedt, 1997); and
- the contribution to total New Zealand emissions (in 2008 terms) from the agriculture sector changes from 62% (GWP₂₀), to 46% (GWP₁₀₀) to 26% (GWP₅₀₀) (Reisinger & Stroombergen, 2011).

It is widely accepted that some type of emissions metric is useful when making trade-offs about mitigation priorities, despite recognition that the choice of metric strongly influences these priorities (Manning et al., 2009; Ocko et al., 2017). However, which metric is most appropriate is inevitably a value judgement about how important warming is over different time periods (Tanaka et al., 2010). As the IPCC (2013, p. 15) states,

the most appropriate metric and time horizon will depend on which aspects of climate change are considered most important to a particular application. No single metric can accurately compare all consequences of different emissions, and all have limitations and uncertainties.

Making choices about emissions metrics

New Zealand uses GWP₁₀₀ to calculate CO₂e in its emissions inventory because this is the metric used under the Kyoto Protocol of which New Zealand remains a party (New Zealand Parliament, 2014; UNFCCC, 2008). New Zealand applies the Kyoto Protocol framework of rules to its emissions from the 2013 to 2020 period (MfE, 2017g) and is likely to continue to do so after the period ends with respect to GWP₁₀₀ (MFAT, pers. comm. 19 December 2017). New Zealand also converts all GHGs into CO₂e for the purposes of its targets (including its NDC to the Paris Agreement)⁸⁰ and policy mechanisms (New Zealand Government, 2011a).

Discussion of emissions metrics in New Zealand is not new. For example, Hollis et al. (2016) suggested giving lower relative weights to short-lived gases like CH₄ (Box 8.3). In a report for the New Zealand Government, Manning et al. (2009) foreshadowed the conclusion of the IPCC (2013) that different metrics are complementary – it is unlikely to be useful for policymaking purposes to continue to rely on one single metric, or do away with emissions metrics completely. Indeed, no single emissions metric will be the “silver bullet” for making emission reduction choices – either in the context of reducing climate damage, or protecting New Zealand's economic self-interest (Hollis et al., 2016).

Box 8.3 **Should New Zealand independently amend GWP₁₀₀ values?**

In analysis prepared for the Parliamentary Commissioner for the Environment, a group of New Zealand researchers argued to reduce the GWP₁₀₀ value for CH₄ to below its current value of 28 until such time as CO₂ emissions are declining towards zero (Hollis et al., 2016). However, they also noted that the exact figure to choose is unagreed, as the arguments put forward for different values depend on the specific policy goal and “reflect judgments about politics, economics and the intersection of policy and science” (Hollis et al., 2016, p. 33).

Uncertainty about GWP values is problematic because it works in direct opposition to desirable long-term stability for businesses and other investors. It could also result in substantial difficulty in terms of translating between domestic and international mitigation if New Zealand traded emissions reductions

⁸⁰ The Paris Agreement allows for countries to choose how to express their respective contribution to the global emissions reduction effort, including in terms of emissions metric. For example, Brazil used GTP₁₀₀ in addition to GWP₁₀₀ in its first NDC (Government of Brazil, 2015).

units internationally in the future. As a result, the Commission does not recommend New Zealand use independently determined GWP₁₀₀ figures for its domestic policymaking purposes at this stage.

Even so, when thinking about the future stock of emissions that represents peak warming of no more than 2°C, an emissions metric is needed. It is necessary to compare the climate effects of short- and long-lived gases within the temperature constraint, and will be needed to determine New Zealand's mitigation targets (section 8.6). At the point when an emissions steady-state is achieved, a conversion rate will also be necessary to calculate how many fewer tonnes of long-lived gas emissions will allow for a certain emissions budget of short-lived gases (or vice versa) and still be consistent within the overall steady-state limit. This is a scientific calculation based on the radiative efficiency⁸¹ of different GHGs (Andy Reisinger, pers. comm. 2 February 2018).

F8.4

The choice of emissions metric makes a significant difference to the estimated effect of the different GHGs on warming over a given period; and so can strongly influence mitigation priorities. Choosing an appropriate metric will depend on factors such as attitudes to risk, and which aspects of climate change are considered important. No single metric can accurately compare the consequences of GHG emissions, and all have limits and uncertainties

8.4 New Zealand's short-lived and long-lived gases

New Zealand's GHGs, their atmospheric lifetimes and GWP₁₀₀ are displayed in Table 8.1.⁸² It shows that New Zealand's GHG emissions are mostly long-lived, apart from CH₄ and some HFCs which are short-lived.

Table 8.1 New Zealand's short-lived and long-lived gases

Gas	Short- or long-lived	Atmospheric lifetime	GWP ₁₀₀	Percentage of gross emissions (2015)	Main source in New Zealand
Carbon dioxide (CO ₂)	Long-lived	Up to millennia	1	44.8%	Transport
Methane (CH ₄)	Short-lived	12 years	28	42.7%	Agriculture
Nitrous oxide (N ₂ O)	Long-lived	121 years	265	10.5%	Agriculture
Hydrofluorocarbons (HFCs)	Short- and long-lived	Between 5.2 and 47.1 years	677 - 4 800	1.9%	Substitutes for ozone depleting substances (eg, refrigeration)
Perfluorocarbons (PFCs)	Long-lived	Between 2 600 and 50 000 years	6 630 - 11 100	0.07%	Aluminium production
Sulphur hexafluoride (SF ₆)	Long-lived	3 200 years	23 500	0.02%	Electrical equipment and other product use

Source: MfE (2017g); Myhre et al. (2013).

Notes:

1. GWP₁₀₀ figures are standard values from the IPCC's Fifth Assessment Report (Myhre et al., 2013) (ie, they do not take into account climate-carbon feedbacks due to large uncertainties about these mechanisms). New Zealand's inventory currently uses the Fourth

⁸¹ Radiative efficiency is a measure of the net energy change in the atmosphere caused by climatic factors.

⁸² All figures in this section refer to gross emissions (ie, excluding land use, land-use change and forestry (LULUCF); Chapter 2).

Assessment Report GWP₁₀₀ figures for accounting purposes. However, because the most recent GWP₁₀₀ figures are recommended to be used where possible (Greenhouse Gas Protocol, 2016; Trottier, 2015) Fifth Assessment Report figures are used here.

2. GWP₁₀₀ figures for CH₄ refer to CH₄ from biogenic sources (such as livestock) rather than from fossil sources (such as coal mines or natural gas leaks), which has slightly different GWP figures (a GWP₁₀₀ of 30, rather than 28); see Myhre et al. (2013).
3. Seven different HFCs are emitted in New Zealand. The table shows the lifetimes and GWP₁₀₀ of these specific gases: HFC-125 (lifetime: 28.2 years, GWP₁₀₀: 3 170), HFC-134a (lifetime: 13.4 years, GWP₁₀₀: 1 300), HFC-143a (lifetime: 47.1 years, GWP₁₀₀: 4 800), HFC-227ea (lifetime: 38.9 years, GWP₁₀₀: 3 350), HFC-245fa (lifetime: 7.7 years, GWP₁₀₀: 858), HFC-32 (lifetime: 5.2 years, GWP₁₀₀: 677), HFC-365mfc (lifetime: 8.7 years, GWP₁₀₀: 804).
4. Three PFCs are emitted in New Zealand. The table shows the lifetimes and GWP₁₀₀ of these specific gases: PFC-14 (lifetime: 50 000 years, GWP₁₀₀: 6 630), PFC-116 (lifetime: 10 000 years, GWP₁₀₀: 11 100) and PFC-218 (lifetime: 2 600 years, GWP₁₀₀: 8 900).

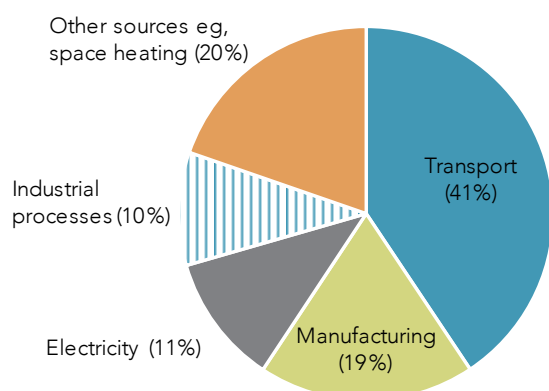
While the standard cut-off for a GHG to be considered short-lived is 20 years, delineating HFCs in a manner that most closely aligns their impact to peak warming suggests that taking a 30-year distinction is likely to be more appropriate (S. M. Smith et al., 2012). This difference is however minimal – for New Zealand, the difference between taking a 20 and a 30-year cut-off is the allocation of HFC-125. This accounts for 31% of all HFC emissions, but only 0.01% of New Zealand's total emissions. Taking a 30-year cut-off results in the following:

- **Short-lived gases:** CH₄, HFC-125, HFC-134, HFC-245fa, HFC-32, HFC-365mfc (44% of all emissions)
- **Long-lived gases:** CO₂, N₂O, PFCs, SF₆, HFC-143a, HFC-227ea (56% of all emissions)

Carbon dioxide (CO₂)

Almost half of New Zealand's GHG emissions are made up of CO₂ and most are from fossil-fuel combustion. CO₂ emissions rose by 41% between 1990 and 2015, and its proportion as a share of New Zealand's gross emissions has also risen, largely due to less forestry offsetting (MfE, 2017g). Transport is the largest source of CO₂ emissions (Figure 8.3), although a substantial amount also comes from other sources pervasive across the economy such as manufacturing and electricity.

Figure 8.3 New Zealand's CO₂ emissions by source

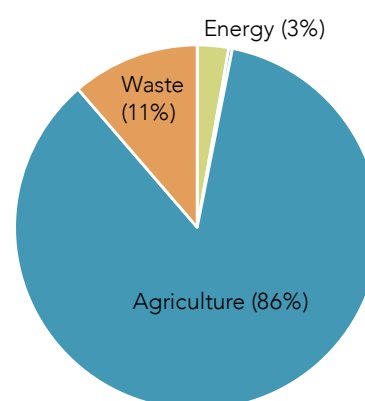


Source: MfE (2017j).

Notes:

1. In Figure 8.4, CH₄ emissions from industrial processes and product use (0.3% of the total) are not labelled due to scale.

Figure 8.4 New Zealand's CH₄ emissions by source



Methane (CH₄)

CH₄ is New Zealand's dominant short-lived gas. Total CH₄ emissions rose slightly between 1990 and 2015 (5.1%), but the proportion of New Zealand's emissions arising from CH₄ has been decreasing over time (due largely to greater emissions of CO₂). In most other developed countries CH₄ is predominantly caused as a consequence of fossil fuel production.⁸³ In New Zealand it occurs primarily in the agricultural sector as a result of animals digesting their food (through a process known as enteric fermentation) (Figure 8.4 and

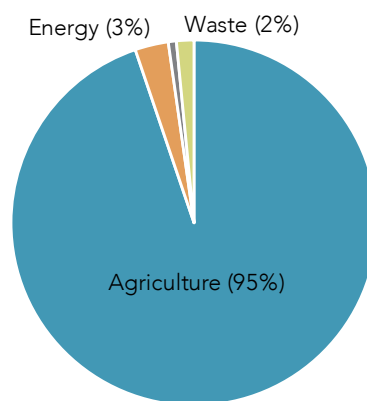
⁸³ For example, 31% of US CH₄ emissions are from natural gas and petroleum systems, compared to 25% from enteric fermentation (US EPA, 2017a).

Chapter 10). As a result, reducing New Zealand's CH₄ emissions means reducing stock numbers, or lowering the amount of gas released per unit of agricultural produce (Chapter 10).

Nitrous oxide (N₂O)

N₂O is a relatively powerful long-lived gas that, in New Zealand, overwhelmingly arises as a result of agricultural production (Figure 8.5).⁸⁴ Within agriculture, virtually all N₂O emissions are caused by urine and dung deposited by grazing animals and the application of synthetic fertilisers to pastures. Emissions of N₂O rose 48.5% between 1990 and 2015 – a percentage increase higher than seen for any other GHG (MfE, 2017g). Reducing N₂O emissions in New Zealand is mostly a question of reducing stock numbers and controlling nitrogen inputs on farms (eg, by more efficient fertiliser use, Chapter 10).

Figure 8.5 New Zealand's N₂O emissions by source



Source: MfE (2017j).

Notes:

1. Not labelled (due to scale) are N₂O emissions from industrial processes and product use (1% of the total).

Fluorinated gases

Fluorinated gases (F-gases, also known as synthetic gases) comprise hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃).⁸⁵ F-gases comprise 2% of New Zealand's GHG emissions and arise entirely from industrial processes and product use.

New Zealand does not produce any HFCs or SF₆ (all are imported). HFCs are mainly used in industrial processes for refrigeration and air conditioning (where HFCs are used as a coolant, and emissions occur as they leak out slowly over time). SF₆ is used in the electricity-distribution sector (eg, in electrical switchgear, where emissions also arise from leakage and during maintenance processes) and for small-scale medical and scientific applications (eg, in eye surgery). Practically all PFC emissions in New Zealand are caused as a by-product of domestic aluminium production at Tiwai Point (MfE, 2017g).

Under current settings, New Zealand's HFC emissions are projected to double by 2030 (MfE, 2017k), due to, for example, greater use of air conditioning as average temperatures increase. However, New Zealand plans to regulate HFCs in response to commitments made under the Montreal Protocol on Substances that Deplete the Ozone Layer (Box 8.4). The period 1990 to 2015 saw a 94% reduction in PFC emissions (due to improved management of anode effects in aluminium production) and a smaller downward trend of an 11% reduction in SF₆ emissions (MfE, 2017g).

⁸⁴ In other developed countries (eg, the United Kingdom or the United States), agriculture accounts for approximately 75% of N₂O emissions (Skiba et al., 2012; US EPA, 2017b).

⁸⁵ While nitrogen trifluoride (NF₃) falls under the UNFCCC, New Zealand does not produce or consume NF₃ so it is not discussed further.

Box 8.4 Regulating HFC emissions in response to the Kigali Amendment

Agreed in 2016, the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer focuses on phasing down HFCs by cutting their production and consumption.⁸⁶ It aims to achieve an 80% reduction in HFC consumption by 2047, and is expected to avoid up to a 0.5°C increase in global temperature by the end of the century.

As a party to the Montreal Protocol, New Zealand is proposing an import licensing system, including import caps, to phase down HFCs. This system would work in conjunction with the existing arrangements under the New Zealand Emissions Trading Scheme, and would enable New Zealand to ratify the Kigali Amendment (MfE, 2017k). It comprises a series of progressively more restrictive stepped import controls that would limit imports by 2036 to 19% of baseline consumption (average imports from 2010 to 2015). If enacted, this system would be the primary mechanism to reduce HFC emissions in New Zealand.

Given the structure of the import licensing system (reducing imports to 19% of baseline consumption, rather than 0%) and the intent to globally phase down, rather than phase out HFCs, New Zealand could still see some HFC emissions by 2036 and later (particularly within products or vehicles). However, technological change inspired by requirements to meet Kigali Amendment obligations in other countries makes it likely that alternatives will appear as substitutes to HFCs (much as HFCs themselves were substitutes to ozone-depleting substances, the original intent of the Montreal Protocol).

As noted in the discussion on emissions metrics, GHGs have different marginal abatement costs. This relates to the availability of mitigation choices or technologies, as well as how much mitigation is valued in specific policy mechanisms (eg, by using GWP₁₀₀ to calculate the cost of a unit in the New Zealand Emissions Trading Scheme, NZ ETS).

In New Zealand, some GHGs from particular sources will be cheaper to abate than others. For example, because of the availability of replacement technologies for fossil-fuel vehicles (such as electric vehicles, Chapter 11) or carbon-intensive electricity production (such as wind power, Chapter 12), some sources of CO₂ are likely to be relatively low-cost to mitigate. Other sources of CO₂, such as from industrial processes where alternative technologies are not yet apparent (Chapter 13), may be much more expensive. This is the point of having a comprehensive ETS that targets least-cost mitigation options across the economy.

Reducing emissions of one type of GHG may also lead to the co-benefit of reducing other types of GHG. For example, in the agricultural sector, reducing on-farm N₂O emissions is likely to be a priority because of its high GWP₁₀₀ figure (which means it has a higher relative emissions penalty in an ETS) and the availability of mitigation options (Chapter 10). However, some actions to reduce N₂O emissions (such as reducing stock numbers and nitrogen fertilisers) may also reduce agricultural CH₄ as a consequence.

8.5 International and domestic targeting of different gases

It is rare to explicitly prioritise emissions reductions of specific GHGs

As a result of efforts to decarbonise electricity, many other countries are reducing emissions of long-lived gases, especially CO₂. However, it is rare for other countries to explicitly aim to reduce long-lived gases – most targets and policies are still in CO₂e. For example, Germany's *Energiewende* (energy transition programme) focuses on moving away from fossil-fuel energy sources such as coal in order to achieve a goal of 60% renewable energy target by 2050 (BMW, 2011). This results in a strong focus on CO₂ emissions reductions given the high proportion of CO₂ as part of Germany's existing emissions profile.

What this example serves to illustrate is that most other developed countries do not need to explicitly target CO₂ for the simple reason that most of their emissions are from CO₂. In other words, for many of

⁸⁶ Note that the Kigali Amendment only controls bulk HFCs (ie, not HFCs contained within goods or vehicles).

New Zealand's comparators, a CO₂ focus is not substantially different from a CO₂e focus. China is an exception in that it has an explicit goal of reducing CO₂ emissions per unit of GDP by 2020 to 40%–45% of 1990 levels (Carbon Brief, 2015).

Because different GHGs have different abatement costs (because they arise from different economic activities), it is clear that countries take into account various mitigation options for different individual gases when making policy decisions. Yet even countries that have a relatively large proportion of their electricity from renewable sources (such as Iceland, Norway, Brazil or Canada, and including New Zealand), and so may have a lower relative proportion of CO₂ emissions, invariably present headline mitigation targets in terms of “greenhouse gases” or “CO₂e”.

At a sub-national level, cities and regions target mitigation in a wide variety of ways. These range from reducing emissions by specified percentages, to carbon neutrality, to being fully net-zero in relation to all GHG emissions. Most efforts, like those at the national level, focus on CO₂e. A notable exclusion is California. Under a headline legislated commitment to reduce overall GHG emissions to 40% below 1990 levels by 2030, Senate Bill No. 1383 requires a 40% reduction in emissions of CH₄ and HFCs by 2030 compared to 2013 levels. The key rationales for the law are to reduce short-term temperature change and provide health co-benefits (section 8.2) (Brown, 2016). The law specifically targets reductions in CH₄ from livestock and dairy manure management operations.

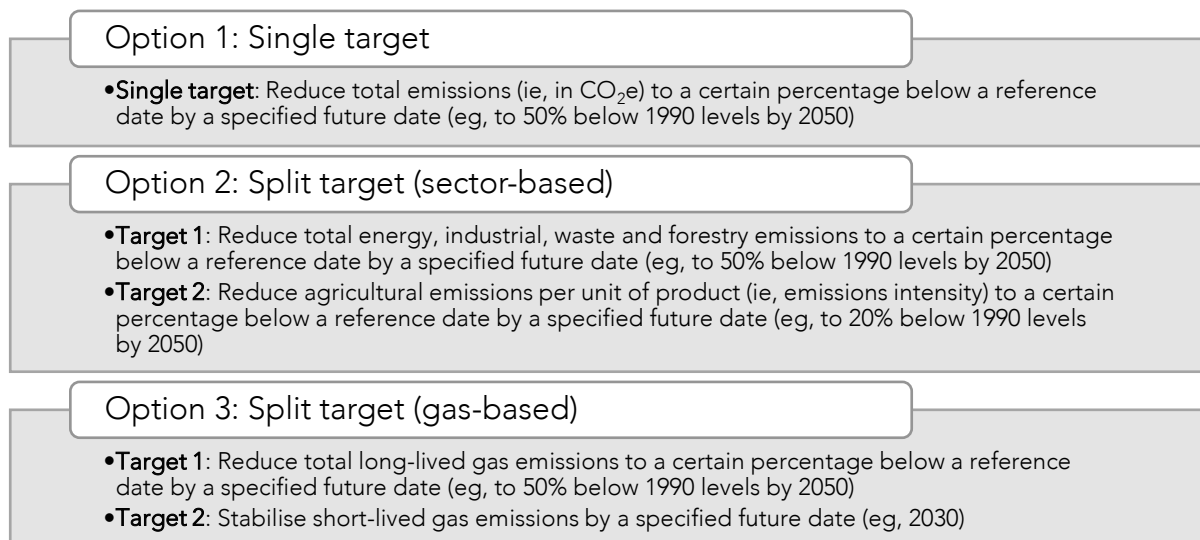
New Zealand's experience with prioritising reductions of different gases

In New Zealand, most GHGs are addressed within a CO₂e framework. Some gases are exposed to greater mitigation drivers than others. For example, CO₂ from fuel combustion and CH₄ from waste are subject to the NZ ETS. Other gases, such as agricultural CH₄ and N₂O, are mostly unregulated to the exclusion of agriculture from the NZ ETS. However other policy drivers do implicitly target emissions reductions of particular gases. Examples include:

- road user charge exemptions for electric vehicles (resulting in avoided CO₂ emissions, Chapter 11);
- research activity directed towards agricultural mitigation technologies (which directly aims to reduce both CH₄ and N₂O, Chapter 10);
- regulation of nitrate levels in waterways (with the co-benefit of reduced N₂O emissions, Chapter 10); or
- the Synthetic Greenhouse Gas (SSG) Levy that targets small importers of HFCs and PFCs.

In New Zealand, despite the dominance of the CO₂e framework, the idea of more explicitly separating short- and long-lived gases with different policy mechanisms or targets is not new. Kerr (2016b) outlined how agricultural GHGs (CH₄ and N₂O) could be dealt with separately in terms of policy mechanisms and targets. Distinguishing between short- and long-lived gases is a core element of Generation Zero's proposal for a Zero Carbon Act (Generation Zero, sub. 119), and Simon Upton, Parliamentary Commissioner for the Environment, has also highlighted the possibility (Upton, 2016).

Different gas-based targets were also examined in the lead-up to the United Nations Framework Convention on Climate Change (UNFCCC) 21st Conference of the Parties (where the Paris Agreement was ultimately agreed). Figure 8.6 explains, using hypothetical target ranges and dates, the difference between three of the main options that were considered. In documentation prepared for the Government, the Treasury (2015b) recommended a split target based on sectors (option 2). The key rationale was that option 2 better reflected the scientific need to focus on long-lived gases as compared to option 1, but was the least-cost option that the Treasury considered was also internationally credible.

Figure 8.6 Options for New Zealand’s 2030 target

Source: Based on The Treasury (2015b, p. 13).

Notes:

1. Target 2 under option 3 does not specify a level at which short-lived gases should stabilise (the implication of the target is only that they do not continue to rise); but it would need to be developed with reference to the level of warming caused by long-lived gases.

A single target based on CO₂e (option 1) was ultimately chosen by the Government. This was, in part, because taking a split target at the level that New Zealand was contemplating was considered to be potentially damaging to New Zealand’s reputation. Concerns raised by the Ministry of Foreign Affairs and Trade regarding the ability of New Zealand to secure access to international emissions trading markets, and to secure optimal arrangements regarding forestry accounting rules, were of particular relevance to this decision (Office of the Minister for Climate Change Issues, 2015).

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The idea of prioritising emissions reductions of short- or long-lived gases is not new in New Zealand. Researchers and policy officials have previously highlighted the possibility of, or recommended, New Zealand distinguishing between short- and long-lived gases in terms of policy mechanisms and targets.

Prioritising different gases or sectors can also be described as a “two-baskets” approach (Daniel et al., 2012; S. C. Jackson, 2009). The issues paper for this inquiry briefly outlined the two-baskets approach and Box 8.5 presents submitters’ views.

Box 8.5 Submitters’ views on the two-baskets approach

Of the 34 submitters who directly responded to question about whether New Zealand should adopt a two-baskets approach, just over half (56%) responded in favour (with 35% opposed and 9% providing no clear view). Generation Zero (sub. 119) provided a particularly detailed response about design considerations for a two-baskets approach.

Many submitters in favour focused on its scientific merits.

Council agrees that New Zealand should adopt the two baskets approach. Given the disparate contribution to climate change, setting separate targets is appropriate. (Rangitikei District Council, sub. 35, p. 4)

The two baskets approach has some merit given NZ’s mix of gases and high shares of methane. (Massey University College of Sciences, sub. 76, p. 1)

DINZ and B+LNZ believe that the physics and chemistry of short-lived gasses are fundamentally different to CO₂ from fossil fuels and if the world wants the most efficient and effective response to climate change, they should be treated separately. (Beef and Lamb NZ and Deer Industry NZ, sub. 98, p. 9)

Other supporting arguments were also presented, including signalling, and the ability to achieve a softer transition.

A two-basket approach would thus support a less ambiguous long-term signal for the trajectory of long-lived GHGs, which so far has been lacking for New Zealand. A switch to a two-basket approach in my view can only be justified if it is coupled with a clear vision for New Zealand to achieve net zero long-lived GHG emissions by a certain date. A two-basket approach thus presents an important opportunity to provide clearer long-term signals. (Andy Reisinger sub. 28, p. 5)

Adopting the two baskets approach, for example, would allow for a softer transition to a low-emissions economy for agricultural business owners. (LGNZ sub. 36, p. 7)

Several important caveats were highlighted in some submissions in favour, mostly in relation to New Zealand's reputation. For example, Professor Robert MacLachlan (sub. 9) argued that it should only be adopted in New Zealand as an internal policy framework. Other submitters contended that New Zealand should continue to align to the international framework for GHG accounting (Guardians of NZ Superannuation, sub. 32; Scion, sub. 67), particularly given uncertainties regarding the impact of CH₄ emissions and risks to New Zealand's reputation (Enviromark Solutions, sub. 108).

Other submitters argued that a two-baskets approach should only be implemented if international scientific consensus was reached on such a system and if it was then adopted in international GHG accounting methodologies (Ballance Agri Nutrients Limited, sub. 34; Wiremu Thomson, sub. 78). NZ Carbon Farming (sub. 95, p. 22) also identified a risk that discussion regarding a two-basket approach could impede the urgent adoption of "an overarching plan with sector-based targets and measures to drive action".

Of submissions that opposed the two-baskets approach, two key arguments were that:

- the NZ ETS is already too complex and such an approach would be pushing the science beyond its current limit (Bioenergy Association, sub. 37; Hitashi Zosen Innova Australia Pty Ltd, sub. 68; Oji Fibre Solutions, sub. 71); and
- it implies regulatory distortion and political expediency by treating sectors differently (NZ Institute of Forestry, sub. 73; Todd Corporation, sub. 122).

8.6 A New Zealand approach to short- and long-lived gases

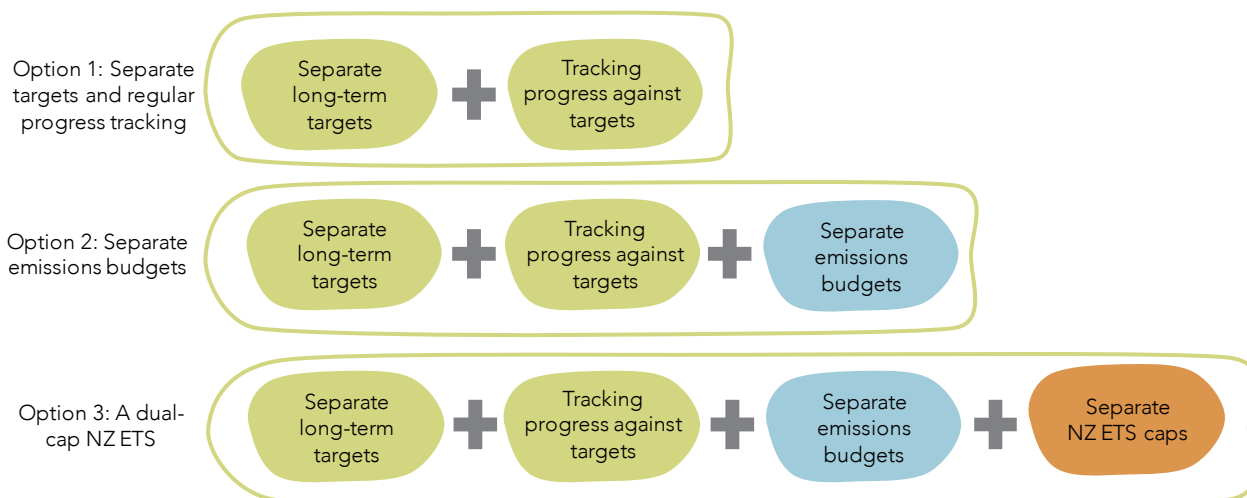
New Zealand has committed to ensuring that both its short- and long-lived gases are appropriately mitigated in accordance with the Paris Agreement. Yet, unlike most other developed countries, whose emissions profiles are dominated by CO₂ so that it is, by default, the main focus of mitigation attention, New Zealand faces a particular and distinctive challenge. Because New Zealand's emissions profile has a relatively high proportion of short-lived CH₄, bundling short- and long-lived gases together, particularly in terms of target setting, is problematic.

This is because it does not allow adequate transparency (and therefore targeting) about which emissions reductions are needed. Critically, it does not clearly signal that giving greater relative priority to achieving net-zero long-lived gases is important because of their atmospheric persistence, and that the quicker such gases are mitigated, the more likely the 2°C goal will be achieved. In other words, it does not provide sufficient direction to prioritise "steps that stop stock accumulation while managing the warming that the flow of short lived gases provides" (Upton, 2016, pp. 4-5).

The Commission does not recommend that New Zealand abandons GWP₁₀₀ to calculate CO₂e. Retaining the ability to understand national targets and policies within this framework is important because it is the “language” of international emissions accounting and agreements. The Commission does however recognise that other emissions metrics (such as GTP) may provide useful complementary perspectives on emissions reductions priorities, particularly in light of the different physical characteristics of GHGs (Thomas et al., 2016).

So, what might be the right solution to tackling New Zealand’s short- and long-lived gas emissions? There is a spectrum of potential mechanisms to reflect the different atmospheric properties of GHGs in laws and policies. In deciding the best approach, factors such as flexibility, complexity, uncertainty, the international context, and likely mitigation potential must all be taken into account. The following sections consider three options to treat short- and long-lived gases differently, building on each other with additional policy specificity (Figure 8.7).

Figure 8.7 Options for treating short- and long-lived gases differently



Option 1: Separate targets and regular tracking of progress

Option 1 is the baseline option. It constitutes the minimum components the Commission considers necessary to provide relatively greater priority towards emissions reductions of long-lived gases in the New Zealand context. Option 1 comprises a single overarching target expressed in CO₂e, underpinned by separate long-term domestic targets for short- and long-lived gases. This framework is supported by a regular series of reviews to assess progress.

The important caveat must be noted up front about the use of the term “target” to refer to the separate end-points for short- and long-lived gases. Especially as regards short-lived gases, these separate targets may possibly be more appropriately thought of as “principles”, “goals” or “tenets”. This is because the innately uncertain nature of the short-lived gas budget consistent with 2°C, results in substantial complexity in terms of their expression in law (eg, how they should or could be expressed in primary legislation). The discussion below goes into more detail about the location of the separate targets in law.

Separate short- and long-lived gas domestic targets supported by a single all-gases target

A long-lived gas target of net-zero by a specified end date

The long-lived gas target has an end goal of net-zero by a specified point in time (eg, 2050). It is important to specify a date for long-lived gases to reach net-zero so as to achieve an orderly transition towards a low-emissions economy (Rogelj et al., 2015b).⁸⁷

A short-lived gas target of stabilisation within a temperature limit

The target for short-lived gases focuses on stabilisation within a temperature limit, and also by a specified end date. In other words, this means capping the rate of emissions of short-lived gases at a particular

⁸⁷ The minimum ambition of net-zero could be ratcheted up over time if necessary. For example, if further global effort is needed in the future to avoid extreme climate change (together with the development of enabling technology), a negative emissions goal may be considered appropriate.

volume. The idea of stabilisation is the principle. Setting an underpinning and more explicit *quantity* goal for the actual stabilisation level for short-lived gases (ie, maximum emissions rate) is also needed to provide clearer direction to mitigation action, particularly for the agricultural sector. The quantity goal could be expressed in several ways, such as identifying a projected percentage reduction in short-lived gas emissions from the present, or an estimated quantity of allowable emissions by a future date.

Importantly, this quantity goal can only be a projected estimate because of the uncertainty around mitigation trajectories, particularly for long-lived gases (eg, based on modelling of likely emissions reductions pathways). Therefore, the actual mitigation volume targeted under the stabilisation principle will need to be updated regularly as the low-emissions trajectories of New Zealand and other countries become apparent. Even so, the benefit of a downward trajectory that also begins now for short-lived gases is that it provides an important market signal that behaviour change is required in the agricultural sector (Kerr, 2016).

Determining the quantity goal will be reliant on several components, including:

- the global stock of both short- and long-lived gases (Rogelj et al., 2015a);
- New Zealand’s historical and ongoing contribution to the global stock of GHGs;
- the abatement potential for short-lived gases that is considered acceptable in terms of social and economic consequences; and
- an assessment of what New Zealand’s “fair share” of global short-lived gas emissions comprises (MfE, 2015b; The Treasury, 2015b).⁸⁸

The above issues are relevant because they recognise competing values and priorities, and allow for a policy decision that is proportional to its anticipated associated economic and social costs over time, including transaction and compliance costs, and the costs of not transitioning to a low-emissions economy.

Separate domestic targets supported by a single all-gases target

The separate targets are domestic in that they do not replace, but are additional to, a single all-gases target for the purposes of New Zealand’s international commitments. New Zealand, as a developed country, “should continue taking the lead by undertaking economy-wide absolute emission reduction targets” (UNFCCC, 2015b, p. 4). While separate gas targets that cover the whole of the economy could arguably meet this definition, having a single target that communicates the overall rate of emissions reductions is useful. This is because it helps to retain credibility with the international community, and consistency with the international framework of emissions reductions.

This would not preclude New Zealand from separately reporting against its short- and long-lived gases in its NDC to the Paris Agreement, including a description of how such an approach is contributing to the global effort to reduce emissions. This would be helpful because, as Millar et al. (2017, p. 5) state, “separate reporting of long-lived and short-lived greenhouse gases in national pledges would help clarify their long-term implications”. New Zealand’s experience with clearly defined separate targets would also likely provide a very valuable example for other developed countries whose agricultural emissions will become proportionately greater as they succeed in abating their energy-related emissions.

Targets in domestic law

As laid out in detail in Chapter 7, it is important to carefully consider the nature of mitigation targets. It is clear that the single all-gases target must be set in primary legislation. This provides for consistency with the international UNFCCC architecture, and helps to provide an overarching direction for mitigation action.

However, as noted above, determining how to reflect the separate targets, and especially the short-lived gas target, in law is more complex. Some benefits exist to having the separate short- and long-lived gas targets set in primary legislation (in addition to the all-gases target). These include that so doing emphasises the

⁸⁸ Another potential consideration is the availability of negative emissions technologies. If levels of long-lived gases can be further reduced in such a manner, greater room is available within the overall stock of GHGs for a larger stock of short-lived gases to reach the same temperature level.

distinction between the net-zero long-lived goal and the stabilisation short-lived goal, and also provides durability for future governments to operate within this split framework.

Given the precision of the long-lived gas target (ie, that it aims for net-zero by a specified end date), this target is more suitable to be set in primary legislation. But, the same cannot be said for the short-lived gas target. This is because of the substantial uncertainty about the allowable volume of short-lived gas emissions within the temperature limit. This uncertainty is incompatible with the need for a well-designed target that, among other characteristics, provides clarity about the nature of the obligation to meet the target, and is not easy to amend (Chapter 7). Indeed, the fact that regular revision of the specific emissions quantity underpinning the short-lived gas target will be needed over time makes it particularly unsuited to the durability required of a target established in primary legislation.

Alternatives to setting the short- and long-lived gas targets in primary legislation exist. These include noting in primary legislation the *principle* behind treating short- and long-lived gases differently (ie, that long-lived gases need to get to net-zero, and short-lived gases do not), and directing subsequent government policy to take account of, or have due regard to, or not act in a manner inconsistent with, this principle. Another potential option is for the primary legislation to *require* the creation of different short- and long-lived gas targets, but leaving the actual specifics of these targets to be developed via other mechanisms (eg, similar to the emissions budget process, see also Chapter 7).

Further work will be required on this point. It is clear that the specific wording and location of the separate short- and long-lived gas targets is a complex legislative issue and must be carefully considered.

Targets by GHG, not by sector or economic activity

Finally, the separate domestic targets are distinguished by GHG, not by sector or economic activity. The scientific justification for an approach based on sectors is not convincing, and risks being seen as a device to protect the agricultural industry and make New Zealand “look protectionist” (Professor Robert McLachlan, sub. 9, p. 18).

Regular review and tracking against progress

A review process is an integral requirement of this option. This is so that the future Climate Change Commission (Chapter 7) can advise the Government whether New Zealand appears to be tracking well towards its targets, or whether policy adjustments are required. It appears sensible that this review process would coincide with other reviews of New Zealand’s mitigation progress as discussed in Chapter 7.

The suite of policy measures contained within this report are extensive. If successfully implemented, they are likely to significantly alter New Zealand’s emissions reduction trajectory and put the country well on the path towards meeting its targets. The rationale for these recommended policy measures (based on, for example, technical potential to mitigate, or to avoid emissions leakage) also naturally complements an approach that gives relatively greater priority to emissions reductions of long-lived gases. Long-lived gases are, fortunately, and on the whole, likely to be cheaper to abate in New Zealand than short-lived gases (with some notable exceptions, such as CH₄ from waste which should be reasonably cost-effective to mitigate, Chapter 14). For example, the modelling shown in Chapter 3 clearly shows that reducing emissions from transport by way of electric vehicles would substantially reduce prices in the NZ ETS. However, specific policy design measures will also be important. For example, the quantity of free allocation of New Zealand Units (NZUs) within the NZ ETS (Chapter 4) is likely to be a dominant driver of the speed at which mitigation of both short- and long-lived gases occurs in the agricultural sector.

As a result, it may be unnecessary to more explicitly direct policy towards specific treatment of short- and long-lived gases to achieve the separate targets. However, if considered necessary, the Government could consider moving towards separate emissions budgets and/or caps under the NZ ETS as outlined below, or adjusting the settings of other complementary measures. In other words, target differentiation does not, by necessity, prescribe policy differentiation (Andy Reisinger, pers. comm. 27 January 2018).

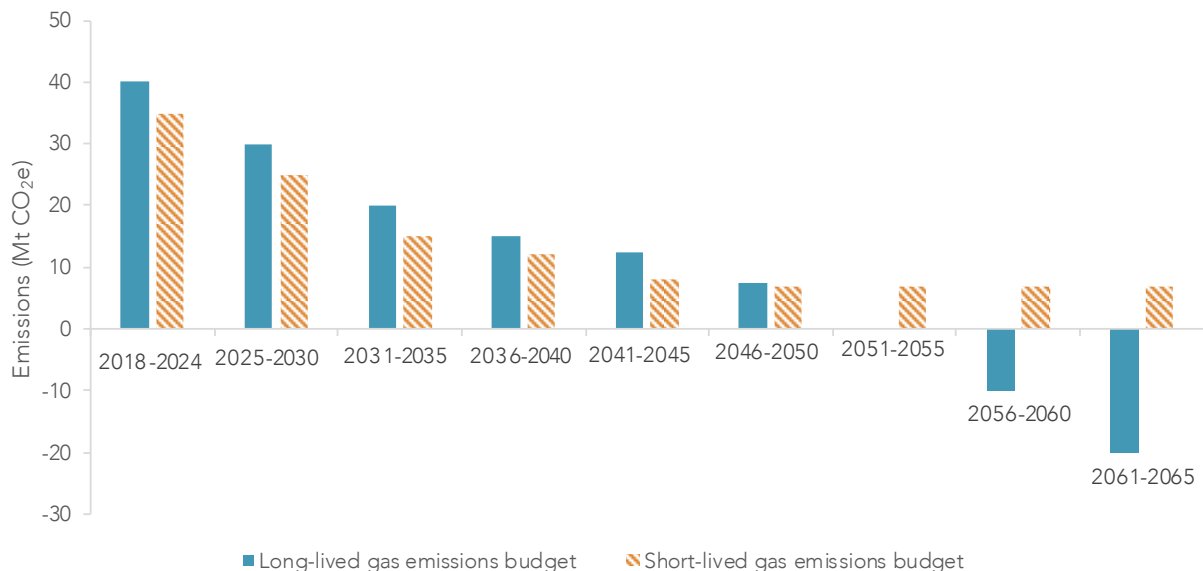
Option 2: Separate emissions budgets for short- and long-lived gases

Option 2 comprises everything in option 1, but also specifies distinct emissions budgets for short- and long-lived gases. The process of creating budgets is discussed in detail in Section 7.6 of Chapter 7, but in summary, is a way to set a limit on the total amount of allowed emissions during a future budget period, while allowing flexibility as to how the overall budget is met. The key distinction between options 1 and 2 therefore is the level of precision and visibility given towards mitigation of each category of gas.

Figure 8.8 provides a stylised depiction of hypothetical separate emissions budgets (including potential negative emissions as shown beyond 2050). As the graph shows, the available emissions budget for short- and long-lived gases declines over time. This is no different to the total volume of emissions reductions required under option 1, but more explicitly defines the *trajectory* of reductions on a gas-specific basis.

Separate emissions budgets could help to provide a stable and certain investment environment by providing a clearly defined pathway for emissions reductions of each gas. The emissions budgets could also clearly indicate that emissions reductions need to occur in the short-term across all sectors of the New Zealand economy, including in agriculture (Kerr, 2016).

Figure 8.8 Stylised depiction of hypothetical separate emissions budgets



Option 3: A dual-cap structure within the NZ ETS

Option 3 comprises the separate targets and associated tracking of option 1, and the separate emissions budgets of option 2, but goes further by amending the NZ ETS by implementing a dual-cap structure. In essence, it provides an explicit policy mechanism to direct how the separate targets would be achieved.

Instead of having a single cap relating to all GHG emissions, a dual-cap system is based on a long-lived gas cap and a short-lived gas cap. The cap is set in direct relation to the emissions budget for each category of GHG, and would result in the creation of two types of NZUs: a long-lived NZU and a short-lived NZU. Given that each cap would be set at a different level, the price of each type of NZU would be independently determined. Each cap would have similar rules to the existing NZ ETS, in that a permit would be surrendered for each tonne-equivalent of emissions.

Under a dual-cap approach, mitigation trade-offs between the two baskets underneath each cap would not be possible. This firewall exists to retain the integrity and efficacy of each cap, and the associated price of each type of NZU. Conversely, trade-offs between mitigation of GHGs underneath each cap would be permitted. In other words, abatement flexibility is restricted solely within or between gases of similar atmospheric properties (eg, between CO₂ emissions reductions in transport versus in process heat, or between options to reduce CO₂ or N₂O). As with the existing structure of the NZ ETS, this is to encourage mitigation action at the lowest marginal cost across the economy while recognising the atmospheric impacts of different gases.

Analysis of options

As noted above, the Commission considers that option 1 comprises the minimum necessary components required to provide relatively greater priority towards emissions reductions of long-lived gases in the New Zealand context. Option 2 (separate emissions budgets) and option 3 (separate NZ ETS caps) provide additional precision and direction towards the separate mitigation trajectories of short- and long-lived gases (with the former towards a stabilisation level and the latter towards net-zero). In particular, dual caps under the NZ ETS links mitigation direction with an emissions price, such that emissions reductions of either short- or long-lived gases are able to be clearly valued across the economy.

However, the downside of this greater specificity is substantial. As regards option 2, a significant drawback is that it could easily over-prescribe the trajectory of New Zealand's emissions reductions pathway. As emphasised throughout this report (and especially in Chapter 3), flexibility and the ability to preserve future options is important in the face of uncertainty. Determining separate emissions budgets without foresight of technological innovation may be unwise (even given that a single emissions budget process will, to some extent, require some judgement as to the make-up of sectoral GHGs within each future budget period). In reality, the ability to mitigate may be significantly "lumpier", in that the development of technology may suddenly allow substantial mitigation in one period, rather than a steadily declining trajectory over time.

Option 3 also has several weaknesses. The essence of the dual-cap structure under the NZ ETS is to limit substitutability between short- and long-lived gases using an emissions pricing mechanism. However, as with the problem highlighted in relation to option 2, this structure may unnecessarily restrict efficient mitigation options across the economy during the transition. For example, the inability to trade between baskets creates an opportunity cost, in that it is possible that the same temperature goal could have been achieved at a lower cost via a single emissions price, rather than via two separate emissions prices.

Another downside is the substantial additional complexity it represents. Even though option 3 would not require any additional transaction costs in terms of reporting for these participants (as all GHGs need to be reported), the requirement to manage two separate emissions prices may be overly burdensome.

A final consideration is that a dual-cap NZ ETS could also potentially make linking with other international emissions trading instruments in the future extremely complicated. Relying on project-based units (ie, where the gas-specific mitigation can be directly traced) as opposed to generic emissions units could potentially overcome this complication. Then international units could be properly allocated against either a short-lived or long-lived NZU. However, doing so might unnecessarily limit the ability to purchase international units (ie, it assumes such project-based and traceable units are available). Also, a lack of absolute certainty regarding origin would severely undermine the integrity of each cap.

Therefore, in summary, the Commission considers that option 1 is preferable, in that it comprises the minimum necessary requirements for giving relatively greater priority to long-lived gases, but is not overly prescriptive in determining mitigation pathways. This is particularly appropriate given the uncertainty as to the effect of the significant number of policy amendments already recommended in this report.

R8.1

The Government should establish separate long-term domestic targets for short- and long-lived gases, together with a regular series of reviews of progress against these targets. The long-lived gas target should be a net-zero target by a specified end date and the short-lived gas target should aim for a stabilisation level within a specified temperature limit. The short-lived gas target must be underpinned by an explicit quantity goal (ie, maximum emissions rate).

The Government should support these separate targets with a single all-gases target. The all-gases target should be set in primary legislation. The Government should carefully consider the appropriate legislative instrument to express the separate short- and long-lived gas targets.

8.7 Conclusion

Because of the different atmospheric properties of GHGs, and an understanding that long-lived gases need to get to net-zero and short-lived gases do not in order to limit peak warming, the case for putting greater relative priority on mitigating long-lived gases is strong. While this is well-understood within the scientific community, less policy attention has been paid to this issue globally. This is because most developed countries' emissions profiles are dominated by CO₂, meaning that, by default, long-lived gases are the main focus of mitigation attention.

However, because a relatively high proportion of New Zealand's total emissions are from short-lived gases, the question of how best to prioritise between emissions reductions from short- and long-lived gases is of greater interest. The Commission recommends that separate long-term domestic targets for short- and long-lived gas be enacted, with an associated regime of tracking and progress. While these separate targets will also be supported by a single all-gases target, the intent of separate targets is to provide an important signal for the necessity of achieving net-zero long-lived gases, and a stabilisation rate for short-lived gases that is consistent with New Zealand's contribution to limiting peak warming to 2°C or less.

9 Policies for an inclusive transition

Key points

- New Zealand has a dynamic economy that is constantly adapting in response to changes in technology and consumer preferences. As with previous economic changes, the move to a low-emissions economy will create new opportunities and jobs besides replacing current roles and firms.
- The mitigation policies recommended in this report may raise energy, transport and food prices. These items make up a significant share of lower-income household expenditure. A disproportionate burden of the transition to a low-emissions economy may therefore fall on these households.
- The regressive impacts of mitigation policies are not a reason to delay action on climate change, nor to compromise on the ambition of mitigation policies. The Government has the means to compensate affected households and firms.
- Although mitigation policies will create new opportunities, many households are likely to be negatively affected by changing economic circumstances (for example, because the returns on investments in emission-intensive industries are likely to fall). However, the Commission considers that the focus of any public assistance should be on lower-income households who have a limited ability to substitute towards less emissions-intensive consumption, and those facing large shocks, such as individuals suffering a loss of employment opportunities.
- Various options are available to help lower-income households, including income tax cuts, minimum wage increases, welfare benefits and personal tax credits. The Commission prefers a combination of welfare benefits and tax credits because such benefits and credits are most affordable and targeted, and existing policies can be used. The Government should monitor energy, food and transport price trends to ensure that the benefits and tax credits adjustments are being appropriately adjusted over time.
- Government interventions to encourage “conditioning” investments (eg, household insulation) targeted at lower-income households generate significant health benefits and support substitution towards lower-emission consumption. Available evidence suggests that such investments do not encourage greater energy use and emissions, but rather lead to savings in energy consumption.
- The transition to lower-emission vehicles may be difficult for some low-income households, especially if the price premia for low- or zero-emissions vehicles over fossil fuel vehicles remain high. However, these price differences will be affected by technological and consumer change that cannot be predicted at this stage.
- Interventions that respond to significant shocks to communities resulting from emissions-reduction policies (eg, the loss of a major employer) should focus on the labour market and skills needs of individuals, and should be targeted to those who will have the most difficulty gaining new employment. Yet the Commission has found that the current education and training system is not well set up to meet the needs of people seeking mid-career retraining.

The preceding chapters in this part of the report have dealt with the policy and institutional changes to encourage the transition to a lower-emissions economy. This chapter focuses on how such a transformation can be realised while mitigating against the disproportionate impact of climate-related policies on lower-income households, the disruption from economic transformation, and enabling lower-income households to be part of a “post-carbon society”.

9.1 Transitions in a dynamic economy

The transition to the low-emissions economy will involve significant structural change, with new firms, sectors and occupations rising, while others decline. This will affect individuals, households and firms, as some skills and investments fall in value and others increase, reflecting changes in supply and demand for goods and services. While these changes will create disruptions, it is worth placing them in the context of ongoing economic dynamism. The ‘churn’ of new firms opening, older firms closing, and resulting re-allocation of resources plays a key role in promoting productivity growth and improvements in living standards (Conway, 2016).

Economic transitions are nothing new

New Zealand has gone through many significant economic changes since the signing of the Treaty of Waitangi, reflecting shifts in global demand, technologies, household preferences and domestic policies. These changes affected the returns from skills, capital and other investments, such as shown in the four examples below.

- High global wool prices in the middle of the 19th century saw an expansion of sheep farming, lifting New Zealand’s per capita incomes to some of the highest in the world (Lattimore & Eaqub, 2011). This led to large-scale land conversion, with the amount of land ploughed and sown in grass increasing to around 1.2 million hectares in 1870, 2.6 million hectares in the 1880s and reaching 5.6 million in 1914 (Hawke, 1985).
- The introduction of refrigerated shipping in 1882 dramatically expanded New Zealand’s ability to sell its products overseas, and made the national and international sale of dairy products viable. The growth of the dairy industry was slower, reflecting the need for additional technological development (eg, reliable centrifugal separators) and investment (eg, local processing plant, and refrigerated local transport). Cattle numbers and dairy exports grew quickly from the beginning of the 20th century.
- The gradual urbanisation of New Zealand saw shifts in the composition of the labour market and economy. A more urban and developed society demands more services, so the services sector became the single largest source of employment by the beginning of the 20th century (Easton, 2016).
- Falling terms of trade and rising unemployment and fiscal deficits led successive governments to liberalise the economy over the 1980s and 1990s, including by reducing import protection, ending subsidies to industry and agriculture, corporatising some services and reforming industrial relations law. The resulting economic re-allocation led to declines in demand for labour in some sectors (eg, manufacturing) and for some types of labour (eg, unskilled) (Carroll, 2012).
- More recently, increasing global demand for milk products has seen a large expansion of dairy industry. Dairy cattle numbers increased by around 69% between 1994 and 2015 (MfE & Stats NZ, 2017a) and between 1996 and 2008 almost 300 000 hectares of land used for sheep and beef farming was converted to dairy production (PCE, 2013). In comparison, lower returns for wool and meat led the number of sheep – once the backbone of the New Zealand economy – to fall from a high of around 70 million in the 1980s to around 30 million in 2015 (MfE & Stats NZ, 2017a).

Jobs are constantly being created and destroyed

This economic dynamism, with people responding to new opportunities and changes in prices and demand, flows into the labour market in the form of job creation and destruction. The yearly job creation rate in New Zealand (that is, the gross number of filled jobs created over a year) has been estimated at between 14.8% and 17.5%, while the yearly job destruction rate (ie, the gross number of jobs lost over the year as a proportion of total jobs) sits between 12.3% and 15.3% (Page, 2010). Job creation and destruction rates are higher in some New Zealand industries (eg, agriculture, forestry and fishing; rental, hiring and real estate services) than in others (eg, education and training; public administration; and safety). Using 2001 data, Meehan and Zheng (2015, p. 21) found that the smallest firms in New Zealand played a “relatively large role in accounting for net job creation”.

The low-emissions transition will create new opportunities

While emissions-reducing policies will reduce the demand for some goods, services and skills, they will create new investment opportunities and new forms of employment. Some of these trends are already evident in the United States (Box 9.1).

Box 9.1 The growth of lower-emissions employment

US Department of Energy statistics reveal the impact that lower-emissions technologies are having on employment in the United States.

{S}olar employment accounts for the largest share of workers in the Electric Power Generation sector. This is largely due to the construction related to the significant buildout of new solar generation capacity. Solar technologies, both photovoltaic and concentrating, employ about 374 000 workers, or 43 percent of the Electric Power Generation workforce. This is followed by fossil fuel generation employment, which accounts for 22 percent...and supports 187 117 workers across coal, oil and natural gas generation technologies. (p. 28)

The 2017 USEER [US Energy and Employment Report] also shows that 2.2 million Americans are employed, in whole or in part, in the design, installation, and manufacture of Energy Efficiency products and services, adding 133 000 jobs in 2016. (pp. 8–9)

Currently, more than 259 000 employees work with alternative fuels vehicles, including natural gas, hybrids, all electric, and fuel cell/hydrogen vehicles, an increase of 69 000 jobs in 2016. Hybrids, plug-in hybrids, and all electric vehicles make up over 76 percent of this number, supporting 198 000 employees. (p. 9)

Source: US Department of Energy (2017)

9.2 Impacts of emission-reducing policies on households

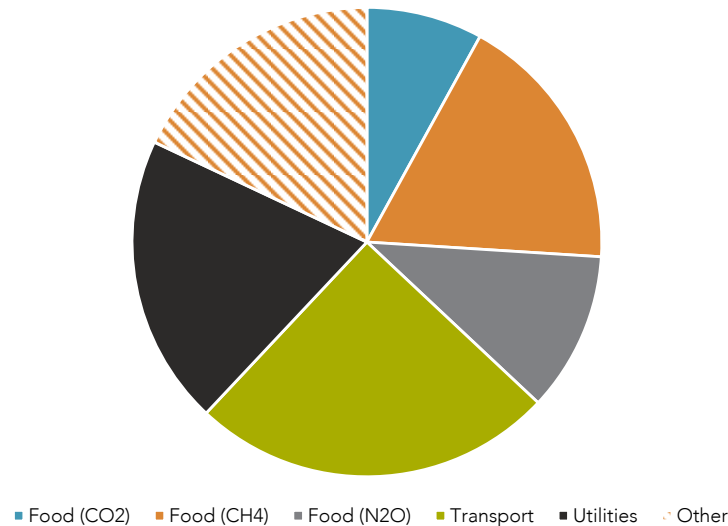
Even given the natural dynamism of the economy, an ambitious policy target for emissions reduction that involves an *intentional trajectory* likely to result in a significant social and economic transformation will be challenging for current and future governments (Patterson et al., 2018).

The Parliamentary Commissioner for the Environment argues that understanding the distributional consequences of setting emission reduction targets is likely to improve the durability of any system of carbon budgets (PCE, 2018). And, as has been found internationally, perceptions of fairness can influence citizens' acceptance of any burdens associated with climate change policies (Adger et al., 2016; B. Anderson et al., 2017; Klinsky et al., 2012).

This section considers the impacts of emission-reducing policies on households in New Zealand.

Food, energy and transport make up the bulk of household emissions

According to Allan et al. (2015), food, transport and energy (utilities) made up around 82% of the average New Zealand household's emissions in 2012/13 (Figure 9.1).

Figure 9.1 Average New Zealand household greenhouse gas emissions by source, 2012/13

Some of these emissions are not currently captured in the New Zealand Emissions Trading Scheme (NZ ETS) and are not reflected in consumer prices. For example, as agriculture sits outside the ETS, the methane (CH₄) and nitrous oxide (N₂O) emissions from food production (eg livestock) are not subject to an emissions price. However, the carbon dioxide (CO₂) emissions that result from the processing of food – eg, drying of milk – are within the ETS, and therefore already feed into consumer prices.

Household emissions do not rise proportionally with growing incomes

Allan et al. (2015) investigated the relationship in New Zealand between household characteristics and greenhouse gas (GHG) emissions from consumption. They found that:

- emissions rise less than proportionately with income, as wealthier households devote a larger fraction of their income to relatively less emissions-intensive services;
- emissions tend to rise with age, possibly reflecting a greater need for heating or greater disposable income;
- household emissions are higher in the South Island (due to colder temperatures and associated heating requirements) and Auckland (due to traffic congestion and a higher share of migrants, who may fly more often);
- homeowners emit more, perhaps reflecting greater wealth and a greater propensity for international travel; and
- expenditure elasticities vary widely between different types of consumption: emissions from household energy do not change much as household expenditure increases, but transport emissions (particularly from air travel) grow in response to rising household expenditure.

For the lowest-expenditure decile of New Zealand households, food and utilities accounted for 70% of emissions. In the highest-expenditure decile households, these items made up just over 50% of emissions (Allan et al., 2015).

Pricing emissions can be regressive as lower-income households spend a greater proportion of their income on food and household energy

As discussed in Chapter 4, a price can be placed on GHG emissions through a variety of mechanisms, particularly taxes or trading schemes. Literature indicates that both taxes and trading schemes can have regressive impacts.

Shammin and Bullard (2009, p. 2432) conclude that in the United States, consistent with other studies, “a traditional cap-and-trade policy is regressive and would cause the cost of reducing GHG emissions to fall

disproportionately on low income households". In a comprehensive analysis of studies that investigate the distributional impacts of carbon taxes on households, Q. Wang et al. (2016) found that emissions pricing is regressive in developed countries such as the United States, the United Kingdom, Denmark, the Netherlands, Ireland, France, China, Cyprus, Sweden, Taiwan and Singapore. However, when domestic energy for cooking and heating is distinguished from transport fuels, they find that, while taxing domestic energy usage is regressive in many countries, taxing transport fuels places a higher burden on middle-expenditure deciles.

In New Zealand, households in the lowest income quintile devote a higher share of their income to food, transport and household energy than others (Figure 9.2).

Figure 9.2 Percentage of expenditure devoted to food, transport and household energy, by household type



Source: Productivity Commission analysis of data from Stats NZ household living-cost price index (HLPI).

Household energy expenditure shares accounts for most of these differences (Figure 9.3).

Figure 9.3 Percentage of expenditure devoted to household energy, by household type



Source: Productivity Commission analysis of data from Stats NZ HLIPI.

In comparison, the highest income quintiles spent more in absolute and relative terms on transport, which aligns with the studies discussed above and the findings of Creedy and Sleeman (2006) on the effects on consumer prices of imposing a \$25 for each tonne of CO₂ carbon tax in New Zealand. Creedy and Sleeman found that although low-expenditure households spent

a proportionately greater amount of their income on carbon intensive commodities such as petrol and domestic fuel and power...the distributional effect of the carbon tax was not unambiguous, in view of the substantial price increases for several commodity groups on which households with relatively higher total expenditure spend proportionately more. (2006, p. 344)

Other studies analysed by Q. Wang et al. (2016) have focused on the impact of emission prices on urban and rural households and between households from different regions. Rural and suburban households have higher carbon tax burdens or welfare losses compared to urban households in Ireland, China and the United Kingdom, France, Indonesia, the Philippines and Thailand. No significant differences were found between households living in rural and urban areas in Denmark and Canada. In Cyprus and Malaysia urban households were more affected than rural households. Carbon tax incidence across regions in the United States are modest, but the impacts across regions in China and Canada are significant.

Analyses based on lifetime, rather than yearly, incomes or consumption tend to find less regressive impacts, reflecting the fact that people's incomes and spending patterns change over time.

F9.1

A large number of studies have analysed the impact of emissions pricing policies – such as cap-and-trade or carbon taxes – in developed countries. While the results vary depending on the sources of emissions and the characteristics of household expenditure, emissions-pricing policies are commonly found to be regressive in their impact.

F9.2

In New Zealand, low-income households spend a greater proportion of their income on food, transport and household energy. This suggests that emissions pricing may impact more heavily on low-expenditure households. But emissions pricing also leads to price increases for commodities on which households with higher expenditure spend proportionally more.

Lower-income families may be unable to substitute to lower-emitting consumption

Households have different abilities to respond to higher emissions prices and change their consumption behaviour. Low income and socio-economic status often go hand-in-hand with older, poorly insulated housing, housing that is further away from jobs often with a lack of access to public transport, and associated use of older and less fuel-efficient cars. Reducing emissions requires investment in insulation and more fuel-efficient transport and household heating. If some households are unable to make these investments, they must bear the burden of higher prices. They can become “locked in” to their emissions (Feng et al., 2010; Meade, 2017). In New Zealand, a significant share of affected households will be Māori, a point emphasised by Te Rūnanga o Ngāi Tahu and the Climate Change Iwi Leadership Group.

Low-income households, which are disproportionately Māori, should be top of mind when considering where costs fall, and also where investment may provide significant co-benefits, for example in terms of better employment and health outcomes. (Te Rūnanga o Ngāi Tahu, sub. 83, p. 12)

Māori households are much more vulnerable to downstream costs created by any ETS. They are less likely to be able to absorb these costs and are unable to easily invest in alternatives to reduce their own costs to offset the ETS. We see the cost of energy increase as the transport and energy sectors will need to adjust their pricing models to pass on costs. Affordability of any policy shift will of course be significant for Iwi Māori. (CCILG, 2016, p. 10)

F9.3

Lower-income households are less able to make investments that enable them to reduce the emissions intensity of their consumption.

The possible scale of impacts on consumer prices

As discussed in Chapter 3, there are many possible pathways to a low-emissions economy. The pace of change, and the degree to which emissions prices rise, depends on the speed of expected and actual technological change, whether existing industries are significantly disrupted, and on the emissions reduction being pursued (ie, whether the target is ‘net zero’ or a low level of emissions by 2050).

Where the expectations of technological change are high, existing industries are disrupted by technology, and the government pursues a low-emissions economy goal (ie 25 megatonnes of GHG emissions by 2050), the pace and range of emissions prices increases will be comparatively slow and low, meaning that the direct flow-on impacts to food, energy and transport costs will be muted. Food price impacts should be further mitigated, at least in the short run, by significant allocations of free NZUs to agriculture.

If a net zero emissions target is preferred and existing industry structures largely survive, government policy – and especially emissions pricing – will play a much more significant role in driving the transition. For example, under the Commission’s “stabilising-decarbonisation, net zero” scenario, emissions prices rise from around NZ\$20/tCO₂e now, to possibly up to NZ\$250 by 2050. This would see a large impact on consumer prices. Previous modelling and empirical studies have estimated the possible impact of emissions prices on fuel and electricity prices.

- Infometrics (2017) estimated that a NZ\$100 a tonne emissions price would raise retail petrol prices by 28 cents per litre.
- Stevenson et al. (2018) investigated the impact of rising emissions prices on the electricity market, and found that annual average wholesale electricity prices rose from around NZ\$80 a megawatt hour (MWh) at a NZ\$20 a tonne emission prices to just over \$100/MWh at a NZ\$80 a tonne emissions price (Chapter 12).

9.3 Potential responses

Regressive impacts are not a reason to delay the climate change response

While the impacts of emissions pricing can be regressive and fall disproportionately on some households and sectors, the government should not delay responding to climate change. Even where the direct impacts of emissions-reducing policies are significant, the government has a range of tools it can use to fully or partially compensate affected individuals or groups.

One key way to counter the regressive impacts of emissions pricing and other climate change policies is to provide financial assistance to affected individuals and households (eg, through transfer payments or the tax system). There are a number of ways in which this assistance can be delivered, with different impacts.

Focus on those who have a limited ability to substitute or who face large shocks

Higher emissions prices will affect a wide cross-section of the community, as they flow through to consumer and producer prices, business revenues and returns on capital. However, for the purposes of providing public assistance, the focus should be on those individuals or households with little ability to substitute to lower-emitting activities or those facing significant shocks as a result of rising emission prices. By and large (although not exclusively), these will be people in lower-income households.

What types of assistance are available for households?

Nolan (2007) notes four main mechanisms are available through which family incomes can be lifted. Each mechanism has its advantages and disadvantages (Table 9.1).

Table 9.1 General advantages and disadvantages of income assistance programmes

Minimum wage	Personal income tax schedule	Family & employment tax credits	Main welfare benefits
- Supports concepts of fairness of reward and socially acceptable incomes.	- Simple. - Broadly received. - Fiscally costly (rate changes more costly than threshold)	- Complex design. - Able to target assistance on basic criteria (eg, joint taxable income,	- Complex design. - Able to narrowly target assistance. - Cost-effective way of providing a lot of

Minimum wage	Personal income tax schedule	Family & employment tax credits	Main welfare benefits
<ul style="list-style-type: none"> - Reduces demand for low-wage labour. - Low (static) fiscal cost to government, but increases costs faced by businesses. - Effectiveness at lifting incomes reduced by poverty traps. 	<ul style="list-style-type: none"> changes and low poverty reduction effectiveness. - Reduction (although often small) in poverty traps. 	<ul style="list-style-type: none"> numbers and ages of children). - Cost-effective way of providing moderate levels of assistance to many households. - Seen to reward work effort, although they create poverty traps. 	<ul style="list-style-type: none"> assistance to relatively few households. - Able to respond to fluctuations in need or family circumstances. - Create poverty traps.

Source: Nolan (2007).

Given the Commission's preferred focus on those with limited ability to substitute or those facing large shocks, neither the minimum wage nor changes to the personal income tax schedule are recommended. As noted above, income tax changes are fiscally expensive, poorly targeted and not very effective at easing poverty. The international literature that examines solely tax-based compensation for carbon or emissions pricing similarly finds that its effects can be regressive, as higher-income households receive a significant share of the compensation (Mathur & Morris, 2014; Rausch et al., 2011).

Minimum wage increases will not be the most targeted or effective way of reaching low-income households. Although minimum-wage workers in New Zealand

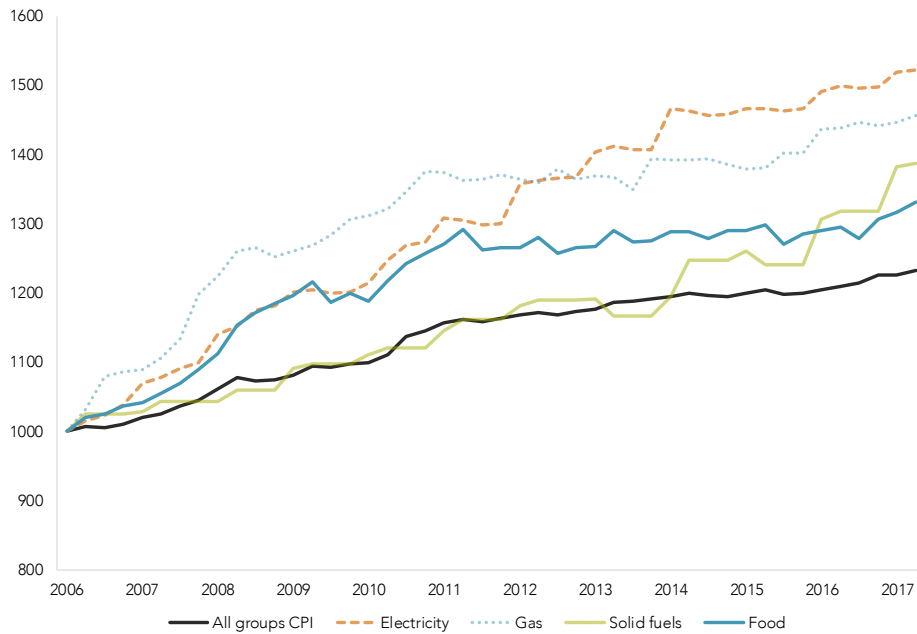
are more likely to live in the poorest households, they are relatively widely dispersed throughout the income distribution. This is particularly true of teenage minimum wage workers. Furthermore, low-income households often do not contain any working members. (Maloney & Pacheco, 2012, p. 648)

Reflecting this wide dispersion, Maloney and Pacheco (2012, p. 648) estimated in 2012 that a 10% increase in the minimum wage, "even without a loss in employment or hours of work, would lower the relative poverty rate by less than one-tenth of a percentage point". Nolan (2007, p. 23) also notes that an increase in the minimum wage "may translate in little extra take home pay as wage increases reduce the income assistance that people on low and middle incomes may be entitled to".⁸⁹ Minimum wage adjustments also do not provide any assistance to people out of work.

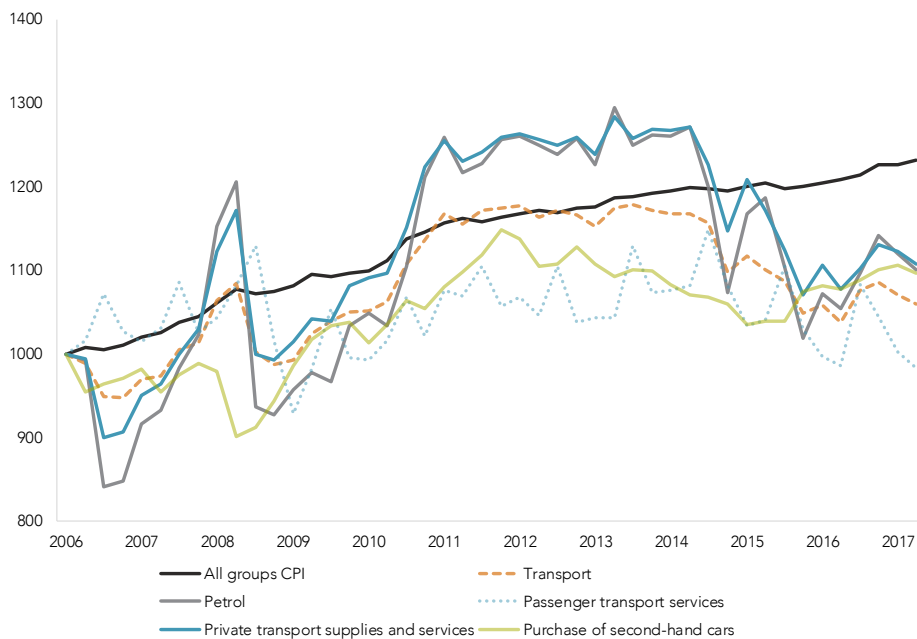
This suggests some combination of targeted tax credits and adjustments to benefits would be the best targeted and lowest-cost option for meeting the income needs of affected households. Combining the two would ensure that both employed and unemployed households are covered. The existing suite of welfare benefits and tax credits appears to cover off most, if not all, households likely to be especially affected by an increase to their cost of living due to an increase in emissions prices.

Benefits are automatically adjusted each year to reflect changes in the Consumer Price Index (CPI). Electricity, gas and food prices have risen faster than the general CPI in recent years (Figure 9.4), but most transport-related costs have tracked close to, or below, the general CPI.

⁸⁹ This withdrawal of other assistance in response to higher wages is known as the 'poverty trap'.

Figure 9.4 Changes in the CPI and selected household energy and food prices, 2006–2017

Source: Productivity Commission analysis of Stats NZ data.

Figure 9.5 Changes in the CPI and selected transport prices, 2006–2017

Source: Productivity Commission analysis of Stats NZ data.

Adjustments based on the main CPI may misrepresent the impact of price changes on lower-income households, who consume a different “basket” of goods and services (as can be seen in Figure 9.2 and Figure 9.3). Stats NZ produces a regular household living-cost price index (HLPI), which measures the impact of price changes on different household types (eg, by their income or expenditure levels or beneficiary status). The most recent (December 2017) HLPI results showed that the annual cost of living had risen faster for the lowest-spending households than the highest (Stats NZ, 2018b).

Much of this increase, however, was due to rises in the cost of items not directly affected by climate change mitigation policy, especially rents. Over a longer period, food and energy prices across the different household groups broadly track each other (Figure 9.6 and Figure 9.7). Transport prices are slightly more variable, but this volatility is more significant for higher-income households (Figure 9.8).

Figure 9.6 Food price index by selected household type, 2008–2017

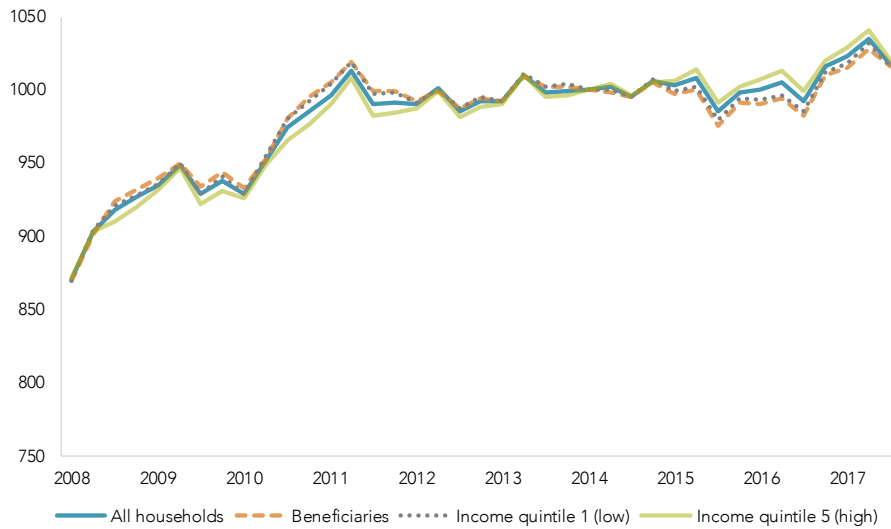


Figure 9.7 Household energy price index by selected household type, 2008–2017

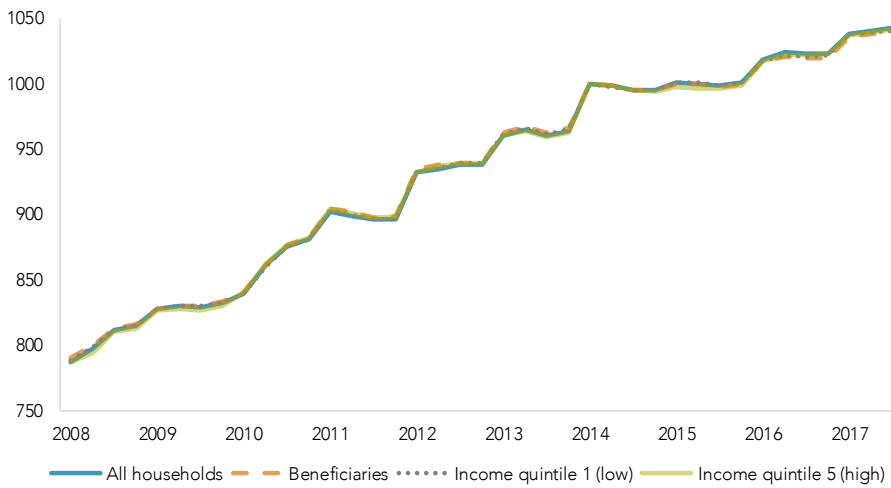
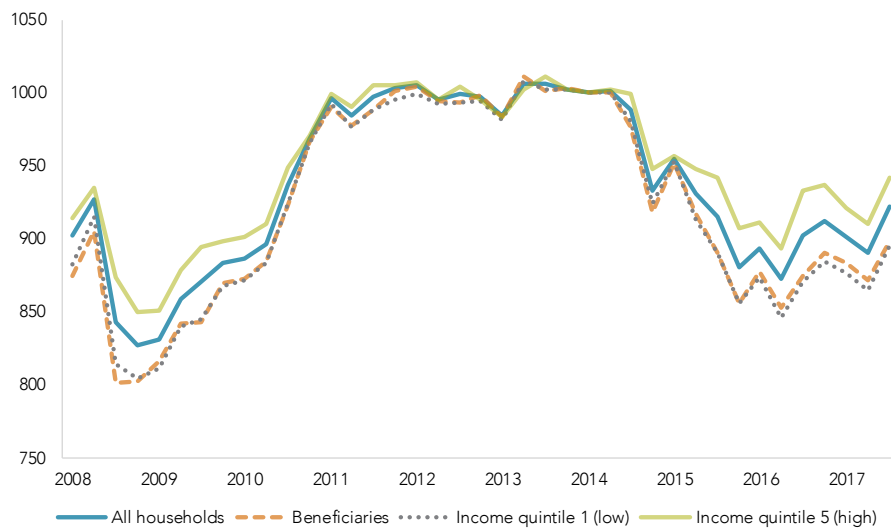


Figure 9.8 Transport price index by selected household type, 2008–2017



Source: Productivity Commission analysis of Stats NZ data.

In practice, therefore, for the purposes of compensating lower-income households for *emissions-reducing* policies, adjustments based on CPI appear adequate.

Working for Families and other tax credits are not automatically adjusted for changes in the cost of living, although they have been periodically updated by governments through the annual budget process.⁹⁰ The most recent adjustment was in December 2017, with increases to per-child payments and abatement thresholds and the reinstatement of a credit for 'independent earners' (individuals in employment on low to moderate incomes, without dependents). Such adjustments come at a significant fiscal cost,⁹¹ but will be important for ensuring that tax credit-based assistance adequately offsets the financial impact of emission reductions for lower-income households.

F9.4

The existing suite of benefits and tax credits should be adequate for offsetting direct impacts of emissions-reducing policies on the cost of living for lower-income households, provided tax credits are regularly adjusted for inflation.

Assisting households to substitute away from high-emissions consumption

Housing

Income-based assistance delivered through benefits, tax credits or both may not be sufficient to allow lower-income households to make the sorts of investments in energy efficiency needed to offset the impact of rising energy or transport costs. The high one-off costs of, for example, installing better heating or household insulation may be beyond the means of these families. This may be a particular issue in rental accommodation, where landlords do not pay the electricity bills and so may have weak incentives to invest in insulation or more efficient appliances such as heaters (Barton, 2012). US and Australian research indicates that tenants are much less likely to use or own more efficient appliances (Australian Bureau of Statistics, cited in APC, 2005; Davis, 2011; Gillingham et al., 2012).

The Government currently provides insulation subsidies targeted towards landlords and lower-income households, reflecting the significant health benefits associated with warmer and drier housing (Grimes et al., 2012a). Uptake by landlords has, however, been relatively low and the scheme is scheduled to finish in June 2018 (Collins, 2017). Changes to rental standards will require ceiling and underfloor insulation (where feasible) from 2019 and may increase landlord efforts to improve the quality of their housing. Stronger incentives may be necessary to encourage behaviour change by landlords, if the current rental standards regulation proves inadequate.

One risk with such investments is that they may encourage greater energy use, leading to an increase in emissions – the so-called “Jevons paradox”. This effect is named after 19th century economist William Stanley Jevons, who observed that technological efficiency improvements which enabled more economical use of resources actually increased their overall consumption:

It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth...[every] improvement of the engine, when effected, does but accelerate anew the consumption of coal. (Jevons, 1865, cited in Alcott, 2005, p. 12)

In theory, therefore, better-insulated and more efficiently heated homes could lead to greater energy use and higher emissions. However, empirical research suggests this risk may not be significant. An evaluation of the Government's earlier home insulation scheme (which was available to all households) found “[e]lectricity savings and total metered energy savings...for houses that had insulation retrofitted” (Grimes et al., 2011).

Our preferred estimate (based on a cleaned dataset) finds that 0.96% of average annual household electricity use is saved as a result of having insulation retrofitted, while 0.66% of average annual total metered energy is saved. Some other estimates (based on broader samples) show greater savings, with up to 1.41% electricity savings and 1.03% total metered energy savings. (Grimes et al., 2011, p. 8)

⁹⁰ NZ Superannuation is often adjusted by more than the CPI.

⁹¹ The most recent (December 2017) adjustment to Working for Families cost an estimated \$2.003 billion over five years.

F9.5

Public interventions to promote investments such as home insulation have a number of benefits, especially for individual and household health. The interventions do not appear to increase energy consumption.

Transport

Given the prominent place of transport in household emissions and living costs, a second area where additional targeted support could be considered is assistance for low-income households to replace an emissions-intensive vehicle. New Zealand has one of the highest rates of car ownership in the developed world, reflecting the important role that private vehicles play in enabling people to be mobile.

Chapter 11 discusses opportunities to reduce emissions in the transport sector, and makes recommendations to increase the uptake of lower-emissions vehicles, including:

- feebates (rewarding low-emission practices through rebates);
- other support for the development of underpinning infrastructure (eg, charging stations for electric cars); and
- higher emissions standards for fossil-fuel vehicles entering New Zealand.

The chapter also seeks feedback on whether to phase out imports of fossil fuel vehicles in New Zealand by a set date.

The uptake of lower-emissions vehicles across the population should have benefits for lower-income households, such as reduced exposure to noise and air pollution and less associated health damage. This will especially be the case for those who live close to major roads and highways, where noise and air pollution may be concentrated and land (and housing) is often cheaper, reflecting the lower amenity value. However, the benefits from lower pollution may not accrue entirely or even largely to lower-income households. If lower-income households living near roads and highways are renting, some of the benefits will be capitalised into land values and be captured by landlords.

However, shifting from fossil-fuel vehicles to low-emission vehicles may be challenging for lower-income households. While policies such as feebates may be sufficient to change the behaviour of wealthier households, it is unlikely they would be enough for those on lower incomes, especially since feebates would only apply when vehicles enter the fleet. The price premium for electric vehicles over fossil-fuel vehicles is currently large, effectively putting them beyond the reach of lower-income households, at least in the short run.

Higher emissions standards for vehicles or a compulsory phase-out of fossil-fuel vehicle imports would also have adverse distributional effects, by limiting the choices of people with limited capital who prefer to purchase cheaper but less efficient vehicles (APC, 2005). These effects are likely to be small with emissions standards, since the regulations would apply only to vehicles entering New Zealand. A compulsory phase-out of fossil-fuel vehicle imports would have a slightly higher impact; but, as it would not directly reduce the current fleet, this impact would also be limited.

Chapter 11 also envisages a more 'mode neutral' government planning and funding system for land transport, implying greater support for and access to public transport. This may ease constraints for some low-income households, although it is unlikely to meet all such households' needs. For example, comparatively high concentrations of lower-income households are located in Northland and East Cape; yet population densities are low, making it hard to create or maintain viable public transport links.

Designing compensatory policies for transport is a good example of the challenges created by uncertainty. Rapid technological and consumer change may lead to a fast and reasonably smooth adjustment. For example, greater uptake of low-emission vehicles may see faster 'filtering' of the existing electric vehicle and hybrid fleet into the second-hand market, reducing their price premium over fossil fuel vehicles. In this case, the need for government intervention to assist low-income households may be minimal.

However, rapid change may also complicate the process of adjustment. If the global transition away from fossil fuels proceeds quickly and demand for petrol declines accordingly, this could lead to falls in the price of petrol. This in turn would make continuing to run fossil-fuel vehicles affordable and could discourage switching to low-emissions vehicles. In such a circumstance, the government may need to take steps to prompt switching and encourage alignment with national emissions budgets – eg, by increasing levies on high-emission vehicles and/or through targeted ‘buybacks’.

Given these uncertainties, the Commission concluded that it is too early at this stage to design effective and well-targeted compensatory transport policies. The Government should, however, continue to monitor the uptake of low-emission vehicles by different household types and any impacts on the mobility of lower-income households. Where significant and negative impacts on mobility are identified, the Government could intervene through targeted subsidies to affected households or additional investments in public transport.

F9.6

The shift to low or zero-emissions vehicles may be difficult for some low-income households, given the current high price premia for electric and hybrid vehicles over fossil-fuel vehicles. Depending on the rate of technological and consumer change, this price premium may fall dramatically, minimising any need for government intervention to support low-income households. Uncertainties mean that it is too early at this stage to design effective and well-targeted compensatory transport policies.

Direct assistance to affected firms?

Financial assistance could also be provided to industries or firms facing closure or decline as the result of policy change. New Zealand has provided such financial assistance in the past, though on a small scale. During the withdrawal of agricultural protection and subsidies in the 1980s, government provided assistance to farmers to restructure their debts and exit agriculture entirely, if their farms were no longer viable (Gouin et al., 1994). Similar types of assistance could, theoretically, be provided to firms affected by climate change mitigation policies. For example, the Commission’s modelling of mitigation pathways (Chapter 3) suggests that rising emission prices will see the continued decline of sheep and beef farming, as increasing demand for forests and the low-profit margins from meat lead more farmers to convert their land to forestry.

In practice, however, providing such assistance would be risky and raise questions of fairness. The provision of assistance could encourage lobbying for wider forms of government support, and may distract affected employers, investors and workers from adjusting to changed circumstances. The broad-based nature of the transition to a lower-emissions economy means that it may be difficult to distinguish whether a specific firm has failed due to emissions mitigation policies, as opposed to other factors. This stands in contrast to the adjustment programmes of the 1980s, where affected parties were easily identifiable, and where government action (the withdrawal of protection) was the primary cause of financial stress.

It is also worth noting that the take-up of the ‘exit’ grants in agriculture was much lower than anticipated, with only 1% of farmers leaving the industry (Vitalis, 2007). The overwhelming majority of farmers changed their businesses and adapted. Similar adjustments are likely to occur in the future.

F9.7

Providing financial assistance to firms facing closure or decline as the result of policy change would be risky, encourage unproductive lobbying and raise questions of fairness.

Additional assistance to communities facing large shocks

The transition to a low-emissions economy may mean the closure of large, locally important firms. Particularly for some smaller communities, the loss of a major employer may create a large shock, spilling over into other areas (eg, leading to smaller businesses closing as unemployment rises and consumer spending falls). Some stakeholders have argued that this economic change and disruption requires additional targeted support. Drawing on international work on the ‘Just Transition’ to a low-emission economy, the New Zealand Council

of Trade Unions has argued for a range of initiatives to promote community and sector resilience and adjustment, including the initiatives noted below.

- New job opportunities in the low carbon economy and the transformation of existing jobs and industries should be promoted through public and private investment in low carbon development strategies and technologies
- Formal education, training, retraining, and life-long learning should be promoted for working people, their families, and their communities
- Organised economic and employment diversification policies should be developed for sectors and communities at risk
- Re-deployment of workers affected by transition should be promoted, including through industry-wide multi-employer pooling to match workers with new jobs
- Social protection measures, including active labour market policies, should be developed to support workers in industries undergoing change. (New Zealand Council of Trade Unions, 2017, p. 5)

The Commission has made recommendations about supporting the development of new, lower-emissions technologies elsewhere in this report (Chapter 6) and the potential to work with affected firms in agriculture to identify pathways to lower-emission production (Chapter 10). As noted above, the Commission also agrees that strong social protection measures, such as welfare benefits and tax credits, will play an important part in ensuring an inclusive transition. One outstanding question is whether place-based interventions are needed for communities facing shocks.

Labour market and skill-based interventions have the highest chance of success

Climate-change focused adjustment programmes are relatively new, and the Commission was not able to identify evaluations of such schemes. However, a wide range of similar interventions exist from which lessons can be learned. In particular, the Commission has drawn on research into adjustment programmes targeted at assisting areas or workforces affected by the decline of key sectors or firms. The key lessons appear to be that:

- policies aimed at retaining specific firms or ensuring their viability ultimately prove futile; and
- policies that improve the skills and labour market attachment of affected workers are best, but need to be carefully targeted.

The futility of trying to retain struggling firms

Australia has a long history of providing assistance to regions or areas affected by economic decline or the loss of major employers. Beer (2015, p. 23) notes that there were “135 structural adjustment programmes operating [in Australia] between 2000 and 2012”, which cost over A\$88 billion in total outlays. The Australian Productivity Commission (APC) has assessed many of these interventions over time, in particular through its annual *Trade and Assistance Reviews*.

One high-level conclusion reached by the APC is that interventions which aim to retain struggling firms or help them remain viable ultimately fail. In commenting on assistance provided in response to a steel company entering administration, the APC observed that “direct support to ‘struggling firms’ has demonstrated little long-term success, and the manufacturers and employers eventually exit” (APC, 2017a, p. 7). Short- or even medium-term public assistance is generally not sufficient where economic circumstances have fundamentally shifted against a firm.

Labour market and skills-based assistance is preferable, but needs to be designed well

There is more agreement around the benefits of labour market and skill-based adjustment schemes, though with some limitations. Workers with low or no qualifications are more at risk of displacement, and more likely to experience longer periods of unemployment (OECD, 2017a). The APC (2017b, p. 181) has argued that labour market assistance should be “reserved for those who would have the most difficulty becoming re-employed”, to avoid unnecessary expense or crowding out other job seekers. The APC (2017b, p. 179) has also highlighted problems where training provision “does not align with contemporary business needs or

where displaced workers are encouraged to transition ‘into well-known industries and employment opportunities rather than sectors with long-term prospects’.

Labour market assistance should be centred on the needs of *individuals*, rather than *regions*. Daley and Lancy (2011) highlight the poor outcomes and low value for money of regional job-attraction schemes, which subsidise business expansions in particular areas as a way of reducing unemployment or responding to the loss of large employers. In fact, tension is likely between the labour market needs of individuals and regions. As Beer (2015, p. 28) notes,

[p]erhaps perversely, labour market programmes can be seen to carry risks for regions. If successful, they may provide an avenue for the accelerated departure of skilled workers to other communities or cities.

As the NZPC (2017a) has noted in its earlier work on urban planning, mobility within and between regions helps to avoid labour market shortages, improves skills matches and is an important way of ameliorating the negative effects of unemployment. Looking at the experience of freezing works closures in New Zealand, Grimes and Young (2011) similarly found that, where communities facing the loss of a major employer are located close to urban areas, displaced employees are able to find work more easily. The aim should be to facilitate labour movements where improved opportunities are likely, rather than inhibit them.

F9.8

Interventions that respond to the “shock” of the loss of a major employer in a region should focus on the labour market and skills needs of individuals, and should be targeted to those who will have the most difficulty gaining new employment. This may include helping people move out of the affected region, to areas where employment prospects are stronger.

Current re-training provision is unhelpfully constrained by policy

The ability of individuals to acquire new skills over their lifetimes is likely to take on greater importance, not just because of the economic changes resulting from climate change but wider technological advancements, such as automation (NZPC, 2017b). However, the current education and training system is not well set up to meet the needs of people seeking mid-career retraining. The OECD (2017a) has commented that the training and career guidance system in New Zealand is heavily skewed towards “young people moving to the job market, while services available to guide adults in need of (re-)training are limited” (pp.18-19).

The Commission noted in its inquiry into *New models of tertiary education* (2017b), the barriers to mid-career retraining include:

- funding and regulatory settings that focus on younger, full-time learners completing full qualifications;
- limits on student support (ie, loans and allowances) that particularly affect people aged over 40; and
- funding rules that make recognition of prior learning difficult.

The Commission also observed weak connections between industry and tertiary education providers, and learner assessment practices by providers that limit the transfer of job-relevant skills.

F9.9

The current education and training system is not well set up to meet the needs of people seeking mid-career retraining.

There is not a strong policy case for hypothecating ETS revenue

Research into the distributional impacts of emissions pricing often assumes that the revenue created from an emissions price or trading system is ‘recycled’ back into compensation or other support for households and firms. The proposed changes to the NZ ETS in 2017 – especially the auctioning of NZUs – will generate revenue that could be dedicated to compensate or otherwise ameliorate the impact of climate change policies. This can also assist with the public presentation and acceptance of emissions-reducing policies.

However, hypothecation – that is, the ‘ringfencing’ of revenue from a particular sector or activity for expenditure back into that area – is not common practice in New Zealand. As the Tax Working Group (2018, p. 45) notes,

h) hypothecation can ensure that the public understand and support the need for the tax (if they understand and support the need for the spending it funds). But there are some downsides to hypothecation. The government spending may be justified regardless of how much money is raised by the tax – hypothecation might limit worthy spending in the area if the tax revenue falls short. At the same time the level of spending in other areas might be more worth than the hypothecated area – hypothecation might limit worthy spending in other areas if the tax can only fund spending in one particular area.

Hypothecation makes most sense where the link between the taxed activity and subsequent expenditure is strong. The leading example of hypothecation in New Zealand is the National Land Transport Fund (NLTF), which pays for road maintenance and improvements, public and active transport, and road safety activities. The NLTF is funded primarily from user fees (eg, road user charges, fuel excise duty and motor vehicle registration), which are reasonable proxies for road use. The link between the revenue generated by NZU auctions and compensation for households is not as strong.

If there are concerns about public acceptance of NZU auctions, this could be managed by placing it in the wider context of the government’s emission-reductions strategy, which provides assistance to individuals and households (through the tax and transfer system), new technologies (through expanded innovation investments) and trade-exposed firms (through free allocations).

F9.10

The policy case for hypothecating revenues from the auction of New Zealand Units towards assistance for households is not strong. Hypothecation makes most sense where the link between the taxed activity and subsequent expenditure is strong.

9.4 Conclusion

Like previous economic transformations, the shift to a low-emissions economy will create both opportunities and risks. Some existing firms and jobs will disappear, while new business and occupations will emerge. Risks can be minimised and opportunities maximised if people are able to easily acquire new skills and move between jobs.

Some of the emissions-reducing policies discussed elsewhere in this report may increase the cost of some essential household goods and services, such as food, transport and energy. These items make up a larger share of expenditure for people on lower incomes. So these individuals could disproportionately feel the burden of adjustment. However, this burden can be eased by existing policies, such as the benefit and tax credit system. Other existing policies, such as targeted subsidies for household insulation and regulatory interventions to raise the quality of rental housing, may also assist such households to substitute away from higher-emitting forms of consumption (as well as creating other benefits, such as better health).

Where the impacts from climate change mitigation policies create significant ‘shocks’ to communities – eg, through the loss of a major employer – these interventions should focus on the skills and labour market needs of the affected individuals. This will require some retooling of the current education and training system, to better meet the needs of people seeking retraining.

Part Four:

Emission sources and opportunities

Part Four looks across the New Zealand economy at the specific emitting sources including land use, transport, electricity, heat and industrial processes, waste and the built environment. It identifies the opportunities and challenges for reducing emissions from these sources and recommends a range of complementary regulation and policies for achieving emission reductions.

10 Land use

Key points

- Land use will need to change substantially if New Zealand is to transition to a low-emissions economy by 2050. In particular, land planted in forests will need to increase by between 1.3 million and 2.8 million hectares, mostly converted from marginally profitable beef and sheep farms. Rapid growth in horticulture (from a relatively small base) could also play a significant role in reducing agricultural emissions. The needed rate of change is comparable to the rate at which beef and sheep farming converted to forestry, dairying and other uses, over the last 30 years.
- Agricultural emissions have risen over recent decades because output has risen much faster than the emissions intensity of output has fallen. Scope exists for further modest reductions in emissions intensity, using a combination of higher productivity and wider adoption of current low-emissions practices. Research into new technologies has an uncertain potential to further reduce agricultural emissions in the medium to long term. Yet the potential payoff to successful research justifies scaling up current efforts.
- While, on paper, ample land is available for accelerated afforestation, the economics are less clear. The current price of New Zealand Units (NZUs) in the New Zealand Emissions Trading Scheme (NZ ETS) should encourage more afforestation, but suitable land is likely to become more expensive over time to plant (as lower cost options are used up). More certainty around the NZ ETS and a more predictable emissions price path will help. The Government should also take a more active approach than in the past to afforestation opportunities on government-controlled land.
- Agriculture (including horticulture and cropping) should be fully covered by the NZ ETS. But, agriculture, like other emissions-intensive trade-exposed sectors, should receive free allocation of NZUs. An emissions price will incentivise farmers to use management practices and current and emerging technologies to reduce emissions. Incentives will be stronger if the point of obligation is at the farm level. The Commission seeks feedback on whether the point of obligation to surrender NZUs should be at the processor or the farm level (or a mix of both).
- Māori own and control a significant and growing proportion of land in New Zealand. Legislation recognises and protects their ancestral relationship to land, which encourages a multi-generational approach to how it is developed. The resources and experience that come with Treaty settlements have strengthened land-use governance arrangements. Yet barriers remain, particularly as a result of multiple ownership and land tenure limiting access to investment capital.
- Horticulture is already (without an emissions price) more profitable than dairying on some land types and locations. Yet barriers to land change exist, such as a lack of skills; unfamiliarity with opportunities; risk aversion; and the need for new supply chain, infrastructure and marketing arrangements and development of higher-value products. Regulatory barriers and institutional lock-in may also be holding back land-use change. The Government should work with industry organisations, iwi and local government to find ways to address these barriers, building on current initiatives.
- Policy stability and a measured approach to phasing out free allocation of NZUs for agricultural emissions are important to avoid significant economic and social dislocation in the transition to a low-emissions rural economy over the next three decades. Farmers, industry organisations, iwi and Government should work together to take the opportunities for prosperity that come from addressing climate change and other challenges facing the rural economy.

This chapter investigates:

- the role of land-use change, particularly afforestation at scale, in New Zealand’s transition to a low-emissions economy;
- how land use and emissions from land use have changed over the last thirty years and prospects for the next thirty years;
- opportunities to reduce emissions within the agricultural sector, and the practices and technologies that will reduce emissions;
- the potential to sequester carbon through forestry;
- barriers to changing land use;
- the role of emissions pricing in encouraging adoption of low-emissions practices and technologies; and a shift to lower-emissions land uses;
- policies that will complement an emissions price; and
- the impact of land-use change on businesses, communities and regions; and the opportunities that will arise for a smooth, just and prosperous transition.

Box 10.1 explains the land-use categories and terms used in this chapter.

Box 10.1 Land-use categories and terms used in this chapter

The New Zealand Greenhouse Gas Inventory classifies agriculture as a major sector for reporting emissions. This includes emissions from pastoral farming – the farming of livestock; and from horticulture (growing fruit, vegetables and flowers) and cropping (arable farming). This chapter uses the term “agriculture” to include pastoral farming, horticulture and arable farming. “Pastoral farming” refers to livestock farming, mainly dairy, beef and sheep farming.

The inventory classifies forestry as one of a number of land use categories (which also include, for instance, cropland, grassland and wetlands). In this chapter, “forests” primarily refer to planted forests, whether exotic or native. Forests may be planted for harvest, or be permanent.

A substantial part (29%) of New Zealand’s land area is covered by naturally established permanent native forests. These forests are generally protected from deforestation and so do not feature in greenhouse gas (GHG) emissions accounting. Nor are these forests, unless deforested, included in the New Zealand Emissions Trading Scheme.

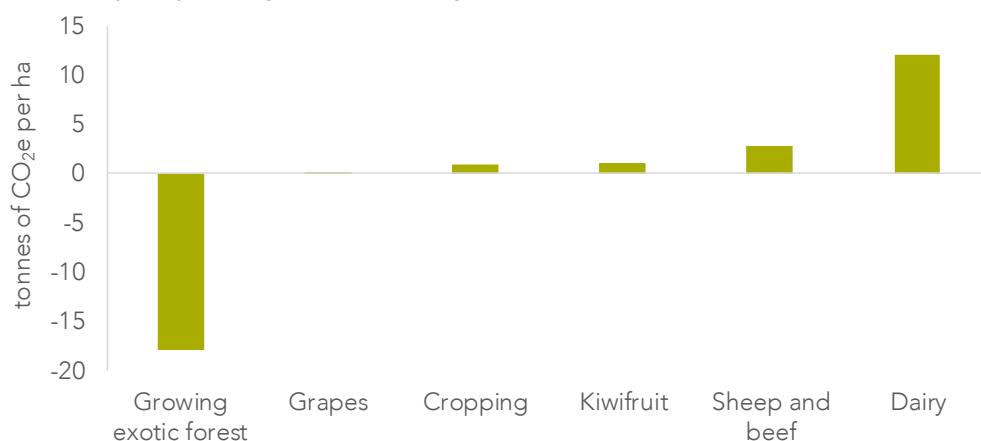
Carbon sequestered in naturally establishing exotic trees (sometimes classified as “wildings”) does not count towards meeting New Zealand’s international emissions reductions targets.

Source: MfE (2017g).

10.1 A low-emissions transition requires land-use change

Biological emissions from agriculture account for nearly half of all New Zealand’s GHG emissions, far more than any other industry. Forestry, on the other hand, currently offsets around 30% of gross emissions. This makes land use and land-use change a central part of New Zealand transitioning to a low-emissions economy.

The way land is used has a big impact on emissions. For instance, agriculture, especially dairying, is typically much more emissions intensive per hectare than horticulture and cropping (Figure 10.1). As a result, moving to a very low-emissions economy will require both adopting practices and technologies that reduce emissions from agriculture; and some shift from agriculture to lower-emissions land uses.

Figure 10.1 Indicative yearly biological emissions per hectare from different land uses

Source: Clothier et al. (2017); Reisinger et al. (2017); MAF (n.d.).

Notes:

1. Emissions vary considerably within particular land-use types. The estimate of emissions from sheep and beef farming are an average of Reisinger et al.'s (2017) estimate for North Island and South Island farms. Clothier et al. (2017) estimates average horticultural and arable emissions based on the calculation protocols of the Intergovernmental Panel on Climate Change. MAF estimated GHG removals from forests as the overall average carbon sequestration rate for exotic forests during a rapid growth phase.
2. The data cover only emissions from biogenic sources. Adding emissions from fossil fuel use would have only a small impact on the relative emissions intensity across land uses. The data does not include differences in carbon sequestered in soils.

Chapter 3 reports the results of modelling of pathways to net zero or very low net emissions by 2050. All the scenarios require a substantial shift in land use. For instance between 1.3 million hectares and 2.8 million hectares of new forest will need to be planted; land devoted to sheep and beef farming will fall by similar amounts; and horticultural land could double or even triple in area. At the same time, improved farming practices and technology will reduce emissions from animals, fertiliser, urine and dung.

Accelerated afforestation would buy New Zealand time to put in place economically and technologically more difficult options to lower emissions (both in land use and in other parts of the economy). The knowledge, technologies and resources for afforestation already exist. Yet, the time offered by afforestation to find new technologies may be no more than several decades (David Evison and Euan Mason, sub. 27; Scion Research, sub. 67). At some point beyond 2050, carbon sequestration through afforestation will reach a limit as economically viable land for new forests is used up (RSNZ, 2016; Vivid Economics, 2017a). A great many submitters supported land-use change as a main route to a low-emissions economy (Box 10.2).

Box 10.2 Submissions on land-use change and a transition to a low-emissions economy

A great many participants saw changing land use as a key to meeting New Zealand's climate change mitigation targets, particularly by increasing afforestation and decreasing areas for agriculture.

The transition to a low-emissions economy will take decades. In order to achieve net emissions reductions, increased carbon sequestration through afforestation is essential in the short to medium term. A clear policy in relation to the contribution forestry will make in terms of this transition is crucial and required as a matter of extreme urgency. (Oji Fibre Solutions, sub. 71, p. 2)

Land use change is essential [for meeting New Zealand's Paris commitments] in the absence of wholesale change in the use of fossil fuels or farming practices". (The Forestry Leadership Group – Climate Change, sub. 1, p. 1)

Land-use change is of fundamental importance if the land sector is to be part of New Zealand moving towards a low-emissions economy. (Andy Reisinger, sub. 28, p. 2)

... a barrier [to reducing emissions] in recent times has been economic strategies which depend on growing the volume of primary production and lead to neglect of environmental harms and limits.

Better opportunities for New Zealand in an emissions-constrained future lie in diversification of land use and food production, and a focus on environmental excellence. (The Morgan Foundation, sub. 127, p. 2)

Without a significant reduction in national livestock numbers, particularly cattle, any measures intending to reduce agricultural GHG emissions are likely to have very limited effect. Therefore incentives and/or penalties must be implemented to encourage diversification into low GHG-emitting land-use including horticulture and/or forestry. The current decline in forestry must be reversed. While mature forests are effectively carbon-neutral, a major programme of planting over the next, crucial decades will enable NZ to sequester a considerable amount of carbon. Once again, this cannot simply be left to the invisible hand of the market. (Graham Townsend, sub. 105, p. 1)

... given the widely acknowledged limitations of existing technology and approaches for reducing livestock emissions, it is clear that diversification of land use represents a primary opportunity, and that heavy reliance on the dominant industry model is a major barrier. In other words, pursuing growth potential in companion or alternative land use activity must be given high priority for a low-emissions economy pathway. (Te Rūnanga o Ngāi Tahu, sub. 83, p. 8)

F10.1

Land use will need to change substantially if New Zealand is to transition to a very low-emissions economy by 2050. In particular, the transition will require a large and sustained increase in afforestation.

10.2 Changing land use in New Zealand

This section assesses whether the rate and type of land-use change required to achieve a very low net emissions economy by 2050 is feasible, given patterns of change over the last several decades.

Over the last 25 years, New Zealand has experienced significant changes in land use (Figures 9.2, 9.3 & 9.4), such as:

- a steady reduction in pastoral farmland since the 1990s;
- a substantial rise in plantation forest land in the mid-1990s, and a subsequent small decline in the 2000s;
- a significant increase from 1990 to 2015 (from a low base) in land used for horticulture and cropping; and
- a large shift away from beef cattle and sheep farming towards dairy cattle farming since the 1990s (section 9.3)

Figure 10.2 Absolute changes in rural land use between 1990 and 2015

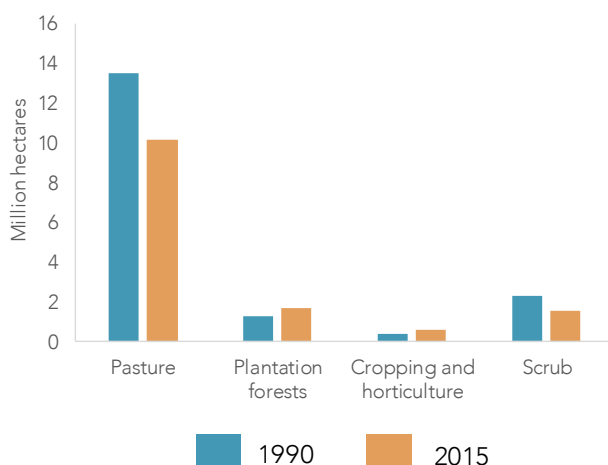


Figure 10.3 Relative trends in pastoral and forestry land use, 1990–2015

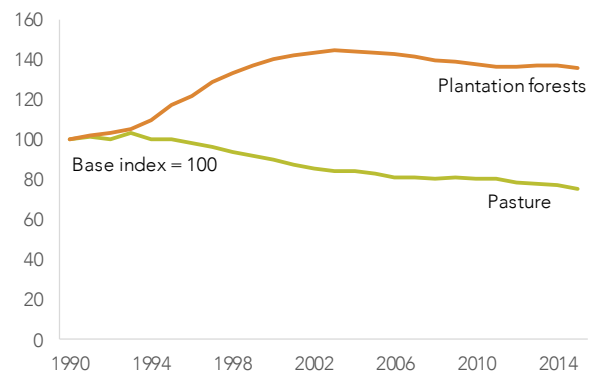
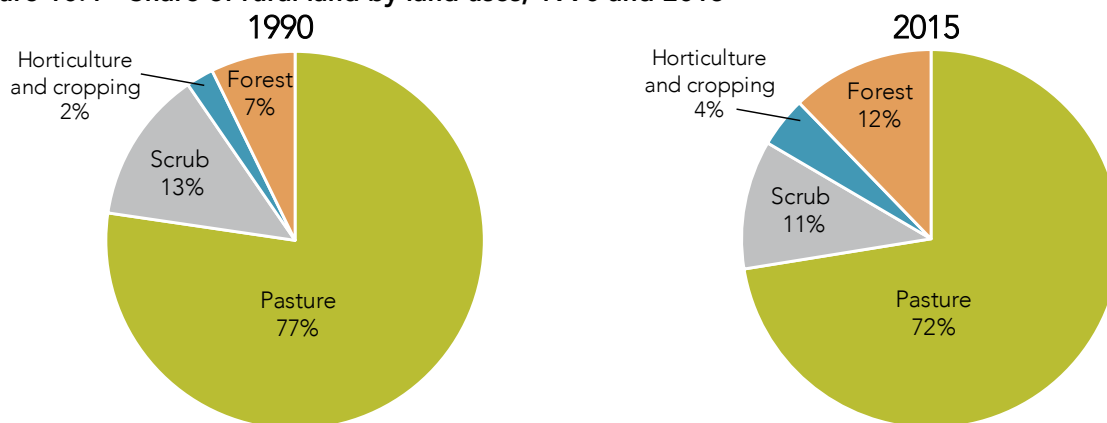


Figure 10.4 Share of rural land by land uses, 1990 and 2015

Source MPI (2016a); StatsNZ (2017a)

Notes:

1. Estimates of agricultural land use are taken from the annual StatsNZ agricultural production census. StatsNZ did not undertake census surveys between 1997 and 2001, so estimates for this period are linearly interpolated.
2. Estimates of forestry only include plantation forests. Natural forests, excluded from these estimates, make up approximately 29% of New Zealand's land area.
3. In Figure 10.4, the total area of rural land decreased between 1990 and 2015 by about 3.5 million hectares, or in percentage terms by about 20%. This is a result of rural land being converted to non-rural uses. Rural land includes all farm land and plantation forests.

Roughly 3 million hectares (or around 30%) of pastoral farmland shifted to other uses between 1990 and 2015 – an average of 130 000 hectares each year (Figure 10.2).⁹² A large proportion of these 3 million hectares was converted to non-farming uses, such as urban development, conservation, and other public purposes. In particular around 425 000 hectares was transferred into the conservation estate either through “whole property purchases” or as a result of tenure reviews under the Crown Pastoral Land Act 1998 (Land Information New Zealand, pers. comm., 15 March, 2018; Department of Conservation, pers. comm., 19 March, 2018).

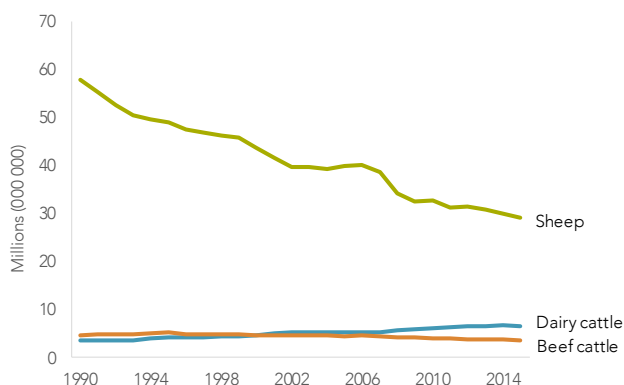
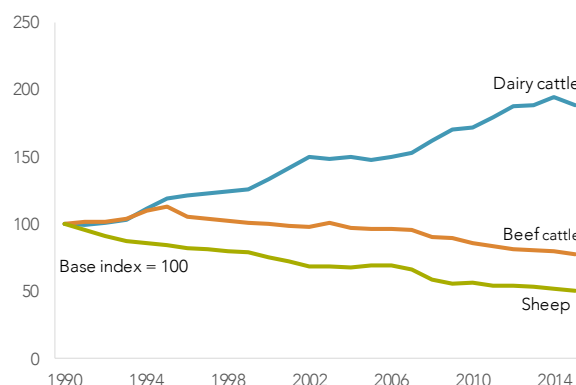
A smaller proportion of pastoral farmland was converted to forests, horticulture and cropping land. New Zealand's plantation forests increased in area by about 450 000 hectares, and their share of rural land increased by 5 percentage points, over the 25-year period (Figure 10.4). Horticultural and cropping land also increased by roughly 200 000 hectares (doubling their share). Within the horticultural sector, the area of land in wine production increased sevenfold from around 5 000 hectares to 36 000 hectares (Horticulture New Zealand & Plant & Food Research, 2015). Land for cropping increased by around 142 000 hectares over the period (Commission estimate based on StatsNZ data).

The increase in afforestation in the 1990s (and its subsequent decline) as well as the rise in dairying reflect changes in the expected relative profitability of different land uses. Relative trends in commodity prices are the primary driver of changes in profitability (section 10.6).

Pastoral farming has shifted strongly into dairying

Since 1990, livestock farming has shifted substantially from sheep and beef farming towards dairy farming (Figures 9.5 and 9.6). Before then, around 95% of New Zealand's livestock were sheep and beef cattle. The dairy herd has since nearly doubled, while sheep numbers halved and the beef cattle herd fell by 20%. The comparatively high profitability of dairying has been the main driver of conversions of sheep and beef farms to dairying (Kerr & Olssen, 2012).

⁹² The trend away from pastoral farming had started earlier with the removal of government agricultural subsidies from the mid-1980s (Vitalis, 2007) and this was reinforced by a fall in agricultural commodity prices and later a spike in log prices in the 1990s (Kerr & Olssen, 2012).

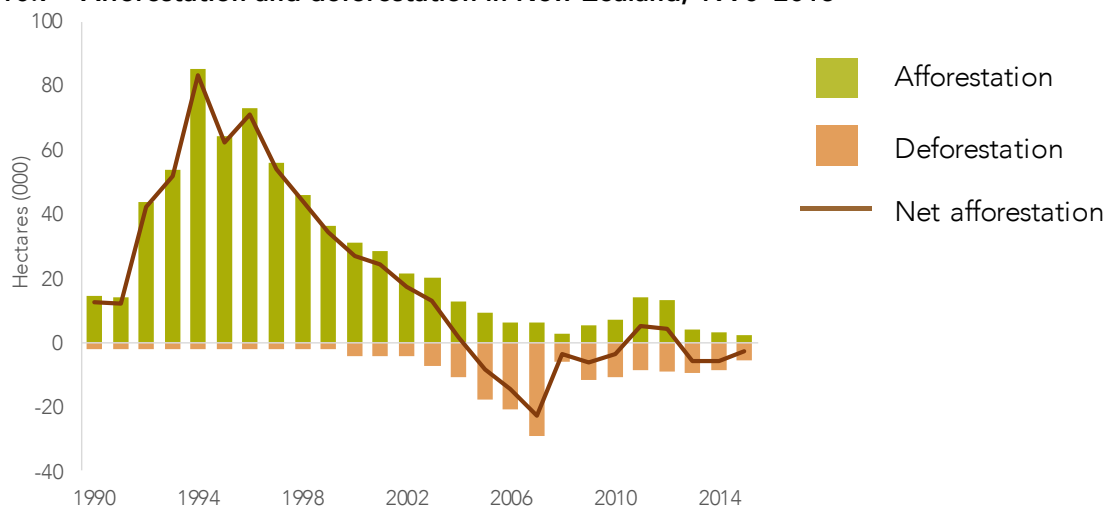
Figure 10.5 Livestock numbers across sectors, 1990–2015**Figure 10.6 Relative growth in livestock numbers across sectors, 1990–**

Source: StatsNZ (2017a)

Planting of new forests peaked in the mid-1990s

Most of the increase in New Zealand's forest land between 1990 and 2015 occurred before 2000 (Figure 9.2). Historically high timber prices in the 1990s, combined with a collapse in farm prices from the late 1980s and a passing enthusiasm for forestry as a retirement nest egg, stimulated a boom in planting. Between 1990 and 2000, an average of around 50 000 hectares of new forests were planted each year, mostly *pinus radiata*. These rates were much higher than deforestation rates over the same period. Yet, since 2000, planting has fallen to historically low levels, while deforestation has increased (MfE, 2017g).

Between 2000 and 2015, about 160 000 hectares of forest land was cleared and converted to other uses. The area of commercial forests declined from 1.77 to 1.72 million hectares (RSNZ, 2016). In 2015 only around 2 400 hectares of new forests were planted, while over 5 400 hectares of forest land was converted to other uses (MfE, 2017g). The Royal Society concludes that "[r]ecent new forest planting rates in New Zealand have been too small to significantly offset future CO₂ [carbon dioxide] emissions" (RSNZ, 2016, p. 148).

Figure 10.7 Afforestation and deforestation in New Zealand, 1990–2015

Source: MfE (2017g)

Notes:

1. MfE has limited information on deforestation prior to 2000 and on deforestation from pre-1990 forests before 2008. It therefore assumes that deforestation of pre-1990 natural forests occurred at the same annual rate before 2008, and that deforestation for all other forests was zero before 2000.

A steady drop in the global timber price and the announced introduction of the New Zealand Emissions Trading Scheme (NZ ETS) were key causes of deforestation before 2008. Many foresters chose to deforest to avoid having to surrender credits (Carver et al., 2017). Since the scheme's introduction, and with a fall in the emissions price, planting has failed to keep up with deforestation. Planned deforestation over the next 15

years is also high, though plans to deforest have fallen as the emissions price recovered (section 10.7). The proportion of small forests reaching harvesting age over the next decade increases the uncertainty around deforestation outcomes (Manley, 2017a).

Are the required rates of land-use change feasible?

The transition pathways in Chapter 3 require substantial changes in land use (section 10.1). Forest land will need to increase by up to 2.8 million hectares, with a corresponding shift out of beef and sheep farming. A smaller area of land (up to 1.0 million hectares) may also need to shift to horticulture. For most pathways, the shift out of pastoral farming is substantially less than the fall of roughly 3 million hectares between 1990 and 2015 (Figure 10.2). Yet a large proportion of this fall was a shift to non-farming uses and a significant proportion was the transfer of very low intensity high-country leasehold land into the conservation estate.

The transition pathways will require an average of between 44 000 and 90 000 hectares of new forests to be planted each year over the 32 years to 2050. This is far higher than the average net 18 000 hectares that was planted each year over the period from 1990 to 2015 (section 10.2). New planting did reach a brief peak of 100 000 hectares in 1994 and averaged around 50 000 hectares over the decade from 1990 to 2000 (MPI, 2017f). While planting at the modelled rates is technically feasible, availability of suitable land for planting, and profitability are key determinants of further afforestation (sections 10.5 and 10.6). Models always involve some uncertainty, especially when they are extended far into the future and beyond the historic price ranges of the data on which they are based.

The modelled increase in horticulture land (100% – 200% under some scenarios) is also substantially faster than the 44% (or 38 000 hectare) increase in horticulture land between 1990 and 2015. Also, while ample land suitable for horticulture is likely available, apparently profitable opportunities are not being taken up (Clothier et al., 2017; Reisinger et al., 2017) (section 10.6).

Overall, the rates of change in land use required to move to a low-emissions economy are comparable to the rates of change New Zealand has experienced over the last 30 years (section 10.2). While circumstances are different, this suggests that the changes are feasible and that the rural economy will likely have the capacity to adjust positively to new opportunities as they emerge. Yet barriers exist to changing land use. Finding ways to address these will help ease the transition (section 10.10).

F10.2

The rate of land change needed to transition to a low-emissions economy over the next three decades is comparable in magnitude to the overall rate of change over the last three decades. Yet high rates of afforestation will need to be sustained for a much longer period in the future than happened in the past; and the past movement into horticulture may need to accelerate.

10.3 Land use emissions and emissions trends

This section briefly sets out trends in emissions from land use. It focuses primarily on biological emissions (mostly methane (CH₄) and nitrous oxide (N₂O) from pastoral farming). Other emissions, for instance from the use of fossil fuels for transport, milk powder drying and heat for greenhouses, are covered in Chapters 11 and 13.

Importantly, agricultural emissions are both short-lived in the atmosphere (mostly CH₄) and long-lived (N₂O). N₂O comprises around 21% of agricultural emissions. To stabilise global warming, net emissions of long-lived gases need to stop, but a flow of short-lived gases can continue, though at a reduced level (Chapter 8). Urine and dung deposited by grazing animals account for over 75% of N₂O emissions from land use. Most of the remaining N₂O emissions result from using fertilisers and from crop residues (MfE, 2017g). Prioritising a substantial fall in N₂O emissions will, as a result, likely require shifts in farm practice (eg, better fertiliser application, using herd houses or stand-off pads), a reduction in stock numbers and a shift in land use.

Land use provides an opportunity to offset gross emissions by sequestering carbon in forests. Forests currently sequester around 23 megatonnes of CO₂ each year, compared with almost 30 megatonnes

sequestered in 1990 (MfE, 2017g). Soils also sequester very substantial amounts of carbon (Box 10.3). Yet, because of measurement difficulties, the New Zealand GHG Inventory only accounts for carbon in soils when land use changes (MfE, 2017g).

Box 10.3 Carbon sequestered in soils

Carbon sequestered in soils accounts for a substantial part of global carbon stocks. Far more carbon is present in soils than in the atmosphere or in live plants and animals (Meduna, 2017; Schwartz, 2014). A small percentage increase in the amount of carbon stored in the world's soils (as little as 0.4% a year) could entirely offset fossil fuel emissions (see eg, Locke, 2015; Wise Response Society, sub. 102; Clare St Pierre, sub. 115). Historically, the cultivation of soils has led to a loss in soil carbon in many places (as much as 50% to 70% in the North American prairies and the north China plains, for instance) (Schwartz, 2014).

The amount of carbon present in soils is closely associated with the type of vegetation growing on it, and, when farmed, the regime used to manage successive crops and to maintain pastures. Global carbon stocks can be substantially increased by changing the way land is used, and by improving farming practices. The depth of plant roots and the associated mycorrhizal fungal activity influences the amount of soil carbon.

New Zealand pastoral soils already have relatively high levels of soil carbon (on average around 106 tonnes of carbon a hectare (McNally et al., 2017; Reisinger et al., 2017; Clare St Pierre, sub. 115). Yet, scope exists to increase soil carbon on pastoral land, while raising productivity. This is achievable through better management (for instance using deep-rooted pasture plants, optimizing the use of fertilisers and reducing tillage) (Tony Banks, sub. 3; Ross Clark, sub. 24; Auckland Council, sub. 97; Wise Response Society, sub. 102; Clare St Pierre, sub. 115). McNally et al. (2017) estimate a theoretical potential for increasing soil carbon under New Zealand pastures ranging from an extra 10 to 42 tonnes a hectare – enough to offset the increase in agricultural GHG emissions between 1990 and 2014.

Even so, Meduna notes that while even increases of less than 1% in soil carbon could mitigate current emissions “[i]t is always contingent on soil type, management practice and climate, and the costs of measuring soil carbon can be significant” (2017, p. 1). The effect of different practices in different situations on soil carbon is not well understood. Soil carbon increases over time on hilly sheep and beef farms with less intensive stocking, but tends to decline on flat-land pasture (Meduna, 2017). While McNally et al. (2017) and Ballance Agri-Nutrients (sub. 34) argue that irrigation can increase soil carbon by increasing the production of plant dry matter, other researchers have found that, at least in some circumstances, irrigation decreases soil carbon (Meduna, 2017; NZAGRC, 2017). The New Zealand Agricultural Greenhouse Research Centre (NZAGRC) is undertaking research to better understand how farm management practices influence soil carbon (Dairy New Zealand, sub. 18; NZAGRC, 2017).

The New Zealand GHG Inventory (MfE, 2017g) accounts for soil carbon changes only when land use changes. The changes in soil carbon are estimated from a model based on representative soil samples and data on climate, rainfall and terrain. No credit is given in international GHG accounting, or in the NZ ETS, for increasing soil carbon within an existing land use (Meduna, 2017). The difficulties in understanding the complex interactions of different management practices and their effects on soil carbon; and of measuring changes in soil carbon at the farm level, pose challenges for recognising soil carbon sequestration through the NZ ETS.

Agriculture and GHG emissions

Farming livestock to produce food is emissions intensive – New Zealand’s pastoral farms emitted over 35 megatonnes of carbon dioxide equivalent (CO₂e) in 2015. About 73% of these emissions were CH₄ from ruminant digestion. Over 20% was N₂O emitted from soils.⁹³ The two main emissions sources are:

- **Enteric fermentation** – Ruminant animals such as sheep and cattle produce CH₄ when digesting food. In the process of *enteric fermentation*, microbes break down carbohydrates in the rumen, a stomach chamber. Some of these microbes (methanogens) produce CH₄. The animals burp out CH₄ as a result of regular contractions of the rumen.
- **N₂O emitted from soils** – The urine and dung that livestock deposit on soils and the synthetic fertiliser that farmers apply to pasture contain nitrogen. Microbes in the soil interact with excess nitrogen not used to fertilise pastures to release N₂O into the atmosphere. Urine and dung are the biggest source of New Zealand’s N₂O emissions, and account for over 75% of N₂O emissions from land use.

Another 3% of emissions is CH₄ produced by decomposing manure on pastures or held in effluent ponds. Unlike many other countries, New Zealand’s animals graze on pasture rather than being fed grains using feed lots. So, they spend relatively little time off pasture (MfE, 2017g).

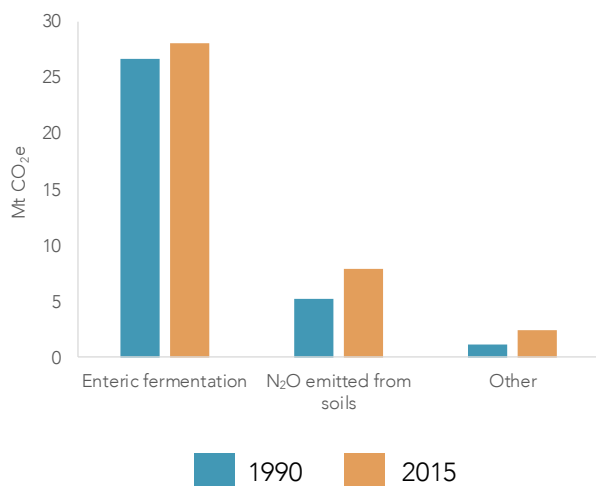
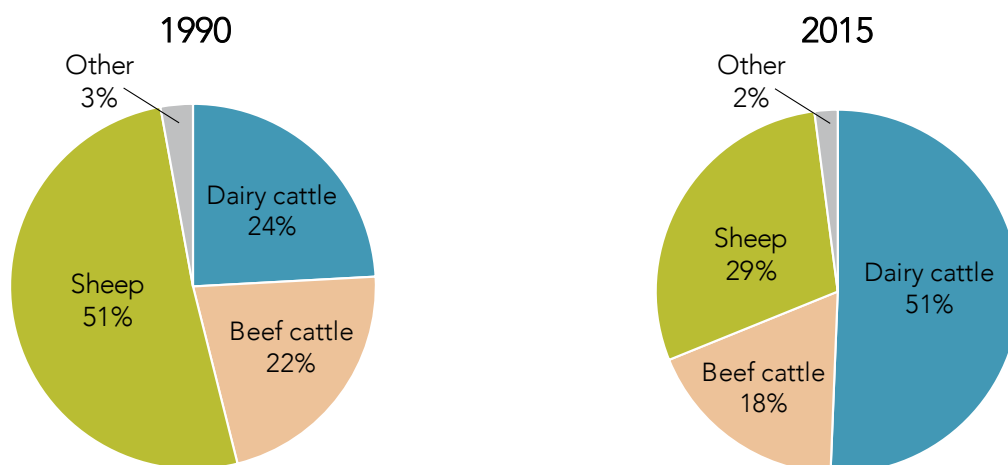
New Zealand’s Greenhouse Gas Inventory includes emissions from horticulture and cropping as part of agricultural emissions (and does not account for them separately). Horticultural and cropping emissions are less than 3% of all agricultural emissions, and are mostly N₂O from fertiliser use. A minor amount comes from crop residues (Reisinger et al., 2017).

Agricultural emissions have risen, mostly due to dairying and use of nitrogen fertiliser

Between 1990 and 2015, agricultural emissions rose by about 16%, largely driven by the intensification and growing overall volume of dairying as well as by the increasing use of synthetic fertilisers. With a larger number of dairy cows and more intensive production, emissions from dairying rose by 130% over this period. This increase was partially offset by lower beef and sheep emissions, mainly due to herd numbers dropping. As a result, CH₄ emissions from enteric fermentation only rose by 5%, between 1990 and 2015 (Figure 10.8). A fivefold increase in the use of nitrogen-containing fertilisers helped contribute to a 51% rise in N₂O emissions (MfE, 2017f). Increasing fertiliser use has contributed to gains in farm productivity. But it has also generated greater nitrate leaching (section 10.8).

Due to these trends, dairy farming’s share of total agricultural emissions more than doubled from 24% to 51% between 1990 and 2015 (Figure 10.10). While New Zealand is home to far more sheep than cows, cows (especially dairy cows) are much more emissions intensive than sheep. A dairy cow produces on average roughly seven times more CH₄ than a sheep (MfE, 2017g).

⁹³ Processing agricultural outputs (eg, generating heat to dry milk) and transporting produce and inputs also produce emissions, although a much lower amount than direct on-farm emissions. Horticulture also produces emissions to heat greenhouses, for instance. Mitigation of these non-biological emissions is addressed in Chapters 11 and 13.

Figure 10.8 Change in emissions across sources, 1990 and 2015**Figure 10.9 Percentage change in production, livestock, and emissions, 1990–2015****Figure 10.10 Contribution to New Zealand's agricultural emissions across sectors, 1990 and 2015**

Source: Productivity Commission analysis of MfE (2017h), LIC and DairyNZ (2016), and StatsNZ (2017a) data.

10.4 Opportunities to reduce emissions in agriculture

This section assesses the availability and technological feasibility of options to mitigate emissions from pastoral farming, and their potential impacts on profitability and suitability to New Zealand's farming system. It also briefly discusses options to mitigate biological emissions in horticulture and cropping.

Reducing emissions behind the farm gate

Pastoral farming plays a major role in New Zealand's economy. The sector contributes about 6% of New Zealand's GDP, and about 40% of New Zealand's goods exports. Close to 40% of New Zealand's land is used for pastoral farming. Even under the more ambitious pathways to a low-emissions economy, pastoral farming is likely to remain a large part of the rural economy (see section 10.2 and Chapter 3). To meet New Zealand's targets, it is imperative that the sector continues to reduce its emissions intensity and gross emissions. Vivid Economics (2017b) estimates that agricultural emissions must reduce by 30% for New Zealand to achieve net zero emissions by 2050. This will come from a combination of lower stock numbers, reduced emissions intensity using currently available practices, and from new technologies as yet unproven.

Current mitigation options

Currently, options suitable for a majority of New Zealand farms do not exist to make big reductions in biological emissions while maintaining production. Smaller reductions (up to 15%) are possible by increasing productivity and more widely adopting existing lower-emissions management practices (Anastasiadis & Kerr, 2013).

Emissions vary widely across New Zealand's farms. For instance, the highest-emitting farms produce roughly twice as much CH₄ emissions and three times as much N₂O emissions as the lowest-emitting farms per hectare of farm (Kingi et al., 2015). Much variation is due to factors such as climatic and soil conditions. However, the way the farm is managed is also important. As a result, the main current options to reduce emissions are:

- productivity gains that improve profitability while lowering emissions (eg, continuing genetic gains);
- reducing stocking rates;
- reducing nitrogen inputs; and
- other farm practices that lower emissions (such as milking once a day, and using stand-off pads).

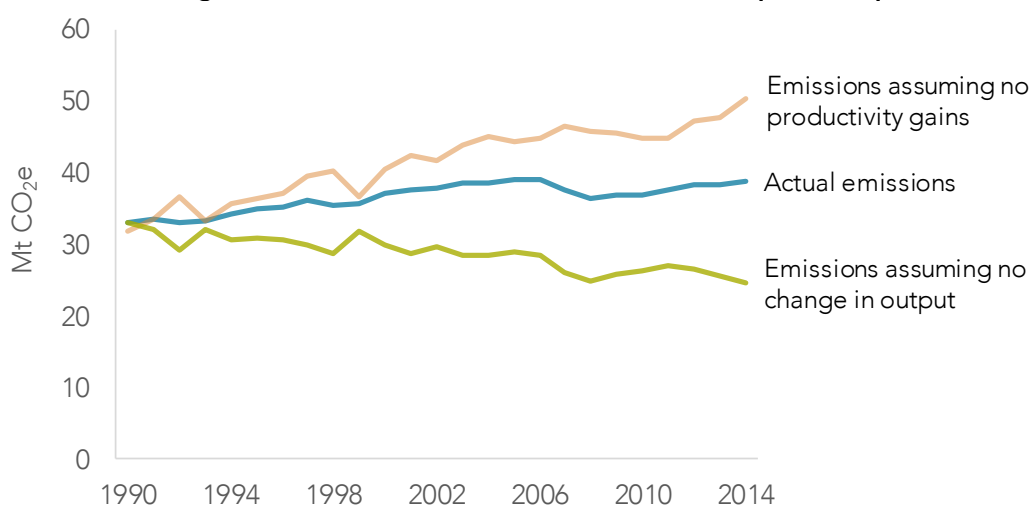
Mitigation options to reduce on-farm emissions do not necessarily improve farm profitability and are generally more likely to reduce farm profits (Vivid Economics, 2017b). Yet Reisinger et al. (2017) conclude that mitigation options that would not reduce farm profits are available for some farms (even though some reduce total production).

Gains in productivity can continue to limit the rise in agricultural emissions

In general, the output of higher productivity farms is less emissions intensive. A more productive animal produces more output of milk or meat, but is also likely to produce more emissions (Reisinger et al., 2016). Even so, a more productive animal produces fewer emissions per unit of production.

Steady gains in pastoral farming productivity since 1990 have enabled New Zealand to maintain or increase production, even though animal numbers have fallen overall (section 10.3). Lamb production in 2015 nearly equalled 1990 levels with only half the number of sheep, while beef farming increased production, with fewer cattle. The national dairy herd doubled in numbers, while milk production tripled, as the average cow produced over 40% more kilogrammes of milk solids in 2015 compared with 1990.

Figure 10.11 New Zealand's agricultural GHG emissions trends, actual compared to potential



Source: RSNZ (2016).

Notes:

1. Emissions data has been adjusted to reflect the downward revision of agricultural emissions in New Zealand's 2015 GHG inventory.

As a result, the productivity gains achieved over the last 25 years helped to curb the increase in agricultural emissions (Figure 10.11). Without gains in productivity (and assuming production grew at the same rate), total agricultural emissions would have increased by about 58% rather than 16% between 1990 and 2015. On the other hand, if total agricultural output had stayed constant at 1990 levels, emissions would have fallen by about 25% (with the productivity gains). Factors driving these efficiency gains include improved management of pasture, more efficient use of fertiliser, more optimal stocking rates and improved breeding (NZAGRC & PGgRC, 2016).

F10.3

New Zealand's agriculture sector achieved steady productivity gains over the last 25 years, leading to a reduction in emissions per unit of milk and meat produced. Yet, because dairy cattle numbers and total production rose substantially, absolute emissions have risen.

Reisinger et al. (2016) expect farm productivity to continue to improve though at a declining rate, leading to ongoing falls in emissions intensity on the average farm, even without new initiatives. Raising the performance of less efficient farms, would likely further reduce emissions intensity.

Reducing stocking rates

Reducing stocking rates (number of animals per hectare) directly reduces emissions and can improve profitability and productivity in some circumstances. Reisinger et al. (2017) estimate that lower stocking rates can reduce emissions by up to 10% on dairy farms and by 2% to 5% on sheep and beef farms, while maintaining production and improving profits. In some cases, reducing stocking rates can be profitable even without productivity gains (PCE, 2016).

Reducing nitrogen inputs

Reducing nitrogen inputs into farm production is the main avenue for reducing N₂O emissions. The major sources of nitrogen are from the supplementary feeds that animals eat, and the nitrogen fertilisers applied to pasture. New Zealand's animals consume much more nitrogen than they need for their optimal growth and productivity (Reisinger et al., 2016). Use of supplementary feeds and nitrogen fertilisers for sheep and beef farms is typically low (Beef + Lamb NZ & Deer Industry New Zealand (DINZ), sub. 98), so opportunities to reduce nitrogen inputs are mostly limited to dairying.

Modelling suggests that removing the use of nitrogen fertilisers reduces N₂O emissions by 6% to 14%, though with reduced production and varying impacts on profitability across regions (Reisinger et al., 2017). The use of precision technologies can also help to optimise the use of fertiliser. DairyNZ (sub. 18) notes that "[r]educing the nitrogen fertiliser applied per hectare requires significant skill and careful feed budgeting" to ensure pasture production is not affected (p. 6).

Another way to reduce nitrogen inputs on farms is by using supplementary feeds that contain less nitrogen (such as maize silage). An animal's diet heavily influences the nitrogen content of their excrement, and therefore their N₂O emissions. Emissions reductions of over 10% are achievable in some regions (Reisinger et al., 2017). However, the benefits of reducing emissions by using low nitrogen feeds are partially offset by the N₂O emitted by the fertilisers used to grow the feeds (DairyNZ, sub. 18).

Reducing nitrogen inputs has the co-benefit of reducing nitrate leaching into waterways and improving water quality (section 10.8).

Other farm practices to lower emissions

Applying nitrogen inhibitors, such as dicycandiamide (DCD), to pasture has the potential for minor N₂O reductions in aggregate. The cost of emissions reductions, at roughly \$650 per tonne of N₂O, makes DCD use economically viable for only a small proportion of dairy farms (Reisinger et al., 2016). In any case, DCD sales ceased after traces of the compound were found in milk product. The product is currently unavailable in New Zealand. Given its high price, if DCD was reintroduced to the market, it would be more likely used to mitigate both emissions and nitrate leaching rather than for emissions alone.

Switching from milking dairy cows twice a day to once a day presents another mitigation option for dairy farmers, with potential emissions reductions of up to 10% while maintaining profitability (Reisinger et al., 2017). Another possible way of mitigating N₂O emissions is taking stock off pasture using stand-off pads, though this can involve large capital costs (DairyNZ, sub. 18). Also, Indigo Biozest (sub. 92) submitted that their product has been shown in trials to lift animal productivity, and reduce GHG emissions and nitrate leaching. Better understanding of its impact on emissions would require more comprehensive testing.

F10.4

No mitigation option currently exists for achieving dramatic reductions in New Zealand's agricultural emissions without substantially reducing production. Yet, many farmers can achieve modest reductions (perhaps up to 15%) through productivity gains and shifting to low-emissions practices. Some options can also improve farm profitability. More options are currently available for reducing nitrous oxide emissions than methane. Options for sheep and beef farming are much more limited than for dairying.

Despite current mitigation options, agricultural emissions are likely to rise

Even with the current mitigation options available, absolute agricultural emissions are very likely to rise, given current patterns of growth in agricultural production. Based on Ministry for Primary Industries (MPI) projections of livestock numbers, Reisinger et al. (2016) estimate that agricultural emissions in 2030 will be roughly 5% to 11% higher than 2015 levels. They conclude:

Absolute emissions from agriculture will continue to rise, making any reduction target below 1990 or 2008–2012 levels highly challenging and, based on current knowledge, impossible unless the expansion of the agricultural sector itself were constrained or new, highly efficacious mitigation technologies successfully developed and rapidly and widely adopted (p. 53).

F10.5

Despite the present opportunities for mitigating on-farm emissions, New Zealand's absolute agricultural emissions are projected to rise, due to anticipated increases in agricultural production. Reducing absolute emissions will require a combination of constraining production and achieving significant breakthroughs in developing new mitigation technologies.

Emerging opportunities for reducing emissions from pastoral farming

New Zealand, along with many other agricultural producing countries, has invested in developing breakthrough technology that can dramatically reduce on-farm emissions. Options such as selective breeding and a methane inhibitor are emerging. To have a meaningful impact on emissions, any new technology will need to suit New Zealand's farming system and be accepted by farmers, industry and consumers.

Breeding low-emitting animals

Some ruminant animals emit more CH₄ than others, partly due to their genetic make-up. For instance, high-emitting sheep produce up to 50% more CH₄ emissions than low-emitting sheep. In 2014, the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) began work on identifying genetic traits for low-emitting cattle (NZAGRC & PGgRC, 2016).

Selectively breeding low-emitting animals provides a clear opportunity to reduce emissions over time. Farmers already breed sheep and cattle to maximise their economic value. The breeding value of animals is largely based on factors related to their production efficiency, fertility and longevity. The inclusion of low-emission traits could be available in breeding indices for sheep and cattle within five years. Further, breeding low-emitting animals is unlikely to significantly affect production (NZAGRC & PGgRC, 2016).

If every sheep was a low emitter of CH₄, total agricultural emissions could be up to 5% lower than at present. For cattle, total emissions could fall by up to 10% (PCE, 2016). Yet, reaching the point where all livestock are low emitters takes time. For sheep, this process would likely take decades. Because all beef and dairy calves

born each year come from a small number of bulls, distributing these traits throughout the national herd could be relatively faster.

Methane inhibitors

A methane inhibitor is a chemical compound fed to an animal to target the methanogens by either killing them, or depriving them of the hydrogen they need to produce CH₄. One inhibitor under development has been proven to reduce an animal's CH₄ emissions by 30%, and is planned to be released in 2019. However, the inhibitor is delivered by mixing it in with cattle feed, rather than applying it to pasture, so is not well suited to New Zealand's grazing system (particularly beef and sheep farming).

Delivering a methane inhibitor in New Zealand would likely require putting the chemical compound in a large tablet or formula that dissolves slowly in the rumen. As this would take considerable skill, time and labour to administer, the compound would need to be effective at low concentrations. Otherwise, the inhibitor would need to be administered frequently, which would come at a cost and would be impractical (PCE, 2016). Inhibitors will likely be more suitable for dairy cattle than other livestock, as milking enables more frequent contact with animals.

Even if a successful inhibitor was only available for dairy farms, it would potentially have a significant impact on agricultural emissions. Work is under way to develop a cost-effective inhibitor that reduces CH₄ emissions by more than 20% and can be used practically in New Zealand. Some compounds have shown promising results, although a commercially available inhibitor is not expected until after 2023 (NZAGRC & PGgRC, 2016).

A methane vaccine

A methane vaccine in theory would trigger an animal's immune system to generate antibodies that suppress the CH₄-producing methanogens in an animal's rumen. Prototype vaccines developed in New Zealand have proven successful in laboratory trials. Trials on sheep are under way to test their impact on animal emissions (NZAGRC & PGgRC, 2016). The partnership of the NZAGRC and the Pastoral Greenhouse Gas Research Consortium (PGgRC) aims to develop a vaccine that delivers at least a 20% reduction in CH₄ emissions, without limiting production.

A vaccine would be ideal for New Zealand's pasture-based system. Farmers already vaccinate livestock to prevent disease, so adding another would be simple and cheap to administer and less likely to meet consumer resistance. A vaccine would also be unlikely to affect the quality of meat or dairy products (PCE, 2016). If the vaccine helped to increase an animal's production, the vaccine's net economic cost could be negative (Vivid Economics, 2017b).

The development of a methane vaccine is still in early stages and the emergence of such a technology is not guaranteed. Even given the huge potential benefits of a vaccine, as Andy Reisinger (sub. 28) submits, successfully developing an effective vaccine is "extremely challenging". A product will nearly certainly not be available before 2030 (PCE, 2016). Rangitikei District Council (sub. 35) emphasises the need to ensure a successfully developed vaccine has no unintended adverse effects (eg, reduced productivity, different product taste and compromised food safety).

F10.6

The development of an effective mitigation technology could have a significant impact on New Zealand's agricultural emissions. While options such as a methane vaccine and inhibitor show some promise, the prospects of a successful technology are highly uncertain and the benefits dependent on their suitability to New Zealand's farm systems.

Reducing emissions in horticulture and arable farming

Horticulture and arable farming currently account for less than 3% of biological emissions from agriculture (section 10.3). Yet, the Chapter 3 transition pathways envisage that horticulture and arable farming will expand two- or threefold up to 2050. If so, effective strategies to reduce horticultural and arable farming

emissions will become more important for New Zealand's transition. This is particularly so, as biological emissions from horticulture and arable farming are mostly long-lived N₂O arising from the use of fertilisers.

Strategies to reduce arable and horticultural biological emissions vary by crop. They mostly involve more precise application of fertiliser; better crop rotation, tilling and ploughing practices; and avoiding soil compaction particularly when conditions are wet. Some of these strategies would also improve farm profitability (Clothier et al., 2017).

10.5 Sequestering more carbon in forests

Growing forests sequester carbon that currently offsets around 30% of New Zealand's gross GHG emissions. Accelerated afforestation will play a key role in New Zealand transitioning to a low-emissions economy (section 10.1). A substantial number of submitters supported accelerating afforestation (subs. 2, 12, 15, 19, 31, 67, 71, 77, and 97).

Mature native forests cover 29% of New Zealand's land area, while a further 8% is planted in commercial forests.⁹⁴ For the purposes of GHG emissions accounting, mature forests that replenish themselves naturally, and commercial forests that are harvested and equivalently replanted, are carbon neutral (on natural forests see Holdaway et al., 2016).⁹⁵

Which species, which planting regimes?

The Ministry for Primary Industries (MPI) told the Commission that it was important that the "right trees are planted in the right place for the right reasons" (pers. comm., 6 December, 2017). This partly reflects past experience with bursts of planting for harvest in unsuitable, inaccessible terrain, far from ports and excessively subject to erosion.

Many areas of marginal land are unsuited to harvesting, but suitable for forests that are intended to be permanent and never harvested. The economics of permanent forests or "carbon farming" are very different to planting for harvest. Thinning and pruning may boost harvest values but not carbon sequestration. As a result, permanent forests sequester more carbon and over a longer period than forests planted for harvest. Permanent forests do not need access to infrastructure for harvesting purposes and are suitable for establishing at scale (NZCFG, sub. 95).

On some marginal lands the most profitable approach, depending on the emissions price, may be simply to plant and leave *pinus radiata* to grow. With a suitable seed source, unharvested exotic forests could eventually revert to native forests as native species re-establish naturally (M. Anderson, 2016; Forbes et al., 2016, David Evison and Euan Mason, sub. 27; NZCFG, sub. 95; G. M. J. Hall, 2001; E. G. Mason & Morgenroth, 2017). Even so, MPI advised the Commission that there is little evidence that this is a viable option, and that it might require manual killing of exotic species seedlings to prevent the establishment of a self-sustaining exotic forest (pers. comm., 22 December, 2017). Carver and Kerr (2017) also note that work on this approach has been limited to date, and see a need for further research to see if this is a cost-effective way of establishing natives.

R10.1

The Ministry for Primary Industries should commission further expert research into the potential for permanent exotic forests to convert to native forests and the conditions under which such conversion could reliably and economically occur.

Some submitters and other commentators have strong reservations about large-scale planting of exotic forests, because of their effects on landscape and cultural values, and biodiversity (Contact Energy, sub. 29; Te Rūnanga o Ngāi Tahu, sub. 83; Wise Response Society, sub. 102; Salmond, 2017). The Environmental Defence Society (EDS) submitted on the 2016 Review of the NZ ETS:

⁹⁴ Of this, regenerating native forests are currently sequestering around 6 megatonnes of CO₂ a year (MfE, 2017g).

⁹⁵ In practice, the sequestration of carbon over time, and so carbon neutrality, will depend on what happens to wood once it is harvested, and, particularly the durability of wood products.

EDS does not support an ETS configuration that would lead to a massive expansion of monoculture pine plantations across New Zealand's landscape. That can destroy landscape quality and diminish the experiences for our biggest export earner, tourism. (EDS, 2016, p. 2)

The EDS and a number of inquiry participants (eg, Graham Townsend, sub. 15) pointed to the related risk of wildings spreading: "The ETS must not incentivise the spread of these troublesome weeds" (EDS, 2016, p. 2).

The Forestry Leadership Group (FLG) has, on the other hand, suggested that the Government should consider, in some locations, farming wilding pines with a view to them being replaced eventually with native forest (sub. 1). MPI considers this would not be consistent with international agreements, because simply allowing wildings to grow would not meet the test of "human-induced conversion of land". The expansion of wildings also creates problems for productive or biologically and ecologically significant land, and can disrupt surface and aquifer flows of water (pers. comm., 22 December 2017). Yet, plantation forests also likely have effects on water flows which local authorities regulate; and managing wildings to eventually revert to native forest may meet the test of "human-induced conversion".

Based on current practices, native forests are more expensive to plant (than exotic) (Carver & Kerr, 2017) though planting at scale could be less expensive (Te Rūnanga o Ngāi Tahu, pers. comm., 22 March, 2018). Native forests, left to regenerate naturally, grow slowly and require pest control (RSNZ, 2016). In the first 30 years, native forests sequester only one half or a third as much carbon as *pinus radiata* forest (David Evison, pers. comm., 14 February, 2014). Yet native forests grow and sequester carbon for a much longer period than exotic forests (G. M. J. Hall, 2001). Most native forests are protected from harvesting under the Forest Act 1949 as amended in 1993; and under the New Zealand Forestry Accord (Karpas & Kerr, 2011).

Other types of forests and species not covered by emissions accounting

Forest & Bird (2018) point out that New Zealand's 7 million hectares of existing native forests store about three times as much carbon as pine forests do. Better pest control in existing native forests will greatly increase the amount of carbon they store. Based on past rates, Forest & Bird estimate that pest control in native forests could help sequester 85 megatonnes of CO₂ each year over the next five years (at much lower cost than alternative ways of reducing net emissions).

Other submitters favoured non-forest carbon sequestering species such as miscanthus (GP International Ltd., sub. 20). The Bioenergy Association submitted on the NZ ETS review, "NZ experience is that Miscanthus dry matter production is two to three times that of radiata pine and hence up to ten times that of planted indigenous forest" (Bioenergy Association, 2016, p. 6).

To be counted towards meeting New Zealand's international commitments, planting to sequester carbon must meet certain conditions. These include a requirement that the carbon removals are anthropogenic and additional (in the sense that they would not otherwise have occurred). As a practical matter they must be able to be accounted for at a reasonable cost, and be able to be monitored over time to ensure their longevity. These accounting conventions and practical considerations flow through to specific forest accounting rules for the purposes of the NZ ETS. For instance only forest species that can attain a mature height of 5 metres or more are included (MPI, 2018). This could exclude, for instance, mānuka grown for the purposes of honey.

Availability of land for forestry of different types

Suitability of land for different types of forestry depends very much on local conditions and the economics of alternative uses. Generally, forestry is not an attractive alternative to dairying (where land prices are high) and further conversions are much more likely on marginal land on sheep and beef farms, or marginal land not currently in production (Kerr et al., 2012; Reisinger et al., 2017). But if the land is to be used for harvest planting, it needs to be on suitable terrain, and accessible for logging and transport to ports or downstream processing. The economics of alternative uses will also depend on the prospective price of carbon over the growing period and at harvest and the price of timber at harvest. Small foresters also face cashflow challenges given the 25 to 30 year wait from planting to harvest.

Several broad analyses of land types in New Zealand conclude that ample land is available for further afforestation. E. G. Mason and Morgenroth (2017), for example, identify 1.3 million hectares of highly

erodible land that could be used for planting forests.⁹⁶ Planting would require “minimal” livestock reductions and would have co-benefits in reducing erosion and siltation of waterways (p. 13).

New Zealand Carbon Farming Group (NZCFG) works in partnership with several large emitting companies and with iwi to plant permanent forests on its own and other land. It has raised the possibility of planting on government-controlled land. It estimates, from sub-block analysis, that the Government has 2.89 million hectares of marginal land under its ownership or control and urges the Government to show leadership in enabling planting on this land (sub. 95).

MPI has done initial work on potential afforestation on Crown lands, focusing primarily on Public Conservation Land. It has identified 59 000 hectares as possibly suitable for afforestation (pers. comm., 22 December 2017). Even this is subject to establishing that the land would count as an eligible ‘post-1989’ forest under NZ ETS rules. In many cases the land parcels are small and not likely to be economically viable as forests; some land is subject to Treaty of Waitangi settlements; pastoral leasehold land does not accord afforestation rights; and conservation land is managed for conservation purposes, which is likely incompatible with planting exotic forests (pers. comm., 22 December 2017).

F10.7

New Zealand has sufficient suitable land to greatly expand afforestation to sequester carbon. This land includes over a million hectares of highly erodible land unsuited to pastoral agriculture (though some of this is also unsuited to forestry). The land is both privately and publicly held. The availability of privately-held land will depend on the economics, including the prospective price of New Zealand Units (NZUs) over the growing period and at harvest. The availability of government-controlled land for further afforestation is uncertain.

R10.2

The Ministry for Primary Industries working, with Land Information New Zealand and Landcare Research, should undertake a complete audit of the availability of government-controlled land suited for afforestation (whether native or exotic), and develop policy options that would cost-effectively establish forestry on such land as is available.

10.6 What influences land-use change?

New Zealand’s transition to a low-emissions economy requires substantial land-use change, particularly through a large increase in land devoted to forestry, pending the emergence of new cost-effective technologies to reduce emissions. The transition also requires a shift towards horticulture (section 10.1). This section examines barriers to changes in land use to help identify policy approaches that can support change.

Private landowners are guided by the prospective profitability of alternatives in deciding how to use their land. This will depend on factors such as the price of the land, the availability of upstream supply of inputs to on-farm production, downstream processing and distribution infrastructure and marketing capacity; the availability of knowledge, skills and technology to support the alternative land use; prospective prices in world markets; and adequate cash flows.

Uncertainty about the returns to alternative uses will also influence land-use decisions. Landowners may decide to hold their land in its current use until the factors affecting future profitability become more apparent (Kerr & Olssen, 2012; Schatzki, 2003). Similarly, the need to make investments in new production and in upstream and downstream capacity, and to develop knowledge and skills, may slow land-use change. New Zealand’s existing sunk investments in highly productive pastoral farming capacity and the support of a secure buyer in the form of Fonterra and a growing number of other dairy processors, weigh against change.

⁹⁶ Some land may be unsuitable for plantation forestry because it is too susceptible to erosion during planting and harvesting, or it creates an undue risk of spread of wildings, or it may have environmental and aesthetic values that planting would compromise. The National Environmental Standards for Plantation Forestry (NES-PF) that come into force on 1 May 2018 set conditions around approval by regional councils and territorial authorities for planting on such land (MPI, 2017e).

Fonterra notes that the levels of required investment and potential debt held in dairy farms, the risk of stranded on-farm and processing assets, and effects on employment, are barriers to alternative land uses (sub. 88).

Andy Reisinger observed several factors that may slow the uptake of promising horticultural opportunities:

On paper, horticultural enterprises appear to have higher profitability than dairying in parts of New Zealand, but horticulturalists are not buying out dairy farms in large numbers. This is likely to be influenced by hidden costs, skills barriers, infrastructure, investment costs, risks, along with more systemic influences in terms of attitudes of banks, international markets, export and training mechanisms. (sub. 28, p. 2)

Where price signals are particularly strong (such as the relative rise in dairy commodity prices in the last two decades) land conversion can be faster. Yet the full effect of an increase in commodity prices differentials may play out over 15 to 20 years (Kerr & Olssen, 2012). Factors that could speed change, in addition to strong price signals, include certainty about policy settings that may affect profitability, the availability of skills and knowledge that reduce the risk of making a change, and the availability of funds to support both on-farm and off-farm investments in new productive capacity.

Planting forests for harvesting or carbon sequestration, in particular, means that land will be unavailable for other uses for many years or permanently. Owners may instead hold land in expectation of increases in land value (eg, driven by rising commodity prices). The FLG submitted: “[f]armers avoid afforestation because it reduces farm income, reduces land use flexibility and ties up capital for unacceptable lengths of time” (sub. 1, p. 6).

Foresters also worry about the risk of regulatory changes (such as those that regional councils might put in place) that will prevent conversion from forests to other uses (FLG, sub. 1; Beef + Lamb New Zealand & DINZ, sub. 98). Uncertainty around a future emissions-price policy will add to the uncertainty around future commodity prices and production costs and so increase the option value of delaying land conversion.

F10.8

The need for investments in upstream supply capacity, new on-farm productive capacity, and downstream processing, distribution and marketing capacity; and the time taken to acquire skills and knowledge, may delay changes in land use, even when they otherwise appear profitable. Policy uncertainty affecting future profitability is also a cause of delay.

10.7 Putting a price on all land-use emissions

Under current policy, the NZ ETS does not price biological emissions from agriculture (including horticulture and arable farming). On the other hand, foresters can earn NZUs for the sequestration of carbon. This section considers the merits of, and explores policy options for, introducing a price on agricultural emissions.

A transition to a very low-emissions economy by 2050 will require both a substantial shift in land use (particularly towards forestry) and a reduction in biological emissions from remaining agriculture (section 10.1). An effective price on agricultural emissions (as in other sectors of the economy) would strengthen incentives to shift to land uses that produce lower emissions; and otherwise to develop and use technology and management practices that lower emissions. It would also provide a devolved mechanism to weigh the marginal costs of reducing emissions from particular land uses against the cost of lowering emissions elsewhere in the land sector and in other parts of the economy (see Chapter 4).

The merits of applying a price to agricultural emissions

When the NZ ETS was launched in 2008, the Government intended to include agricultural emissions from 2013, with 90% free allocation based on 2005 emissions. Allocations would phase out to zero by 2030 (Kerr, 2016). Since 2012, successive governments have deferred including agricultural emissions, pending economically viable and practical mitigation options being available, and New Zealand’s trading partners

making greater progress on mitigating emissions (MPI, 2017d). While exempt from emissions pricing, the sector is required to report its emissions each year.⁹⁷

The decision to defer the full inclusion of agricultural biological emissions into the NZ ETS has been highly contentious (DairyNZ, sub. 18; The Morgan Foundation, sub. 127). Some submitters from the agricultural sector recommended keeping the exemption on biological emissions (Fonterra, sub. 88; Beef + Lamb NZ & DINZ, sub. 98). They argued that pricing these emissions, without adequate ability to reduce them, unfairly disadvantages New Zealand farmers compared to international producers. In particular, they argued that pricing emissions would cause some agricultural production to shift from New Zealand to other countries, without reducing global emissions (“emissions leakage”).

On the other hand, a substantial number of submitters advocated bringing agricultural emissions into the NZ ETS.⁹⁸ Key arguments are that a price on on-farm emissions would:

- better incentivise mitigation as well as research and investment into future mitigation solutions;
- improve the efficiency of emissions reductions, as the NZ ETS would cover all emissions; and
- be more equitable, as it would mean all emitters face the same price for their emissions.

Potential response of farmers to an emissions price

Without a price on emissions (or other regulation), farmers are likely to adopt only mitigation measures that also improve their farm profits. Many farms can achieve modest emissions reductions by changing their management practices (section 10.4). Some of these practices are productivity enhancing, and could therefore be profitable for farmers without an additional financial incentive. Yet, as Kerr (2016a) notes, other practices currently require greater incentive to become viable.

[S]ome emissions efficiency improvements will not raise profit – they will come at a cost. For example, if a farmer immediately replaced their entire current herd with high-breeding worth animals, emissions intensity of the farm’s production would be lower but this would come at a high cost. These changes will not occur without encouragement or incentive. (p. 21)

The effect of an emissions price on farming practices is uncertain and will vary across regions depending on effects on profitability (Reisinger et al., 2017). Non-cost barriers will also slow change in practices (section 10.10). Even so, an emissions price would make more mitigation options financially attractive.

An emissions price would also signal future policy directions and make farmers more aware of the link between different management practices and emissions. Introducing a price earlier rather than later would allow a more gradual (and therefore less costly) transition, especially given that required emissions reductions will become more stringent over time if delayed.

Pricing agricultural emissions also makes switching to alternative lower-emissions land uses a relatively more attractive option (section 10.6). The NZ ETS already provides incentives for farmers to convert their pasture to forestry. A rising price on agricultural emissions would provide an increasing incentive to convert farmland to horticulture and cropping.

Pricing emissions would encourage private investment to develop mitigation technologies

Pricing biological emissions would encourage private investment to develop mitigation technologies. Ballance Agri Nutrients submitted:

Currently to develop a new product or service that can result in reduced emissions there is no ability to capture the value from the emission reductions except indirectly where there is a productivity benefit that is captured by the farmer. As a consequence there is a major deficiency in the ability to justify the investment in developing mitigation technologies (as a non-industry good party) because the business case lacks a direct revenue line from that benefit. (sub. 34, p. 7)

⁹⁷ Farmers do bear a direct cost for their emissions from using fossil fuels (eg, transport fuel), and likely some indirect cost passed on from milk and meat processors who consume fossil fuels (eg, burning coal to power milk processing plants) and from off-farm transport operators.

⁹⁸ See subs. 1, 25, 27, 29, 32, 36, 40, 51, 52, 56, 67, 71, 73, 78, 83, 122, and 129.

Guardians of NZ Superannuation (sub. 32) noted that bringing agricultural emissions into the NZ ETS should “generate incentives for agricultural businesses, including suppliers to leverage government research programmes” (p. 8).

An all-sector emissions price would be more efficient and equitable

Pricing emissions and allowing landowners to work out the best way to reduce emissions (or to pay for reductions or carbon sequestration elsewhere in the economy) is likely to be more efficient, than central direction through regulation. Trading NZUs will encourage the lowest-cost emissions reduction options to be used first, and will let land-use choices respond flexibly to new opportunities as they unfold (Chapter 4).

Applying an emissions price to agricultural emissions means that the Government itself would not directly decide how private landowners use their land. An emissions price would be but one factor among many that shaped land-use decisions (section 10.6). Federated Farmers was sceptical about the Government potentially “picking winners” in relation to land use: “We would not be supportive of policies that would curtail the ability of landowners to use their land in an economically optimal manner” (sub. 39, p. 7). The Fertiliser Association of New Zealand also argued against “the prescription of particular land uses because of the risk of locking in uneconomic land uses and inefficiencies in production” (sub. 61, p. 9). Beef + Lamb NZ and DINZ made a similar point (sub. 98). Pricing biological emissions would allow a variety of land uses, though making some relatively more profitable than others.

Exempting agriculture from an emissions price also places a disproportionately (and inefficiently) high emissions reduction burden on other sectors in the context of meeting New Zealand’s emissions targets, especially since agriculture accounts for such a large proportion of total emissions. Foresters, in particular, argued that agriculture not being in the NZ ETS tilts the playing field against other land uses – especially forestry (eg, subs. 36, 48, 67, 71, 73, 83 and 97).

F10.9

Applying a price to agricultural emissions would give farmers more incentives to adopt mitigation options, though the size of the effect is uncertain. An emissions price would encourage more private investment in developing mitigation technologies and also improve the efficiency and equity of mitigation efforts across the economy.

Addressing impacts on international competitiveness and leakage

Introducing a price on agricultural emissions would make New Zealand the only country in the world to have done so. The main arguments for exempting agricultural emissions from the NZ ETS are the effect on the international competitiveness of New Zealand’s agriculture; the emissions efficiency of New Zealand agriculture compared to other agricultural producers; and the limited scope to reduce agricultural emissions.

Agriculture in New Zealand is highly exposed to trade, with more than 90% of produce exported (RSNZ, 2016); yet New Zealand is a price taker in international markets. A price on agricultural emissions could cause emissions leakage. Any leakage would, though, depend on other factors that vary across countries, such as labour and fuel costs and the cost of land. To date, the emissions price in New Zealand has been low compared to fluctuations in agricultural commodity prices – suggesting that other factors would likely be more important currently in deciding the location of production.

Some submitters raised the issue of emissions leakage, since New Zealand is the largest global exporter of dairy and sheep meat products, and among the least emissions-intensive producers in the world (DairyNZ, sub. 17; Federated Farmers of New Zealand, sub. 39; Fonterra, sub. 88; Beef + Lamb NZ and DINZ, sub. 98). Other submitters raised the tangential issue of global food security (Box 10.4).

Box 10.4 Emissions pricing and food security

Some submitters argued that global food security was an important reason for protecting agricultural producers from measures to reduce GHG emissions (DairyNZ, sub. 18; Federated Farmers of New Zealand, sub. 39; Beef + Lamb NZ & DINZ, sub. 98). They sometimes pointed to the Paris

Agreement, which recognised the “fundamental priority of safeguarding food security and ending hunger” (UNFCCC, 2017). This concern is particularly focused on developing countries, and in essence weighs food security against climate change mitigation.

Yet New Zealand contributes little to global food security. It produces around 3% of global dairy produce, 3% of sheep meat and 1% of beef (OECD, 2017). Rising global demand for milk and meat products is linked to the world’s increasing middle-class population. Any reduction in supply from New Zealand will have little impact on markets for food for the poor in developing countries. According to Anders Crofoot, a former National Vice President of Federated Farmers of New Zealand, New Zealand’s agricultural sector does not “feed the poor” (Cited in Kerr (2016a, p. 15)).

Only a small amount of global agricultural production is traded internationally, and less than 1% of dairy products. Agricultural produce in developing countries is largely produced and traded locally, and food security concerns, in any case, focus on the supply of grains.

Ensuring food security is compatible with meeting climate change mitigation goals. As the Parliamentary Commissioner for the Environment (PCE, 2016) emphasises, “[t]he world will continue to need food. But the way in which food is grown and the types of food grown will have to change if biological emissions are to be reduced” (p. 77).

On leakage, DairyNZ submitted:

If a policy framework was introduced which resulted in New Zealand’s milk production curtailing, it is likely a less efficient producer would fill the gap resulting in an increase in global emissions and carbon leakage. NZIER and NZAGRC estimates this could amount to 13 mega tonnes of biological emissions entering the atmosphere from 2020–2030 if New Zealand’s milk production is displaced (sub. 18, p. 17).

Any increase in global emissions resulting from a shift in production depends on the relative emissions intensities of production in particular countries. Some estimates suggest New Zealand’s emission intensity is one quarter of the average farm globally (DairyNZ, sub. 18).

Yet, the gap in supply resulting from reducing New Zealand’s production is more likely to be filled by its trading competitors than “average” farm producers. Comprehensive data on the emissions intensity of New Zealand’s trade competitors is lacking. Even so, output from high-productivity farms tend to be less emissions intensive than from low-productivity farms (Gerber et al., 2013; section 9.4). Productivity is also likely correlated with trade competitiveness. This all suggests that New Zealand’s trade competitors are likely less emissions intensive than the average global farm producer. In any case, New Zealand produces only a very small proportion of global agricultural production (Box 10.4) so any shift in production will have only a modest effect at most on global emissions.

Free allocations of credits within the NZ ETS are designed to protect trade-exposed industries and limit the risk of emissions leakage (see Chapter 4). Under a similar provision for agriculture, farmers would face the full incentive to mitigate emissions at the margin (since they would be able to sell any unused credits). Yet, initially, they would incur only a small part of the full cost of their emissions, protecting the viability of their business. In contrast, exempting agriculture from the NZ ETS (the current approach) removes incentives to lower emissions, and so is an inferior approach to dealing with emissions leakage (Chapter 4). New Zealand may also benefit from being the first to price agricultural emissions, by increasing the international credibility of its mitigation efforts and its reputation for agricultural innovation (section 10.11).

New Zealand’s competitors in Europe and elsewhere will also eventually face the cost of their agricultural emissions. Many developed countries have set economy-wide targets to reduce emissions. As countries’ commitments become increasingly ambitious, they will likely start to regulate their agricultural emissions too (especially as they will make up an increasing share of their emissions).

F10.10

New Zealand's trade competitors do not yet face a price on their agricultural emissions. Given New Zealand's agricultural sector is highly trade-exposed, introducing a price for agricultural emissions without support would reduce the international competitiveness of New Zealand farms and potentially result in emissions leakage.

Yet, with adequate support for farmers (eg, provision of free allocations), pricing agricultural emissions will provide incentives to reduce emissions, while lessening any risk to the viability of New Zealand's agricultural businesses. Also, the risk may not be as severe as some suggest, since New Zealand's core competitors in international trade are likely eventually to face comparable regulation of emissions.

Providing free allocations would also protect individual farmers from the immediate effects of an emissions price on profitability. Otherwise, a farmer currently earning minimal profits or heavily indebted could face financial stress. Other policies could also assist vulnerable farmers and communities through their transition (Chapter 9).

Agricultural emissions should be brought into the NZ ETS

On balance, the Commission considers that the benefits of pricing agricultural biological emissions, including providing greater mitigation incentives and improved efficiency and equity, outweigh the costs. In particular, a substantial change in land use is required for New Zealand to transition to a low-emissions economy by 2050. Bringing agriculture into the NZ ETS will mean that the emissions price is factored into land values and will provide a more even-handed signal favouring forestry and horticulture. Depending on the design, it could also encourage farmers to reduce their emissions from current land uses, beginning where it is easiest and least costly to do so.

As for other trade-exposed sectors, the Government should provide free allocations for a large majority of agricultural emissions during a transition period, to protect the viability of agricultural businesses. Free allocations should be based on some historic emissions threshold (eg, average emissions over a multi-year period), to encourage farmers to limit output to current levels (or lower) and to consider switching to alternative land uses.

Chapter 4 argued that there is a strong case for withdrawing free allocations to emissions-intensive trade-exposed sectors as the stringency of emissions policies overseas increases. This applies to agriculture too. Free credits for agricultural emissions will need to reduce over time to be consistent with a transition to a very low-emissions economy by 2050. The rate at which free allocations are withdrawn over time should also depend on the availability of mitigation options and the stringency of the agricultural emissions policies of trade competitors. The Government should monitor both these factors over time.

R10.3

Agricultural emissions should be fully included in the New Zealand Emissions Trading Scheme (NZ ETS).

R10.4

To address potential effects on emissions leakage and international competitiveness resulting from including agriculture in the NZ ETS, the Government should provide free allocation of NZUs to cover a large majority of agricultural emissions, based on their historic level. The Government should withdraw these allocations over time as the stringency of agricultural emissions policies increases overseas and the availability of mitigation options increases; and to be consistent with New Zealand transitioning to a low-emissions economy by 2050.

Importantly, agricultural emissions are both short-lived in the atmosphere (mostly CH₄) and long-lived (N₂O). N₂O comprises around 21% of agricultural emissions. To stabilise global warming, net emissions of long-lived gases need to stop, but a flow of short-lived gases can continue, though at a reduced level (Chapter 8).

To properly recognise the difference in warming impacts between short-lived and long-lived gases in an emissions pricing system, the Commission recommended in Chapter 8 setting separate targets within the NZ ETS for the two types of gases. Reductions in agricultural emissions would be guided by two targets.

Point of obligation for an emissions price

The impact of a price on agricultural emissions differs depending on whether the price is borne by individual farmers or by processors of agricultural products or inputs. The point in the supply chain obliged to report on and surrender units for emissions is known as the *point of obligation* (Chapter 4). Currently under the NZ ETS, agricultural emissions are reported at a processor level. This section considers the merits of setting the point of obligation for agriculture at the processor level, or at the individual farm level.

Making processors the point of obligation would require processors, both upstream and downstream of where the emissions actually occur, to bear the direct cost of emissions. For instance, this would include fertiliser manufacturers, who produce an intermediate good that when applied to pasture causes N₂O emissions; and meat and dairy processors, who process meat and milk solids that comes from emitting animals. Estimates of emissions would be based on national averages (eg, the average N₂O emissions for a tonne of nitrogen fertiliser used, or average CH₄ emissions for a kilogramme of milk solids).

Under this approach, processors could pass the cost of the emissions price to farmers, whose individual decisions affect the level of emissions. Farmers would then have incentives to reduce their levels of production (eg, reduce stocking rates where this is profitable, or shift land uses) or to reduce the amount of fertiliser they apply to pasture. Yet they would face little direct incentive to change management practices to reduce their emissions intensity. It is possible that processors could provide such incentives, for example by rewarding farmers who adopt good practices and penalising others.

Another option is setting the point of obligation at farm level. Under this approach, individual farmers would bear the direct cost of an emissions price based on a model of their on-farm emissions (rather than directly measuring emissions). This approach would incentivise the adoption of a much wider range of mitigation options compared to a processor level point of obligation, since farm modelling can capture differences in the way farms are managed. In this way, it provides a stronger price signal to reduce emissions. Farmers would benefit from changing to lower emissions practices, such as using low-nitrogen feeds and selectively breeding low-emitting animals, as well as reducing livestock numbers and changing land uses.

Key issues to consider in setting a point of obligation for agriculture

The key issues to consider in choosing the most appropriate point of obligation for agriculture include:

- the range of mitigation options incentivised;
- the types of mitigation options available to farms;
- the cost and complexity involved with estimating emissions and administering the system; and
- the fairness and acceptability of the system among the farming community;

Assuming a point of obligation at the farm level and at the processor level cost the same to implement, a point of obligation at the farm level is a more efficient option since it provides a stronger price signal to reduce emissions. Yet, in practice, making thousands of individual points of obligation at farm level would be much more difficult to administer compared to a processor level, with potentially high transaction costs. These costs could outweigh the benefits of a farm scale system, especially given that limited mitigation options are available. It is also not simple to accurately estimate a farm's emissions.

The rest of this section discusses some of the challenges in implementing a farm-scale system. It then identifies three potential approaches to setting the point of obligation.

Feasibility and practicability of measuring emissions at the farm level

It is infeasible to directly *measure* on-farm emissions accurately, since they are so diffuse. Instead, it is possible to *model* emissions at the farm level based on information about farm livestock, inputs and outputs, and emissions factors associated with these features. The OVERSEER nutrient budgeting tool is most commonly used for this purpose (Box 9.3).⁹⁹

Box 10.5 OVERSEER

Developed in the early 1980s, OVERSEER is a modelling tool used to estimate the nutrient flows in a farm system. It is jointly owned by the Ministry for Primary Industries, AgResearch Limited and the Fertiliser Association of New Zealand. The tool gathers a range of data inputs including animal characteristics, productivity and feed intake, soil type, slope and rainfall. It then produces nutrient budgets to advise farmers on how to use nutrients more efficiently, and so to improve their farm profitability. It also produces reports identifying risks of environmental impacts and how different practices will affect these risks.

The intended purpose of OVERSEER at its inception was as an advisory tool for farmers to use regarding their fertiliser use. Over time, the model has been developed and adapted, in part, as a response to growing concern about farming breaching environmental limits. Under the Sustainable Dairying: Water Accord, Fonterra requires each of its dairy suppliers to provide accurate farm information to model nitrogen loss and nitrogen conversion efficiency using OVERSEER. Now several regional councils have begun using OVERSEER as a tool to regulate nitrogen discharges on farms to address water pollution (section 10.8). According to Hollis et al. (2016, p. 26), the model “has a mixed reputation within the farming community, especially in catchments where it has been used as a regulatory tool”.

While it was not designed to model GHG emissions, OVERSEER can provide estimates of a farm’s emissions. It does this by combining estimated emissions factors from the national GHG inventory with data specific to an individual farm. This allows the model to capture a range of mitigation options for farmers.

Source: OVERSEER (2017); Fonterra (2016); Kerr and Sweet (2007).

A big advantage of using OVERSEER for emissions pricing is that most dairy farmers are already familiar with the model, as they use it for monitoring their nutrient losses. Views were mixed however among submitters about whether OVERSEER is currently a suitable tool for regulating emissions. The Fertiliser Association of New Zealand (one of the owners of OVERSEER) supported using it to estimate on-farm emissions:

FANZ considers that reliably modelling and estimating farm scale GHG loss is feasible, and that farm scale point of obligation provides for flexibility and innovation, and is the most likely way to successfully effect the required behaviour change. Furthermore, authoritative research reports and investigations confirm that OVERSEER operates at a suitable farm scale and is appropriate for estimating GHG emissions in a manner which is consistent with the National Inventory methods. (sub. 61, p. 7)

In contrast, Beef + Lamb NZ and DINZ considered that OVERSEER should not be used for estimating emissions in a regulatory setting, since the model does not capture the “real-time” variation in emissions that results from the dynamic nature of farm systems. They noted that

[w]ork is needed to improve OVERSEER as an emissions modelling tool as it does not currently reflect the full range of on-farm actions that can be taken to reduce emissions, including an assessment of whether they can even be modelled. (Beef + Lamb NZ & DINZ, sub. 98, p. 4)

In 2017, the Biological Emissions Reference Group commissioned AgResearch (also an owner of OVERSEER) to review the suitability of using OVERSEER for reporting emissions at farm level. The study concluded that

⁹⁹ MfE also models on-farm emissions at the national level for the purposes of reporting in New Zealand’s annual GHG Inventory. The Inventory methodology uses national-level data on production and productivity to estimate feed intake and, in turn, estimate CH₄ and N₂O emissions.

“the OVERSEER structure is suitable for farm-scale GHG reporting” (de Klein et al., 2017; p. 5). Even so, AgResearch identified ways to improve the transparency and accuracy of the model and therefore provide greater confidence to farmers in its use; and to refine the model to acknowledge a wider range of farm-level factors. The authors also recommended a process for ongoing alignment of the model with the national inventory model, since this model is used to estimate New Zealand’s emissions in the context of its international commitments.

The advantages of a point of obligation at the farm level are that it provides stronger and sharper incentives for individual farmers to reduce their emissions. The extent to which this is effective (and justifies the increased cost of monitoring and reporting emissions) will depend on what mitigation options are captured by the farm-level emissions model. OVERSEER reliably models some livestock characteristics, stocking rates, types of feed and livestock productivity, all of which are associated with levels of emissions in well-established ways. With further adaptation, it should be capable of modelling and so incentivising other mitigation options that are at the discretion of the farmer. Use of OVERSEER as a regulatory tool will create pressure to refine it to better reflect current and emerging mitigation options.

Regardless of the point of obligation used, further work to improve OVERSEER would be beneficial. As an advisory tool, OVERSEER would “allow farmers to estimate their emissions and model changes to their farm systems and indicative changes in emissions that would be likely to occur” (Beef + Lamb NZ and DINZ, sub. 98, p. 4).

F10.11

The impact of a price on agricultural emissions differs depending on the point of obligation. A point of obligation at the processor level mostly incentivises reduction of output (either through reducing stock numbers where this is profitable, or through changing land use), and therefore provides a blunt price signal to reduce emissions. A point of obligation at the farm level provides stronger incentives for a farmer to change the way they manage their farm as well as to reduce their output.

F10.12

OVERSEER is currently the main tool for monitoring emissions at the farm level, and is already widely used by dairy farmers for nutrient management. While its overall structure is suitable for monitoring farm-level emissions, further work is under way to improve its transparency, the extent to which it captures a wide range of on-farm mitigation options, and to better align the model to the methodology used in preparing the national inventory.

R10.5

Unless and until there is a better alternative, the Government should use OVERSEER to monitor emissions at the farm level. The Ministry of Primary Industries should undertake work with AgResearch and the Fertiliser Association of New Zealand to further improve the capabilities of OVERSEER as a tool for modelling farm-level emissions. The improvements should capture as far as possible the full range of on-farm actions that can reduce emissions.

Even with a reliable tool for modelling on-farm emissions, the cost of monitoring, verifying, and enforcing compliance for many small emitters is likely to be high (Kerr, 2016). Each farm required to report emissions would need to know or learn (in the case of sheep and beef farmers) how OVERSEER works and the process of purchasing NZUs. Checking that every farm is providing accurate information would be impractical. The Environmental Protection Authority, which administers the NZ ETS registry, could check compliance of a sample of farms, with sanctions for non-compliance (as already provided for under the Climate Change Response Act 2002).¹⁰⁰

¹⁰⁰ Similarly, under the Waikato Regional Council’s nitrogen trading programme, farms are audited each year to check farmers are complying with limits. Farmers cover this cost.

Little information is currently available on the likely administration costs of a farm-scale system. The Biological Emissions Reference Group has commissioned work to better understand the costs and potential capability and capacity barriers to using processor and on-farm points of obligation, compared with other regulatory approaches to mitigating biological emissions. As part of the Dairy Action for Climate Change Plan, Fonterra is also trialling the recording of CH₄ emissions for up to 100 of their suppliers, as part of the reports on environmental performance they already provide to these farmers (DairyNZ, 2017).

To make reporting at the farm level a more practical option, one approach is to limit surrender obligations to farms above a certain size threshold. A choice would need to be made about the relative stringency of the threshold. For instance, the Government could set the threshold at a level that simply exempts very small farms from participating in such a scheme (ie, applying the *de minimus* principle), or at a level that only requires the relatively largest farms to participate. The relative cost of monitoring smaller farms is likely to be higher, and the potential emissions reductions lower. Other approaches could be to allow smaller farms to carry out simpler reporting than bigger farms; or to keep the reporting for smaller farms at the processor level (as at present).

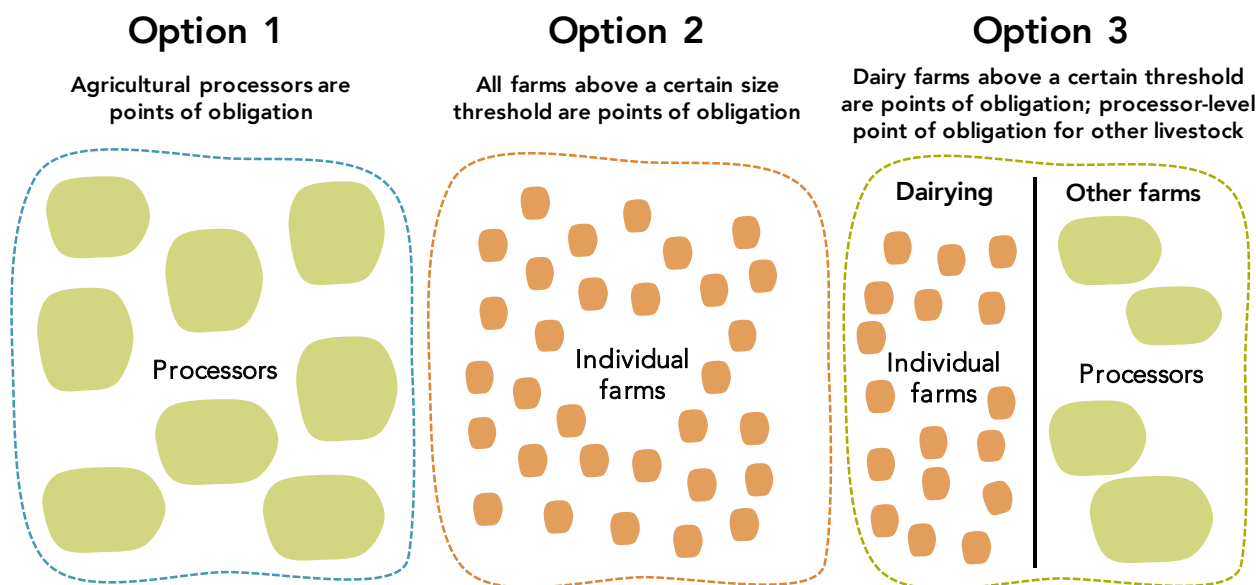
F10.13

A point of obligation at the farm level would require monitoring, verifying, and enforcing compliance for a large number of small emitters. Carrying out this process for all emitters would likely be costly and difficult. Modifying this approach by, for instance, limiting a requirement for farm-level reporting to farms larger than a certain threshold could help to minimise these transactions costs.

Three broad options for agriculture's point of obligation

The Commission has identified three broad options for a point of obligation for agricultural emissions in Figure 10.12 below. It seeks feedback on the advantages and disadvantages of each option.

Figure 10.12 Options for agriculture's point of obligation within the NZ ETS



Notes:

1. "Other farms" refers to small dairy farms, and other livestock farms including sheep and beef, and horticulture and cropping.

While Option 1 (processor level) would provide weaker incentives for reducing emissions intensity, it would be less costly to administer and for participants to comply with. It would require greater reliance on other policies to support adoption of on-farm practices and technology to reduce emissions (section 10.10).

Option 2 (farm level above a certain size) would provide stronger incentives to change on-farm practices and could be more acceptable to the farming community, as it provides farmers with greater flexibility to

respond to an emissions price (Emissions Trading Scheme Review Panel, 2011; Federated Farmers of New Zealand, sub. 39; Waikato Regional Council, sub. 48). Even so, some farmers who have higher than average emissions due to factors outside their control (eg, climate, soil type) may feel that a farm-level system is inequitable. Kerr (2009) points out that gaining broad acceptance among farmers of a farm scale system would be critical for ensuring that the system operates effectively.

In addition to having a full point of obligation at the farm or processor level, other hybrid options exist. Option 3 for example combines a point of obligation at the farm level (above a minimum threshold) for emissions from dairy cattle with a point of obligation at the processor level for emissions from sheep and beef (and other livestock). This approach has several advantages. Most dairy farmers already use OVERSEER, so transitioning to reporting for emissions would be relatively simple unlike for sheep and beef farmers. Dairy enterprises tend to be larger than sheep and beef as well, so the costs of compliance will be relatively low. Since mitigation options for sheep and beef farms are relatively few (section 10.4), a point of obligation that mostly incentivises reductions in output is arguably more appropriate for these farms.

Point of obligation for N₂O emissions arising from fertiliser use

Currently fertiliser manufacturers and importers report on N₂O emissions arising from the use of fertiliser. If agriculture is brought into the NZ ETS, it would be efficient for these businesses to be the point of obligation. In particular, this would cover the vast majority of biological emissions from horticulture and cropping. OVERSEER treats emissions from fertiliser use separately to those arising from livestock, so a point of obligation at the processor level for fertiliser emissions would be straightforward to administer in conjunction with a point of obligation at the farm level for livestock emissions.

Q10.1

What are the advantages and disadvantages of the following options for a point of obligation for agricultural emissions within the NZ ETS?

- Full processor level
- Full farm level, only including farms above a minimum size threshold. A point of obligation at the processor level could be used for farms beneath the threshold and for all horticulture and cropping
- Farm level for dairying, only including dairy farms above a minimum size threshold; processor level for sheep and beef cattle (and other livestock) farming, and for horticulture and cropping.

What other point of obligation approaches should the Commission consider?

Forestry in the NZ ETS

New Zealand is the only country that currently includes forestry in an ETS. Participation in the NZ ETS is mandatory for pre-1990 planted forests and voluntary for post-1989 forests. The main features of the NZ ETS for forestry are (Carver et al., 2017):

- at harvest, owners of pre-1990 forest land must surrender NZUs equal to the resulting reduction in carbon, but can avoid this obligation by replanting (including equivalently in another location) or facilitating natural regeneration (without earning credits for new growth);
- participating post-1989 forests earn NZUs for net carbon sequestered from the time they are registered, and must surrender NZUs (equal to the resulting loss of carbon) at the time of harvest (up to the value of the credits received); if the land is deforested, they must surrender any remaining NZUs earned; and
- forests of more than 100 hectares must use a field measurement approach to assess carbon stocks; smaller forests must use look-up tables.

To date, the NZ ETS has been largely ineffectual in stimulating more afforestation, mostly because of uncertainty around policy and a very low emissions price for much of the period (Carver et al., 2017; MfE,

2016c; subs. 1, 13, 18, 27, 35, 40, 46, 48, 67, 73, 97, 102, 115, and 127). Only around 45% of eligible post-1989 forest land is registered in the NZ ETS. In 2015 around 2 200 participants were registered, covering an area of a little over 300 000 hectares (Carver et al., 2017).

Should forestry remain in the NZ ETS?

Some participants have told the Commission that forestry should not be in the New Zealand Emissions Trading Scheme (NZ ETS). They argue that because forestry offers a relatively low-cost way to mitigate emissions, this will keep the emissions price low. As a consequence, other emitting sectors will not face strong incentives to reduce their emissions. Because options for more forestry will, in the medium term, run out, as suitable land is used up, this will leave New Zealand with substantial gross emissions around mid-century (eg, David Evison, pers. comm., 14 February, 2014). Participants with these views usually recommend that forestry be incentivised through subsidies outside the NZ ETS. The subsidies could be funded from the proceeds of auctions of New Zealand Units.

The modelling of transition pathways in Chapter 3 shows that forestry does offer New Zealand a cost-effective way to reach low or zero net emissions by 2050. Relative to its population size and national emissions, New Zealand has a very large land area suitable for forestry. As a result, the emissions prices needed to achieve very low emissions are moderate compared to international emissions prices consistent with meeting the Paris Agreement goals (Stiglitz & Stern, 2017). Yet, though net emissions are low or zero in all scenarios, substantial gross emissions remain in 2050, ranging from 47 to 59 megatonnes CO_{2e}.

Even so, sectors causing emissions should anticipate a future when mitigation options through forestry will no longer be available or, at least, will be more expensive as the most suitable land is used up. Unless other low-cost mitigation technology has emerged, emitting sectors will anticipate that the emissions price will rise and factor this into their investment decisions thereby steering them towards lower emissions options. Given the long life of many investments (such as boilers for process heat; or refurbishing an industrial plant), it is the future emissions price as much as the current price, that is relevant to these decisions.

While a problem with weak incentives for emissions reductions may not eventuate, the prospective path of the emissions price and of gross emissions is something that the proposed Climate Change Commission (CCC) should monitor. The CCC should consider this path in advising the government on emissions budgets (see Chapter 7). If it were to foresee that a big drop off in forestry sequestration would make it difficult for NZ to meet its targets in the second half of the century, the Climate Change Commission could recommend adjustments to policy settings.

Forestry now has a decade of experience with the NZ ETS with systems established to support participation and significant understanding of how the scheme works. While the scheme can be and should be improved, the Productivity Commission considers that it is best to build on this experience, rather than discard it.

F10.14

Forestry offers New Zealand a path to reducing net emissions to a very low level or to zero by 2050 at moderate cost. Yet there is a risk that a low or moderate emissions price will weaken incentives for other sectors to reduce emissions. This in turn, may make it difficult for New Zealand to achieve emissions reductions targets in the second half of the century, when options for new forestry may reduce or run out.

R10.6

The proposed Climate Change Commission should monitor the effect of forestry on the emissions price and on incentives for emitting sectors to reduce emissions. It should assess whether and how New Zealand can meet its emissions targets in the second half of the century when options for new forestry are likely to reduce or run out. If indicated, it should consider and advise on adjustments to policy settings to deal with this problem.

Proposed improvements to the treatment of forestry in the NZ ETS

During 2015 and 2016 the previous government undertook a review of the NZ ETS which included a specific focus on forestry (MfE, 2015c, 2016d, 2016e, 2017i). Three main issues emerged during the review.

- The complexity of participation for small forest owners relative to the size of their operation. Hughes and Molloy (2017) calculate that the administrative costs of participation for foresters are around \$3 000 each year – and there are risks of penalties around accounting rules (NZIF, sub. 73; Waikato Regional Council, sub. 48). The NZ ETS essentially provides a single, once only cash inflow for foresters, so complexity can easily outweigh any advantages of participation for small forest owners.
- The possible use of “averaging” to reduce uncertainty about liabilities at harvest for forest owners; if replanting, averaging would allow owners to earn credits up to the long-term average carbon sequestered, without having to surrender them at harvest.
- The possible recognition of carbon sequestered in harvested wood products (HWPs), that might reduce foresters surrender liabilities at harvest.

As a result of the review, the previous Government announced (MfE, 2017m) that it would:

- look at a range of possible improvements to forestry operational settings to reduce complexity (subs. 39; 50, 71, 88, and 115 seek reduced complexity and other operational improvements in the NZ ETS);
- seek better alignment between the NZ ETS and other carbon forestry schemes such as the Permanent Forest Sinks Initiative (PFSI); and
- look at averaging as a way to reduce barriers to participation in the NZ ETS.

Oji Fibre Solutions (sub. 71) supported averaging. On the other hand, NZCFG (sub. 95) opposed making “averaging” compulsory, as it would not fit with their permanent forest business model. Carver et al. (2017) favour averaging, but point out that it would blunt incentives to optimise carbon sequestration through adjustments to pruning regimes, planting density and rotation length. Rules would be needed to cover forest management for those choosing to use averaging.

Other approaches to reducing the administrative burden and risks of participation for small forests include using aggregators to manage the administrative arrangements (Karpas & Kerr, 2011) and using financial instruments to manage the risks associated with price uncertainty (Deidre Kent, sub. 87; Coleman, 2011; D. Hall, 2017). The Afforestation Grants Scheme (AGS) currently provides a way for small forests to be rewarded for planting without taking on the full risks of participating in the NZ ETS (Box 10.6).

Box 10.6 Government grants for afforestation and the NZ ETS

The Afforestation Grants Scheme (AGS), established in 2008, is currently funded for five years up to 2020 to encourage new forest planting. Applications are prioritised, if necessary, for their contribution to environmental outcomes. The programme is on track to establish 15 000 hectares of new forests over this period, and a total of \$19.5 million has been allocated to support this. In the year to June 2017, grants totalling \$3.9 million were disbursed. Grants are limited to forests of between 5 hectares and 300 hectares at a rate of \$1 300 a hectare. Grantees are prohibited from receiving NZ ETS carbon credits for a period of 10 years (MPI, 2017a). David Evison and Euan Mason (sub. 27) note that up to 2012 the AGS had led to 12 000 hectares of new planting, the amount being limited by the allocation of government funding.

The Permanent Forest Sinks Initiative (PFSI) requires a commitment from participants to continuous forestry cover for 99 years, in return for which they receive credits for the carbon sequestered. The initiative, administered under the Forests Act 1949, was designed before the NZ ETS was set up, and, in effect, runs parallel to the NZ ETS. Yet, since 2015, NZUs have been the only credits available through the PFSI. Reviews in 2011, 2013 and 2016 all looked at the means to better align administration of the

PFSI and the NZ ETS, but deferred substantive decisions. In the longer run, a high enough emissions price might induce more forest to be held permanently (Tunakino Forestry, 2016).

The Erosion Control Funding Programme had funding for four years to June 2017 of \$23 million. It has supported afforestation of 42 000 hectares since its inception, with almost 1 500 hectares approved for planting in the last financial year.¹⁰¹ Its focus is increasingly on the most erosion-prone land on the East Coast (MPI, 2017a).

Submitters also supported giving greater recognition to carbon sequestered in HWP (subs. 19, 34, 39, 46, and 127) but without adding complexity (subs. 48 and 127). Carver et al. (2017) consider the treatment of HWP. They argue that it would be best to keep this simple by “[e]stablishing a national average for what products harvested trees are turned into and using this to adjust NZ ETS liabilities [or alternatively incorporating] emissions from HWP and on-site residuals into subsequent carbon look-up tables” (p.33).¹⁰² The Morgan Foundation favours a similar approach (sub. 127). The New Zealand Institute of Forestry (NZIF) suggested, on the other hand, that the wood processing sector should be allocated credits for carbon sequestered in HWP (sub. 73). As the Morgan Foundation argues, this would add considerable complexity to the NZ ETS, and other policies could be used to support more wood processing and use of wood products downstream (see Chapter 15).

F10.15

Only a minority of eligible foresters participate in the NZ ETS. Many owners of small forests find participating in the NZ ETS costly and risky relative to any benefits afforded by earning NZUs. Simplifying administration of the NZ ETS for small forests, allowing an averaging approach to surrender obligations over time (on a voluntary basis), and providing policy certainty are all ways to encourage more forest owners to participate.

R10.7

The Government should continue to refine the NZ ETS for forestry to make it easier and less risky for small foresters to participate; and to provide recognition for carbon sequestered in harvested wood products.

Complementing pastoral agriculture with forestry

Pastoral land, particularly sheep and beef farming, includes many areas that are not particularly productive for agriculture, but which could support forests for harvest or permanent forests (Karpas & Kerr, 2011). This could include planting trees in riparian areas fenced off to protect water quality. Many submitters and others supported options to make on-farm and riparian planting more attractive, for instance by making such planting eligible for emissions credits (subs. 18, 22, 37, 39, 48, 67, 68, 88, 98, 115, and 127). Beef and Lamb NZ is currently undertaking an assessment of existing woody vegetation on sheep and beef farms, “with preliminary indications that it is in the millions of hectares” (sub. 98, p. 4).

Reisinger et al. (2017) investigated the economics of on-farm forestry options for the Biological Emissions Reference Group. Generally, the study concluded that forestry (on between 10% and 30% of land) reduced the profitability of the average sheep and beef farm, but by much less than for the average dairy farm. For some sheep and beef farms, forestry on marginal land would be profitable even without an emissions price. The implied cost of mitigation across all options ranged from less than \$10/tCO₂ to \$35-\$45/tCO₂ depending on the type of forest. Most costs were due to effects on the profitability of the pastoral activity (particularly

¹⁰¹ Funding for the Programme has been incorporated into a new appropriation that runs until June 2021 (MPI, 2017a).

¹⁰² Manley and Evison (2017) show that 53% of New Zealand’s national harvest is exported, of which 96% goes to three countries – China, South Korea and India. Carbon stocks in timber exported to India, China and South Korea are halved within one, two and 12 years respectively, and, in aggregate, in just over two years.

spreading fixed costs over a smaller base), rather than the direct costs of afforestation.¹⁰³ Reisinger et al. (2017) note that the economics of planting trees on pastoral land is highly dependent on individual farm characteristics. More fine-grained regional analysis would be required to identify profitable and practical ways to combine afforestation with pastoral farming.

Some inquiry participants argued that the NZ ETS accounting rules should be amended to include smaller areas of planting (eg, Waikato Regional Council, sub. 48; Molly Mellhuish, sub. 79; Federated Farmers, pers. comm. 21 September 2017). Current accounting rules mean that technically relevant plantings (eg, riparian plantings of less than 30 metres wide) are not included in the NZ ETS. New technology could allow finer-scale definition of forest plantings for the purpose of the NZ ETS.

Yet MPI point out that the NZ ETS might not provide sufficient financial incentive to include small “stand alone” areas of trees. For instance, riparian planting at 5 metres wide would generate between 3 and 8 NZUs per kilometre each year, providing between \$60 and \$160 in income. Against this, the fees associated with the NZ ETS are at least \$500 to register and \$102 for returns to claim units (MPI, pers. comm., 22 December 2017).

Other difficulties might also limit planting. Marginal farm land may be scattered in small parcels, creating management difficulties and increasing the cost of fencing. Marginal land may be inaccessible for harvesting or have high harvest costs and so limit planting to permanent forests. Pastoral farmers may see scrub and trees as undesirable and may not warm to the idea of on-farm planting (Karpas & Kerr, 2011; David Evison & Euan Mason, sub. 27). The FLG and Scion submitted that as pastoral farmers are likely to have less knowledge about forestry, they are likely to have heightened perceptions of risk (subs. 1 and 67).

Aggregation of small areas of on-farm planting, both on individual farms and across farms, could reduce the administrative costs of receiving recognition for carbon sequestered and make it more economic to do so (Te Rūnanga o Ngāi Tahu, pers. comm., 22 March, 2018). DairyNZ proposed a hybrid approach combining on-farm planting with purchasing carbon offsets elsewhere. It recommends

establishing an afforestation scheme for the agricultural industry, which captures the carbon sequestered from shelter belts and riparian planting and includes additional mechanisms to incentivise afforestation. It could include community based afforestation blocks where farmers collectively purchase land for the purposes of carbon sequestration. It could enable Dairy companies to plant trees to offset on-farm emissions which make up 85 percent of the dairy supply chains footprint on behalf of suppliers. This would be similar to Air New Zealand’s afforestation scheme where they plant trees on behalf of their customers who voluntarily opt into the scheme. (sub. 18, p. 13)

Small-scale and riparian plantings do not currently count towards meeting New Zealand’s emissions-reduction targets. Any accounting change would need to be able to credibly demonstrate additionality.

Q10.2

With developing technology and aggregation for accounting purposes, is it technically feasible and would it be cost-effective to include small areas of planting (such as riparian planting) within the NZ ETS?

What emissions prices will result in increased forest planting and less deforestation?

The modelling of transition pathways reported in Chapter 3 shows that emissions prices (in the range from \$70 to \$250 per megatonne CO₂e) will incentivise large areas of new forest planting (in the range from 1.3 million to 2.8 million hectares).

A range of previous studies have also estimated the potential effects of an emissions price on net afforestation in New Zealand (Adams & Turner, 2012; Kerr et al., 2012; Manley & Maclaren, 2009). They use a variety of models and assumptions about an emissions price, but come to similar conclusions that a price in the range of \$20 to \$25 would stimulate net afforestation of an additional 250 000 to 300 000 hectares in the

¹⁰³ The study did not include the costs of off-farm infrastructure and supply chains and risk premiums (raised by reducing flexibility in farm operations). Nor did it include changes in land value.

period from 2008 to 2030. Most of the estimated effect on afforestation results from the conversion of marginal sheep and beef land (Kerr et al., 2012).

These conclusions are consistent with the results of annual deforestation surveys which show that as the price of NZUs has risen in the last few years, deforestation intentions have fallen (Manley, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017b). Even so, other policies that price or otherwise regulate the externalities from alternative land uses, such as nitrate leaching, are likely to be having a larger effect than an emissions price on net afforestation rates, in regions where they apply (Manley, 2017a).

New Zealand Carbon Farming Group (NZCFG, 2016), in its submission on the review of the NZ ETS, argued from its own experience and business analysis, that at prices of more than \$19 for a NZU, the volume of planting could easily exceed 50 000 hectares each year. More recently, NZCFG told the Commission that it had planted 25% of all the new forests planted in 2011 and 2012, when the price of a NZU was \$20. When the price collapsed in 2013 it had no choice but to suspend planting, NZCFG noted: “If the price moved again to an appropriate level and there was certainty in terms of current and future policy settings, we would recommence our planting program at large scale” (sub. 95, p. 13). If the price were above \$18.50 and there was policy certainty, they could commit to planting 20 000 hectares of new forests.

Yet, as more land is planted in forests, planting on additional land is likely to become ever more expensive over time, as the modelling of transition pathways in Chapter 3 shows. This is because either suitable cheaper land options have been exhausted; or because it is more expensive to plant and manage forests on remaining available lower-price land.

F10.16

Emissions prices above \$20 and rising to \$70 and above for a NZU in the NZ ETS will likely lead to a substantial increase in afforestation rates, mostly on marginal land currently used for beef and sheep farming. A rising emissions price is likely required to incentivise sustained afforestation over future decades.

10.8 Emissions and regulating co-benefits and co-harms of land use

Some submitters argued that if the costs to the community of effects of agriculture on water quality were appropriately priced or regulated, more land would move from high-emissions agriculture to other uses (eg, Oji Fibre Solutions, sub. 71; NZIF, sub. 73). Other submitters thought that Government financial and funding support for irrigation also favoured high-emissions uses such as dairying (Box 10.7).

Box 10.7 GHG emissions and irrigation

Some submitters saw support for irrigation as favouring high-emissions dairying over other land uses (Bay of Plenty Regional Council, sub.50; Oji Fibre Solutions, sub. 71; NZIF, sub. 73; Wise Response Society, sub. 102). The Christchurch City Council proposed that support for irrigation be limited “to projects which make legally binding commitments to use the irrigated land for low-emissions agricultural/horticultural products” (sub. 13, p. 3). NZ Church Climate Network argued for redirecting current funding support for irrigation to an “Agriculture Transition fund” to support a move to “environmentally responsible farming” (sub. 121, p. 3).

Government support for irrigation development has been administered through a Crown Entity, Crown Irrigation Investments Limited, established in 2013. The largest part of the support has been through a \$400 million co-investment fund. The fund was designed to address a limited market for capital to fund the development of irrigation schemes, to take “irrigator demand ramp-up risk”, and to provide commercial expertise to undertake complex irrigation infrastructure projects. The company seeks to exit its investment once it becomes commercially viable. The company also administers a five-year appropriation of \$56 million to support the development of regional schemes to the point that they become investment ready.

Crown Irrigation has aimed to contribute to a range of environmental, social and cultural co-benefits through its support for irrigation, including improved water quality and more sustainable management of water resources, and protection of tangata whenua interests in waterways. Potentially negative effects of irrigation on water quality and other environmental outcomes are considered in investment decisions, and are subject to regional council regulation.

The new Government intends to wind down support for irrigation (as part of the confidence and supply agreement between the Labour and Green parties). It will however honour existing Crown Irrigation investment commitments (as part of the coalition agreement between the Labour and NZ First parties).

Source: Crown Irrigation Investments Limited (2016).

In general, businesses using land to produce goods for the market may at the same time produce positive benefits for others, for which they are not rewarded; and negative effects on others, for which they do not face the cost. For instance, livestock farming causes nitrates to leach into waterways, reducing water quality, harming aquatic life, and reducing the value of waterways for the wider community (Monge et al., 2017; Yao et al., 2017). Planting large areas of exotic forests likely reduces biodiversity compared to native alternatives and can increase the risk of wildings spreading into sensitive landscapes (Karpas & Kerr, 2011); while planting native forest produces cultural benefits (Carver & Kerr, 2017). Other avoidable harms of plantation forestry include harvesting costs imposed on local communities through deteriorating infrastructure and debris in waterways (Salmond, 2017). Increased forestry may also lead to falls in the rural population and loss of associated infrastructure, such as schools.

The Government putting a price on, or otherwise regulating these effects on behalf of the wider community, is one way to get a socially desirable balance between the interests of private businesses and society. Without such interventions there will be too little or too much of some types of land uses, from a societal point of view. For instance, under the provisions of the Resource Management Act, the National Policy Statement on Freshwater Management sets out how local authorities should manage freshwater quality; and the National Environmental Standards for Plantation Forestry guides the management of potential environmental co-harms of plantation forestry. In turn, regional councils necessarily take a variety of approaches to giving effect to these provisions (Box 10.8). The new Government intends to update the National Policy Statement on Freshwater Management to apply stricter standards and ensure a more consistent approach across the country (Mitchell, 2018).

Box 10.8 **Examples of regulations introduced by regional councils to address water pollution**

The quality of many of New Zealand's rural waterways has deteriorated, partly because of increasingly intensive farming (PCE, 2013). Nutrients in fertilisers, such as nitrogen and phosphorus, not taken up by plants can leach into nearby waterways as a result of rain and irrigation. These nutrients promote the growth of aquatic plants and toxic algal blooms. Increases in animal stocking rates, mostly for dairying, and the use of fertilisers increased rates of nitrogen leaching by 29% between 2000 and 2012 (StatsNZ, 2017c). In response, several regional councils have imposed limits on nutrient loss in their Regional Plans. Policies encourage farmers to optimise their nitrogen inputs and constrain their production. They also discourage landowners, such as foresters, from converting their land to farming.

Environment Canterbury

In 2014, Environment Canterbury (ECAN), in its Land and Water Regulatory Plan (LAWP), introduced caps on the nutrient loss of a farm equal to an individual farm's average losses between 2009 and 2013, to control leaching. This effectively caps yearly nutrient losses within the Canterbury Region at these historic levels. To obtain a resource consent, farmers must complete a Farm Environment Plan to demonstrate that their farming activities will comply with Plan regulations.

In mid-2017, ECAN notified Plan Change 5 to the LAWP. That Plan Change will make limits on nutrient discharges more stringent to reflect best management practices. Limits will depend, in part, on the

nature of the farm, and the catchment where it is located. The regulatory change requires modifying the OVERSEER tool for estimating a farm's nutrient losses, to capture the changes in practice that farmers implement.

Waikato Regional Council – Lake Taupō

Responding to evidence of declining water quality in Lake Taupō, the Waikato Regional Council introduced a nitrogen cap and trade programme, as part of the Council's 2011 Regional Plan Variation Five. The programme's objective is to mitigate the effects of discharges in the catchment so that by 2080 the water quality of Lake Taupō is restored to 2001 levels.

The policy establishes a catchment-wide cap on nitrogen losses by allocating farmers individual nitrogen discharge allowances. Landowners may exceed their allowance provided that any nitrogen losses above their allowance are offset by a corresponding decrease in nitrogen losses elsewhere in the catchment. This creates a nitrogen trading system in which landowners facing high nitrogen reduction costs may choose to buy nitrogen allowances from other landowners, and vice versa.

Source: Barns and Young (2012); Duhon et al. (2015); Environment Canterbury (2018)

Regulating nitrate leaching would reinforce the effects of an emissions price on land-use change. Monge et al. (2017) describe the effects of the Bay of Plenty Regional Council's regulation of nitrate discharges into the Rotorua lakes:

Dairy farmers will face the dilemma of complying with environmental regulations by either de-intensifying current operations, by including forestry, or by paying for the right to operate above the assigned NDA [nitrogen discharge allowance]. (p. 20)

Monge et al. (2017) show that, if nitrate leaching was priced at the rate implied by incentives to reduce nitrate leaching into the Rotorua lakes and carbon sequestered was priced at the then current price of \$7 for a NZU, forestry could be at least as profitable as dairying on typical land in the central North Island. Regulation of water quality by regional councils had a significant effect on reducing deforestation intentions in the same region (Manley, 2017a).

Many of the co-benefits and co-harms of land use vary according to local circumstances. It is appropriate that local authorities are responsible for regulating them under the Resource Management Act in a way that takes these into account. Some submitters argued that such regulation presents an opportunity to influence land-use choices in a transition to a low-emissions economy (ADLS, sub. 7; Te Rūnanga o Ngāi Tahu, sub. 83).

The Commission, on the other hand, sees an effective emissions price as the best way to reduce emissions across the economy in a fair and efficient way (section 10.7 and Chapter 4). A single emissions price cannot, though, reflect the varying range of co-benefits and co-harms associated with different land uses. Additional incentives or regulation, often catchment specific, are needed to secure co-benefits and avoid co-harms. Incentives may take the form of pricing or subsidy of benefits (for instance the biodiversity benefits of native afforestation); levies to compensate for harms (such as the negative effects of harvesting forests on local infrastructure); and regulation of standards to secure benefits or avoid harms.

Native forests offer biodiversity and cultural benefits not afforded by exotic forests. Yet native forests are more expensive to plant and slow growing, so commercial considerations are likely to favour exotic forests for carbon sequestration (section 10.5). Recognising the additional benefits, firms are sometimes willing to offset their emissions through planting native forests, often in association with Māori landowners. Carver and Kerr (2017) identify policy options to increase native afforestation, such as:

- improving information on how much carbon is sequestered through native afforestation, to enable more reliable estimates of emissions credits to be earned from planting;
- allowing natural native regeneration to be eligible for AGS grants; and

- credibly verifying that carbon credits have been generated by native forestry, which would give companies a way to certify that their offsets come from native forestry.

Carver and Kerr (2017) also recommend research to identify land suitable for native regeneration, investigation of cheaper planting options for natives, and planting natives on riparian agricultural land being retired to protect water quality.

Te Rūnanga o Ngāi Tahu proposed additional incentives for native planting (sub. 83) and noted that the “value in indigenous forestry is multi-dimensional incorporating both regenerating native forests and potential for commercial indigenous forestry” (pers. comm., 22 March, 2018).

The new Government has announced that a proportion of the one billion trees it intends to see planted over the next 10 years will be natives (Jones, 2018).

10.9 Māori and land in a low-emissions economy

Māori are substantial owners of productive land, including an estimated 30% of land under plantation forests, 10% of kiwifruit and dairy production and 25% of sheep and beef production (MPI, 2017b, p.11). Almost 40% of Māori freehold land is covered with native forest (Harmsworth et al., 2010).¹⁰⁴ What Māori do with their land is crucial for their economic and social wellbeing (Federated Farmers, sub. 39). It will also have a significant impact on New Zealand’s transition to a low-emissions economy.

Māori have multiple interests in, and likely a range of views on, land use. They are, for instance, landowners under different ownership arrangements; farmers and foresters; iwi with land returned as part of Treaty of Waitangi settlements; and owners and employees of farm supply or primary produce processing businesses. More generally, Māori have ancestral ties to the land. This will have a significant influence on how land is used over time (Emissions Trading Scheme Review Panel, 2011).

Māori have an ancestral and multi-generational relationship with the land

Māori have strong cultural and spiritual connections with their land, protected under New Zealand law. In particular the Resource Management Act 1991 recognises that Māori, as tangata whenua, have an ancestral relationship with the land (ADLS, sub. 7). This relationship gives rise to the ongoing rights and responsibilities of kaitiakitanga.

Kaitiakitanga “denotes the obligations of stewardship and protection ... [and] is most often applied to the obligation of whānau, hapū and iwi to protect the spiritual wellbeing of natural resources within their mana” (New Zealand Law Commission, 2001, p. 40). Kaitiakitanga is closely linked to whanaungatanga – the organisation of relationships through whakapapa or familial connections. The Waitangi Tribunal explains:

Kaitiakitanga is really a product of whanaungatanga – that is, it is an intergenerational obligation that arises by virtue of the kin relationship. It is not possible to have Kaitiakitanga without whanaungatanga. In the same way, whanaungatanga always creates kaitiakitanga obligations. (Waitangi Tribunal, 2011, p. 105)

In a similar vein, Te Rūnanga o Ngāi Tahu (sub. 83) submitted:

Kaitiakitanga is about ensuring that future generations have a relationship with Te Ao Tūroa (the natural world) that sustains them in the way that generations before have been sustained. (p. 5)

Measures to reduce GHG emissions from land use are likely also to have benefits in protecting the health (mauri or life-supporting properties) of New Zealand’s lands, forests and waterways. Māori values about land and the natural environment, and the multi-generational perspective these entail, are a potential source of strength in New Zealand’s search for a path to a low-emissions economy.

¹⁰⁴ The four different types of Māori land are customary land, Māori freehold land, general land owned by Māori, and Māori reserve land. Comprehensive and definitive data on how all types of Māori land are used are not available. Harmsworth et al. (2010) provide a detailed analysis of current land use based on the Māori Land Information Base held by Te Puni Kōkiri and the Land Cover Database held by the Ministry for the Environment.

Te Rūnanga ... recognises that as Treaty partner, Ngāi Tahu must play an active role in the change process. We are well equipped to partner with central and local government, as natural agents of change and intergenerational investors within the Ngāi Tahu takiwā and nationally. (sub. 83, p. 5)

Section 10.11 identifies the value of partnerships of industry and environmental organisations, iwi and central and local government in finding and promoting opportunities to move towards a low-emissions rural economy. Iwi-based organisations are leading a multi-generational approach to climate change mitigation and adaptation. They generally support full inclusion of agriculture in the NZ ETS (CCILG, 2016; Te Rūnanga o Ngāi Tahu, sub. 83).

Opportunities and barriers to reducing net emissions from Māori land

Māori customary, freehold and reserve land is governed by Te Ture Whenua Māori Act 1993, with a strong presumption against alienation (that accords with Māori values about ancestral ties to the land). One result of this presumption is that

Māori land-owning bodies constituted under Te Ture Whenua Māori [often trusts or incorporations] typically face considerable difficulty in raising external capital, and it is extremely difficult (ie, prohibitively costly or otherwise impossible) to rationalise the ownership of Māori land assets. (Insley & Meade, 2008)

Māori land is often held in small parcels and poorly located. Often the land has multiple beneficial owners, making decisions about land use difficult and reducing incentives to make changes. Together, these factors mean that a considerable proportion of Māori land is relatively undeveloped (Insley & Meade, 2008; PricewaterhouseCoopers, 2013, 2014). These same issues create barriers to making changes in farm management practices and technology to reduce GHG emissions (Insley & Meade, 2008).

The particular barriers facing Māori owners have raised calls for researching and developing Māori-specific approaches to lowering emissions from land use (CCILG, 2016; Harmsworth et al., 2010; Insley & Meade, 2008). Government agencies have developed a response. The NZAGRC now has a dedicated Māori research programme under way, which includes initiatives to:

- characterise 29 Māori farms and to monitor their GHG emissions (Kingi et al., 2015); and
- reduce emissions on four farms while improving profitability, and to disseminate the results through on-farm field days (NZAGRC, 2017).

More than 150 000 hectares of Māori land “is hilly, erosion prone, or marginal, was not in trees at 1990, and has the opportunity to be used for carbon farming ... through planting forest or allowing regeneration of scrub and low forest” (Harmsworth et al., 2010).¹⁰⁵ Yet Scion (sub. 67) again noted that “[m]ultiple ownership of Māori land and its consequences for accessing capital is limiting the development of forestry on underutilised Māori land” and noted the lack of finance to undertake long-term forestry investments (p. 2). Partnerships with forestry investors or the Government is an important route for accessing finance to plant forestry on Māori land (section 10.10).

Some forests from Treaty settlements are on land suitable for dairying and could be at risk of deforestation (Manley, 2017a). Even so, Māori are strong advocates for expanding forests, including native forests (CCILG, 2016; Te Rūnanga o Ngāi Tahu, sub. 83). The Climate Change Iwi Leaders Group (CCILG) argued for strengthening of afforestation grants and investment into pest-control in native forests.

Land, and forest land in particular, features in settlements of historic Treaty claims. Policies to reduce agriculture emissions and sequester carbon in forest could potentially affect the value of land and forests. Consistent with this, iwi had a particular interest in the design of the NZ ETS and its bearing on past and future Treaty settlements (Indigenous Corporate Solutions, 2008; Insley & Meade, 2008). Allocations of credits for pre-1990 forests (to compensate for potential liabilities from deforestation) were set at a level that acknowledged that much of this forest was already protected. Any amendments to the NZ ETS will need to consider whether and how those amendments may interact with the provisions of particular Treaty settlement legislation. Te Rūnanga o Ngāi Tahu advised, “as the Crown considers pathways to a low-

¹⁰⁵ Most of this land is in Northland, and in the central and eastern regions of the North Island.

emissions economy, policymakers must be mindful of a fiduciary duty to protect the interests of iwi” (sub. 83, p. 5).

10.10 Complementary policies to reduce emissions from land use

The Commission recommends that the NZ ETS should be the primary policy instrument to motivate action to reduce biological emissions from land use (section 10.7). Yet a range of barriers may slow the response of the land sector to an emissions price. This section assesses complementary policies that address these barriers. These include policies to support research, development and adoption of technologies and practices to reduce agriculture emissions; and policies that support a search for, and change to, low-emissions land uses, particularly horticulture and forestry.

Research into technologies to reduce agricultural emissions

Improved productivity and better farm management practices have been slowly reducing the emissions intensity of New Zealand’s agricultural products over time and this is likely to continue (section 10.4). Even so, more substantial reductions depend on finding and adopting new technologies. Chapter 5 concludes that New Zealand’s strategy for its transition to low emissions should have a strong focus on innovation, which will require significantly more resources devoted to it than the current allocation.

New Zealand is a “world leader in the science and technology of agricultural mitigation” (Fleming & Kerr, 2017, p. 17). Currently, the Government invests roughly \$20 million each year into researching mitigation technologies, most of which helps fund three research centres.

- The Pastoral Greenhouse Gas Research Consortium (PGgRC), set up in 2003, comprises industry participants, government agencies and the National Institute of Water and Atmospheric Research. The PGgRC focuses on the mitigation of CH₄ and N₂O emissions. It works in partnership with the NZAGRC. It is receiving \$37.8 million of funding between 2013 and 2019, half of which comes from the Ministry of Business, Innovation and Employment and the other half from industry.
- The New Zealand Agricultural Greenhouse Gas Research Centre, established in 2009, researches ways to reduce CH₄ and N₂O emissions and increase the carbon stored in soils. It is receiving \$48.5 million of Government funding between 2009 and 2019.
- The Government, working with other countries, helped establish the Global Research Alliance on Agricultural Greenhouse Gases (GRA) in 2009. The GRA researches, and seeks to develop, technologies to lower GHG emissions from food production. The GRA now has 49 members and is funded from voluntary contributions from member countries. Specific research projects also receive funding from other sources. New Zealand hosts the GRA’s secretariat. The GRA’s activities are receiving \$65 million of Government funding between 2010 and 2020.

Some submitters advocated increased funding for agricultural emissions mitigation research (John Crook, sub. 31; Federated Farmers, sub. 39; Waikato Regional Council, sub. 48). J. Robert McLachlan (sub. 9) argued that the current level of government funding for research is “woefully inadequate compared to the size of the [agricultural] industry”, and a barrier to future emissions reductions (p. 6). The PCE argued that funding for a search for a breakthrough technology, such as a methane vaccine, should be increased (PCE, 2016). Andy Reisinger (sub. 28) recommended that the Commission “develop a framework for thinking about and quantifying the benefits of developing [mitigation] technologies, to better inform the quantum of research investment that can be justified” (p. 1).

Under current policies, continuing funding for agricultural emissions mitigation research is uncertain and small (at around \$16 million each year) in relation to:

- the size of the agricultural sector and downstream processing (about 6% of GDP);
- the proportion of total emissions that come from agriculture (almost half);
- the urgency of the risks arising from climate change and New Zealand’s commitments to lower emissions; and

- the total size of Government's contribution of funding for innovation (in excess of \$1.5 billion each year).

Potential payoffs in terms of enhancing New Zealand's international reputation are possible, through the dissemination of a successful technology to reduce agricultural emissions (and possible commercial payoffs) (section 10.11).

Chapter 5 concludes that arguments for increasing funding for emissions-reduction research are strong where New Zealand already has a solid research base and significant emissions, such as in agriculture. On reasonable assumptions, if a vaccine reduced CH₄ emissions by 30%, the annual value in New Zealand alone, at a carbon price of \$50 a tonne, would be over \$380 million. This suggests that, even if the chance of success from research into mitigation technologies is only in the order of 30%, a substantially higher level of funding than the current total level of around \$16 million each year would be justified by the potential returns.

One option to increase funds for research on agricultural mitigation technologies is to use some of the proceeds of auctioning NZUs (see Chapter 5).

R10.8

The Government should increase its yearly funding for research on agricultural mitigation technologies to a level that better reflects the potential value of successful outcomes. Funds could, for instance, be allocated from the proceeds of auctioning NZUs.

Support for adoption of practices and technologies to reduce emissions

Farm management practices that lower emissions, including some that improve productivity, have been known and available for decades. With the help of research and industry advice, farmers continue to identify and adopt new approaches to lowering emissions. Yet, across New Zealand, progress in reducing biological emissions has been slow and overall results modest (section 10.4). Even if a technological breakthrough occurs, it may still take many years for a majority of farmers to adopt it. Journeaux et al. (2017) reported that farmers interviewed for their study thought that it could take 6–10 years to achieve a 10% reduction in emissions and up to 15 years to achieve a 20% reduction.

Causes for slow adoption of new practices and technologies vary. Pastoral farmland comprises roughly 25 000 sheep and beef farms, and over 12 000 dairy farms. Farmers have a variety of world views and objectives. They often rely on other farmers as a key source of information to decide what to try, and so new ideas take time to percolate through (Journeaux et al., 2017). Conversely, many mitigation practices are complex and require a high capability to implement effectively. Beef + Lamb NZ and DINZ noted that "farm systems are not readily changed as they are based on biological systems, and planning is necessarily much longer term than typical industrial or manufacturing processes" (sub. 98, p. 5). Farmers may also perceive emissions reduction strategies as risky.

DairyNZ noted the absence of a "clear set of good management practices to guide appropriate behaviour", low awareness of the issue of climate change, implications of the Paris Agreement and what it means for the dairy industry, and "a lack of capacity and capability within rural professional networks" (sub. 18, p. 10). The Morgan Foundation (sub. 127) identified a lack of relevant independent advice. Beef + Lamb NZ and DINZ argue for "access to expertise and advisory services that can assist farmers to identify practical and affordable changes and adaptations to their current business models" (sub. 98, p. 8). Waikato Regional Council (sub. 48, p. 8) pointed to the positive effect of peer and industry recognition to foster best practice in the pastoral farming sector, which would equally apply to emissions reductions efforts.

The pastoral agricultural sector, itself, through industry organisations and leading companies, is already developing a strategic approach to climate change mitigation. For instance, in June 2017 DairyNZ, in partnership with Fonterra and with the support of government agencies, launched the Dairy Action for Climate Change initiative (which builds on a similar strategy to address water quality issues). The initiative addresses barriers to emissions reductions by building the capability of rural professionals through professional training courses, raising the awareness of farmers, and undertaking GHG pilot case studies on

dairy farms (DairyNZ, 2017). The initiative will have even greater salience if pastoral agriculture is brought fully into the NZ ETS (section 10.7).

F10.17

Based on past experience, adoption of low-emissions farming practices and technology will likely be slow and complex. The dairy industry is putting in place peer and industry support for farmers to adopt new practices and this model could be adopted more widely. Industry efforts to reduce biological emissions will intensify when agriculture is brought into the NZ ETS.

Reducing barriers to a shift to low-emissions land uses

Some of the barriers to moving to low-emissions land uses – particularly horticulture and cropping, and forestry – are the same as those that hinder pastoral farmers adopting low-emissions practices and technology. In particular, landowners may not know about or understand how to put in place alternative land uses, may be uncertain about the hidden costs of change, or may face skill barriers and biases in training arrangements and financial support (Morgan Foundation, sub. 127). The lack of supply chains and processing and distribution arrangements may also hinder land-use change in particular locations.

Andy Reisinger (sub. 28) notes that while on paper opportunities to move into horticulture seem profitable, a better understanding of these barriers and how they may vary by region is needed.

[W]ithout a clearer long-term horizon point, the status quo with its aligned institutions and support mechanisms will be difficult to change. A targeted and objective analysis is necessary to better understand whether the status quo simply reflects the most economically viable form of land-use in most of New Zealand, or whether it largely reflects social and institutional lock-in that prevents genuine opportunities from being realised. (sub. 28, pp. 3–4)

Even so, the land devoted to horticulture and the value of horticultural production and exports (particularly fruit and wine) have been steadily increasing over the last decade or more, and are projected to continue to do so (Clothier et al., 2017; Horticulture New Zealand, sub. 41).¹⁰⁶ Ample land is available that is biophysically suitable for horticulture, though economic suitability would depend on a combination of commodity prices, water resources, human capacity and infrastructure (Clothier et al., 2017).

Dairy industry regulation

Sections 73 and 74 of the Dairy Industry Restructuring Act (DIRA) oblige Fonterra to accept applications to become new shareholders and to accept milk supplied by shareholders (subject to some conditions and exceptions). Fonterra generally collects milk at no cost regardless of location. These obligations are designed to limit the ability of Fonterra to exercise market power, by reducing the risk to farmers of switching to an independent milk processor. Yet the obligation could have the effect of encouraging inefficient suppliers of milk (who are also likely to be more emissions intensive than other farmers). It could also have the effect of causing Fonterra to expand its processing capacity and therefore, possibly, to install new coal boilers in particular locations (Chapter 13).

On the recommendation of the Commerce Commission, the previous Government introduced a bill in 2017 amending the DIRA by giving Fonterra a discretion to reject applications where entry could have “perverse outcomes in encouraging inefficient land use changes to dairying”. A particular concern was the conversion of environmentally sensitive land to dairying. The new Government has instead indicated an intention to review the DIRA, including its effects on land use and the environment (O'Connor, 2018). Chapter 13 asks whether a net benefit would result from giving Fonterra a discretion to refuse milk supply where this could encourage inefficient land use and unduly increase greenhouse emissions (both from inefficient land use and from milk processing).

¹⁰⁶ Horticulture New Zealand (sub. 41) notes that the subsector that uses greenhouses is vulnerable to the emissions price on fossil fuels, as such fuels represent their largest cost after labour. Fuel costs are particularly high for greenhouses in the South Island. The availability, or not, of alternative fuels for industrial energy is discussed in Chapter 13.

Accelerating afforestation

Rapidly planting forests is a key part of a transition to a low-emissions economy (section 10.1). A revamped NZ ETS will take time to put in place and to earn the confidence of investors. In the meantime, the new Government has announced a target of planting one billion trees over the next 10 years, partly as a regional development initiative and partly to accelerate carbon sequestration (Z. Wilson, 2017). It has decided to use Crown Forestry to develop opportunities for the planting of forests. Crown Forestry is looking to lease land suitable for harvest, or to enter into joint ventures with owners. Owners may be eligible to receive NZUs for the carbon sequestered on their land.

Crown Forestry, a commercial trading entity and a functional unit within MPI, manages the Crown Forest Estate. In 2017 this covered 16 forests with a total area of 14 300 hectares, mostly on Māori-owned land; six afforestation leases on Crown forest land; and three forestry loans to the Dunedin City Council (MPI, 2017c). Forest management companies undertake the day-to-day management of Crown Forests. The previous policy was for Crown Forestry to exit from commercial forestry by selling assets on commercial terms. This included selling forest assets to Māori owners of the land on which the forests are situated. In addition, Crown-owned land (and sometimes trees) can be transferred as part of Treaty settlements (MPI, 2017c).

MPI expects that around 500 000 hectares of existing plantation forest will be replanted over the next ten years, though this will have no effect on New Zealand's emissions accounts (pers. comm, 22 December 2018). At a typical planting rate for *pinus radiata* of 1 000 stems a hectare (Farm Forestry New Zealand, 2005), this would fulfil half of the Government's planting target. The remainder would require planting an extra 50 000 hectares each year (around the rates achieved during the 1990s).

The potential for the Government to lease substantial areas of land on commercial terms for afforestation (or to enter into joint ventures with landowners) has yet to be demonstrated. Pending revision to the NZ ETS and its provisions for afforestation, the Government may need to consider an expansion of its current afforestation subsidy programmes (section 10.7). This could be roughly fiscally neutral, by setting the subsidy level to match the emissions credits kept by Government for a defined period. The programmes have the advantage to smaller foresters of reducing the emissions price risk and administrative costs, and smoothing cashflows.

In 2015 forest of more than 1 000 hectares accounted for over 60% of forests registered in the NZ ETS. Overseas investors are potential sources of capital to fund afforestation at scale (CCILG, 2016). The Commission understands that a number of large investors in Australia and North America are willing and ready to undertake such investments. Purchase of land for forestry by overseas investors is subject to the Overseas Investment Act 2005. The Government is seeking to make the sale of forestry rights also subject to the Act, while at the same time streamlining and liberalising the application process to give overseas investors more certainty (The Treasury, 2018).

10.11 A fair and prosperous transition to a low-emissions rural economy

Over the three decades to 2050, the New Zealand rural sector must make a substantial transformation through a combination of land-use change and adopting new technologies to lower agricultural emissions. Tauranga Carbon Reduction Group noted "[a] major barrier is the economic benefits, both to the nation and individual farmers of our unique farming systems. We should not underestimate the huge social and financial costs of any major change to established farm systems" (sub. 77, p. 3). Other submitters foresaw that large-scale afforestation could have (possibly adverse) impacts on the population and prosperity of local rural communities (Federated Farmers, sub. 39; Beef + Lamb New Zealand and DINZ, sub. 98).

Yet the required transition is, in some aspects, comparable in scale to the changes that the rural sector has experienced over the last 30 years and in other periods in its more distant past (section 10.2). With sensible and supportive government policies and a successful rural-urban conversation, the pace, direction and nature of land-use change between 2020 and 2050 can be managed without undue economic or social disruption. The transition should embrace Māori and Pākehā values and attachment to the land, and a wider focus on environmental outcomes, and thereby promote rural wellbeing across the country.

One key to a measured and prosperous transition is the provision of free allowances to agricultural emitters (whether at the farm or processor level) (section 10.7). Allowances should be phased out over time in a predictable way that is consistent with meeting emissions reductions targets and at a pace that gives landowners and processors time to adjust. The effects of a rising emissions price will be factored into land values and should make horticulture and forestry relatively more profitable than agriculture over time. Te Rūnanga o Ngāi Tahu valued policy certainty and time for adjustment:

A ten or twenty year timeframe for certain change is the kind of window that should enable any business or household to make necessary adjustments without radical economic shocks. (sub. 83, p. 12)

Some regions will face larger adjustments than others. Pastoral farming is concentrated in regions such as Southland, West Coast and Waikato, where it currently contributes more than 10% of regional GDP. These are regions falling within the tribal boundaries of two of the longest-settled and best-resourced iwi, Ngāi Tahu and Waikato Tainui (Te Rūnanga o Ngāi Tahu, pers. comm., 22 March, 2018). Building coalitions including primary sector industry and environmental organisations, local government and iwi will help identify and put in place strategies to support adjustment (Te Rūnanga o Ngāi Tahu, sub. 83).

Even during a measured transition, particular rural households and businesses may be vulnerable to adverse changes in business activity, because of high levels of business and household debt or low income and capital. Existing income support policies will help ease these effects (see Chapter 9).

Opportunities in the transition to a low-emissions rural economy

Developing a low-emissions rural economy offers opportunities for New Zealand. For instance, “low-emissions” and “environmentally-friendly” branding of primary produce may afford growing market advantages in a carbon-constrained world (Waikato Regional Council, sub. 48).

New Zealand can also enhance its international reputation by being at the forefront of developing and disseminating technologies and practices to reduce agricultural emissions (Box 10.9). By taking a leading role in this work, New Zealand will have more influence in international climate change mitigation and adaptation forums. Some new technologies, such as a methane vaccine, may also yield a potentially large commercial benefit, given the global scale of the potential emissions reductions (section 10.10).

Box 10.9 Leveraging New Zealand’s lead in reducing agricultural emissions

New Zealand could make a much larger contribution to reducing global agricultural emissions reductions than it can achieve in domestic reductions alone. The emissions intensity of agriculture in New Zealand is much lower than the emissions intensity of many large, but inefficient, global producers. As a world-leading, highly productive producer, New Zealand possesses technical expertise that could assist other countries to reduce their emissions intensity through large efficiency gains. The successful development of mitigation technologies in New Zealand will also benefit agricultural producers globally.

New Zealand already promotes lower global agricultural emissions through the Global Research Alliance on Agricultural Greenhouse Gases (GRA) (section 10.10). Funding helps to build agricultural capability globally as well as to support research on mitigation. Under the GRA, New Zealand co-funds the Global Partnerships in Livestock Emissions Research, which provides funding for collaborative mitigation projects between New Zealand and international researchers. Through the Ministry of Foreign Affairs and Trade’s Aid Programme, New Zealand also assists agricultural producers in several developing regions to become more competitive and productive (in 2013/14, funding equalled about \$40 million).

New Zealand, by helping other countries to achieve reductions in agricultural emissions beyond business as usual, could gain credits to meet its international climate change mitigation commitments. This would likely involve setting up co-operative arrangements with individual countries or regions, to exclude double counting of emissions reductions. The Government is currently investigating potential mechanisms for obtaining international credits.

In 2017, the Government also joined the Koronivia Joint Work on Agriculture under the auspices of the United Nations Framework Convention on Climate Change. The agreement aims to develop and implement new strategies for adaptation and mitigation in the agriculture sector globally. It has a focus on improving soil health and fertility, improved nutrient use and livestock management systems, while attending to socio-economic and food security dimensions of climate change in the agricultural sector.

Source: MPI (2017a); GRA (n.d.); COP23 Fiji (2017); UNFCCC (2017).

Other potential challenges face the rural economy, but also provide opportunities for change consistent with a transition to a low-emissions economy. For instance, climate change itself (at least in the ranges envisaged by the Paris Agreement) may not require large changes in primary production in New Zealand, but could require regional shifts in the production of particular crops. The need to switch to other crops would provide an opportunity to consider alternative low-emissions land uses (Box 10.10).

Box 10.10 **How will climate change affect agriculture and forestry in New Zealand?**

Future climate change caused by global warming might make some current uses of land unsustainable or uneconomic. For instance, changes in rainfall patterns and in mean temperature could change the relative profitability and suitability for particular commodities of some land use (MfE & Stats NZ, 2017b; NZAGRC, 2012). Effects of climate change, including the incidence of drought, will vary across countries, with impacts on trade. Increased frequency of severe storms could make some land more prone to erosion or make some tree species more suitable for planting than others.

Climate-change effects on agriculture in New Zealand could be both direct (through productivity) and indirect, through world prices. Stroombergen (2010) modelled both for the period up to 2070, using the Intergovernmental Panel on Climate Change's projections of global temperatures rising above 3% by 2100, combined with estimates from international studies of effects on commodity prices.

Stroombergen first balanced the effects on production in New Zealand of longer and more frequent droughts, against effects from improved growing rates as a result of higher concentration of CO₂ in the atmosphere ("carbon fertilisation"). Stroombergen found drought alone was likely to benefit New Zealand relative to other producing countries, through higher world agricultural commodity prices (see also NZAGRC (2012)). Yet carbon fertilisation (which affects world producers equally) could reduce or even overturn New Zealand's advantage. The model inevitably does not include many real-world complexities, such as increasing world demand for food, and for biomass for energy; changing tastes; increased conversion of agricultural land to forestry in competitor countries; and increased frequency of severe storms.

The effect of climate change on forests in New Zealand is also uncertain. Generally higher mean temperatures are likely to favour some species relative to others (Rangitikei District Council, sub. 35) and, together with carbon fertilisation, increase growing rates (Watt et al., 2008, Scion Research, sub. 67). Higher mean temperatures are likely to affect the prevalence of plant, insect, and other biotic pests, though the severity is uncertain. Forests in some regions of the country, and on some terrain, are likely to be vulnerable to a higher incidence of extreme wind events.

International measures to mitigate climate change could also affect agricultural commodity prices for New Zealand. The effects will depend on New Zealand's emissions pricing policy relative to other competitors, and on how climate change mitigation is taken into account in trade policies (Stroombergen, 2010; NZAGRC, 2012; Chapter 4).

Climate change over the next 30 years and beyond will likely not dramatically change the viability of agriculture and forestry in New Zealand. Yet regional shifts in suitable growing conditions will likely put

a value on crop diversification that (at the same time) reduces emissions. Shifts in rainfall patterns may also make irrigation more important for horticulture and dairy in some regions.

The emergence of synthetic, low-emissions and low-environmental-footprint alternatives to meat and milk poses another challenge to current patterns of agricultural production in New Zealand (Box 10.11). Industry leaders already see this as a signal to search for higher-value niche products so that they can continue to find a place in global consumer markets. Given its strengths in food technology and food production, New Zealand may even be able to find a place in global value chains for synthetic protein, although it has no comparative advantage in producing or marketing these products at this stage.

Box 10.11 **Alternative protein products – an opportunity or a threat?**

New Zealand farms face a growing threat from emerging plant-based and lab-grown alternatives to milk and meat products. These could massively disrupt traditional agricultural markets and New Zealand's part in them.

Alternative protein products are typically developed in biotech laboratories and factories rather than farms, using plant proteins such as soy and split peas, or animal cells. Producing alternative protein products has a substantially smaller environmental impact and is more resource efficient compared to traditional farming (Bosworth, 2015). One producer found that synthetic beef produces 87% fewer GHG emissions, and uses 95% less land and 74% less water, compared to traditional beef produced in the US (Impossible Foods, 2017).

Investment in these technologies has accelerated in recent years and the products are falling in price (RSNZ, 2016). Bosworth (2015) expects synthetic technologies to soon become cost competitive with traditional agricultural products, and eventually outcompete in cost. Consumer responses will depend on price, acceptability of the technology and its environmental effects, and taste. The views about the prospects of alternative protein products to cause disruptive change for New Zealand firms vary widely (Beeby, 2017; Bosworth, 2017; Mcbeth, 2017). In a recent speech, Sir Peter Gluckman, the Prime Minister's Chief Science Advisor commented:

The environmental numbers associated with these technologies are such that it will have a major impact, perhaps not in the next five years, but in the next 10 to 15 years, particularly if the impact of climate change continues to grow and the world becomes more conscious of the need for everybody to be responding to it. (Reported in Grieveson, 2017)

New Zealand's agricultural sector has experienced the impacts of disruptive technologies before. In the early 1980s, New Zealand's wool industry contributed approximately 18% of New Zealand's total exports – over half of wool was used for carpets (RBNZ, 1982). However, the development of technology for producing lower-cost carpets from synthetic fibres was contributing to a steady reduction in global wool demand (Conforte et al., 2011). Between 1960 and 2013, production of synthetic fibres as a proportion of global fibre production increased from 10% to 70%. The share of wool production fell from 10% to 1.4% over the same period (ANZ, 2013). Since 1990, New Zealand's wool production has halved (Beef + Lamb New Zealand, 2017).

Steven Carden (2018), the Chief Executive of Pāmu Farms of New Zealand, believes that New Zealand could use its reputation as a producer of agricultural products, to compete in a remaining niche market for traditional agricultural products.

New Zealand's pastoral sector will only survive if our animal products are niche and premium. To achieve that our farms need to produce food that is different – and different in a way that's better for consumers. And not just because it's from New Zealand. But because it has scientifically-verified advantages that consumers trust. So they'll pay more for it. Our investments in new

businesses and products like sheep dairy and deer dairy products are examples we think have a future.

...our reality is that we will need fewer animals on our land in the future and more plants. We will need to shift our land uses from farming animals to more forestry and plant products. And to avoid replacing the production of an animal commodity for a plant commodity, our land uses must focus on producing unique plant cultivars that have particular functional health benefits.

Essentially Carden is asking his industry to turn the threat from synthetic proteins into an opportunity, drawing on existing strengths.

10.12 Conclusion

Biological emissions from land use make up almost half of all New Zealand's GHG emissions; while growing forests currently offset about 30% of those emissions. Any plausible transition to a low-emissions economy over the next 30 years requires a large shift (in the order of 1.3 to 2.8 million hectares) in land use – primarily from marginal sheep and beef farming to forestry. While this is, overall, similar to the change in rural land use that has occurred over the last 30 years, the required rate of forest planting that needs to be sustained will be challenging.

Opportunities to reduce agricultural emissions, particularly from dairying, will also be important. Even with current practices and technologies, modest reductions can be achieved without reducing overall agricultural output. The potential reductions from a breakthrough technology, such as a methane vaccine, are large, though research success is highly uncertain.

An emissions price that covers all land use, including agriculture, should be the main driver of change. A well-designed and stable NZ ETS will incentivise more afforestation as well as a search for, and adoption of, low-emissions practices and technologies in agriculture. The Government can best support the rural transition through ensuring emissions pricing policy is stable, and a measured phase-out of free allowances for agricultural producers.

Policies that address barriers to change will also support the effects of an emissions price and reduce its stringency. These policies include a search for new emissions-reduction technologies, developing the acquisition of the knowledge and skills needed in new land uses, and reducing regulatory barriers to change. The Government has a role in working with farmers, industry organisations, iwi, local government and research institutes in developing a range of initiatives.

A transition to a low-emissions economy offers opportunities as well as challenges. Climate change itself may require shifts in the regional pattern of crop production – making it opportune to move to low-emissions uses. New Zealand is a leader in the search for low-emissions agricultural practices and technology. As such, this search can enhance New Zealand's mana in international forums, and could offer commercial returns. Synthetic meat and milk and plant-based proteins are a significant challenge to New Zealand's traditional agricultural production models. Yet the challenge is a stimulus to look for new high-value opportunities in the production of niche foods, which at the same time can lower emissions from land use.

11 Transport

Key points

- New Zealand's transport system is dominated by private road transport. Compared to other developed countries, vehicle ownership rates are high, public transport use is low, and the vehicle fleet is old with poor fuel economy. Rapid population growth and a decline in prices for fossil-fuel vehicles has caused the vehicle fleet to greatly expand.
- As a result, New Zealand's transport emissions have risen more than any other emissions source since 1990. Road vehicles were the primary driver of emissions growth and contribute the vast majority of transport emissions. While significant scope exists for reducing transport emissions, the development and uptake of transport technologies is uncertain.
- The New Zealand Emissions Trading Scheme currently plays a very limited role in reducing transport emissions, since the current emissions price is a relatively small component of fuel prices, and fuel demand is relatively unresponsive to changes in price. Even with a significant increase to the emissions price, additional measures are needed to achieve large emissions reductions.
- Adoption of electric vehicles (EVs) represents the most significant opportunity to reduce transport emissions in New Zealand. EV uptake is rising, though price remains a key barrier, as well as the limited travel range of EVs. Fast uptake will be critical to achieve a low-emissions economy. For the bulk of light vehicles to be electric by 2050, nearly all vehicles entering the fleet would need to be EVs by the early-2030s. To encourage the uptake of low-emission vehicles, the Government should introduce a price feebate scheme, lead on procurement, and continue to support the development of the charging network.
- For heavy vehicles, aviation and shipping, electrification is more challenging. Hydrogen vehicle technology is developing and could provide a useful alternative to EVs. Biofuels have the potential to deliver significant emissions reductions for these modes. Yet, commercial, technology, and coordination barriers pose challenges to the large-scale production of biofuels.
- Measures to reduce emissions from fossil-fuel vehicles are important since a transition away from these vehicles will take decades. New Zealand is one of the few developed countries without vehicle emissions standards. Introducing standards is warranted, and will reduce the risk of New Zealand becoming a dumping ground of high-emitting vehicles from overseas. The Commission also seeks feedback about how New Zealand should achieve a widespread transition away from fossil-fuel vehicles.
- While low-emission vehicles will provide the bulk of transport emissions reductions, other mitigation options can provide minor reductions and valuable co-benefits. One option is shifting modes from private road transport to public transport, cycling and walking. Another is shifting some of the freight load from road to rail and shipping, although possible reductions are limited since most freight trips are over small distances.
- Inadequate pricing of vehicle externalities (including emissions), and the land transport funding system skewing investments towards roading, stifles the potential for mode shifting and leads to excessively high vehicle travel and inefficient vehicle choices. Levelling the playing field for infrastructure investments and more cost-reflective pricing of vehicle externalities, would help to better support low-emission modes of transport. A key recommendation is to focus the Government Policy Statement (GPS) on Transport more on reducing emissions.

Transport is New Zealand's second largest source of greenhouse gas (GHG) emissions, contributing nearly 20% of gross emissions (and about one third of long-lived gas emissions). Yet, compared to other large emitting sources like agriculture and industrial heat, significant scope exists to mitigate transport emissions. For example, opportunities exist to reduce transport emissions through adopting less emissions-intensive vehicles, shifting to lower emission modes of transport, and improving the efficiency of the transport system.

Transport therefore needs to play a large part in New Zealand's overall strategy to reduce emissions. Chapter 3 concluded that the electrification of the light vehicle fleet is one of New Zealand's most important levers for reaching an ambitious emissions reduction target for 2050. Achieving a low-emissions economy therefore requires a steady transition away from fossil-fuel vehicles.

Accordingly, this chapter recommends a range of pricing and regulatory measures to reduce transport emissions. An emissions price will have some impact on emissions, but other options will need to play a part too, such as policies to incentivise the uptake of low-emission vehicles. The external costs associated with current transport use mean that reducing transport emissions can also lead to wider improvements in the health and wellbeing of New Zealanders.

This chapter:

- describes trends and the key underlying drivers of transport emissions in New Zealand (section 11.1), as well as the uncertainty surrounding the development and uptake of transport technologies (section 11.2);
- discusses the role of an emissions price in reducing transport emissions (section 11.3);
- considers the merits of different approaches for regulating fossil-fuel vehicles, including imposing vehicle emissions standards, and committing to phasing out fossil-fuel vehicles (section 11.4);
- recommends a policy package for incentivising the uptake of low-emission vehicles, in particular, electric vehicles (EVs) (section 11.5);
- investigates the role of biofuels in addressing transport emissions that are more challenging to mitigate, such as heavy vehicle emissions and aviation emissions (section 11.6);
- considers the mitigation potential and the wider societal benefits of other options, including shifting to lower-emission transport modes and improving the efficiency of the transport system (section 11.7); and
- addresses the fitness of arrangements for pricing transport services and externalities (section 11.8), and for investing in transport infrastructure, to support a low-emissions transition (section 11.9).

Box 11.1 Vehicle terms used in this chapter

This chapter frequently refers to the *light vehicle fleet* and the *heavy vehicle fleet*. Light vehicles fit into two categories – passenger and commercial. Light passenger vehicles include cars, vans, and people-movers, while light commercial vehicles include goods vans or utes, and trucks under 3 500 kg. Heavy vehicles refer to trucks and buses over 3 500 kg (eg, freight trucks, commercial buses).

The Commission also uses a working definition of *low-emission vehicles* as vehicles that produce zero, or near zero, tailpipe GHG emissions. An EV is an example of a low-emission vehicle that uses electricity from an external source to power its motor. The two main types of EVs are:

- battery EVs (also known as pure EVs) – vehicles fuelled solely by a battery that can be charged by plugging into an electric power point; and
- plug-in hybrid EVs – vehicles that have two engines: one engine is fuelled by a battery like the one used in a pure EV; the other engine is fuelled from a tank that generally uses petrol or diesel.

Fossil-fuel vehicles are both vehicles with internal combustion engines solely powered by fossil fuels and conventional hybrid vehicles. While conventional hybrids are more fuel-efficient than an average

fossil-fuel vehicle, their batteries are only charged by re-capturing energy when braking or from electricity generated by the petrol engine. As such, they produce higher emissions than plug-in hybrids.

Source: EECA (2017b); MoT (2016a).

11.1 Transport emissions in New Zealand

Transport emissions drove the increase in New Zealand's emissions

Transport emissions rose by close to 70% between 1990 and 2015. In absolute terms, transport was by far New Zealand's fastest growing emissions source over this period (MfE, 2017i).

Road transport (largely private vehicle use) is the dominant source of transport emissions, and its emissions have increased substantially over recent decades (Figure 11.1). Light vehicles accounted for about 75% of emissions from road transport in 2015 (Figure 11.2). Heavy vehicles contributed 25% of these emissions, even though they account for only 6% of total vehicle kilometres driven. Heavy vehicles were also responsible for more than 40% of the overall increase in transport emissions between 1990 and 2015 (MoT, 2016a).

Figure 11.1 Transport emissions by mode, 1990–2015

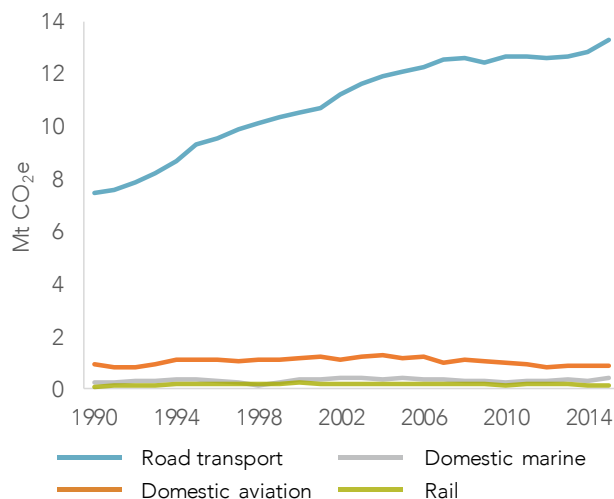
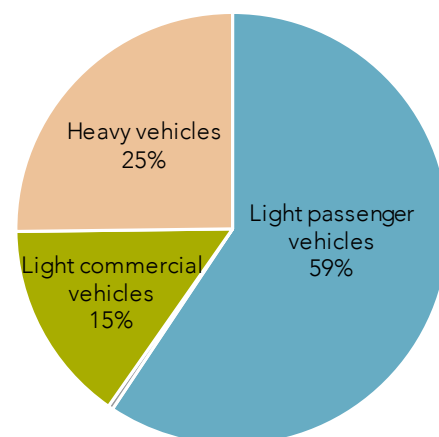


Figure 11.2 Composition of emissions from road transport, 2015



Source: MfE (2017i); MoT (2016a).

Notes:

1. Motorcycles in 2015 produced about 0.4% of road transport emissions.

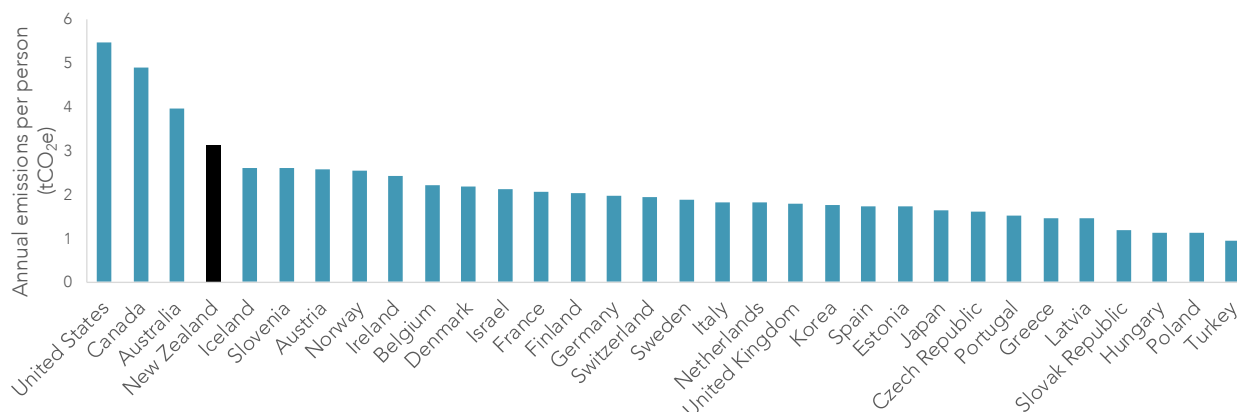
Domestic aviation emissions make up about 6% of transport emissions. These fell slightly between 1990 and 2015, due to a shift to larger aircraft, as well as improved fuel efficiency. Rail and marine emissions rose over this period, but together they make up only 4% of transport emissions.

At present, international reporting frameworks and commitments exclude emissions from international aviation and shipping. The main rationale for their exclusion is the difficulty in fairly attributing these emissions. Based on fuel supplied in New Zealand, New Zealand's international aviation and shipping emissions in 2015 were 2.8 megatonnes (Mt) of carbon dioxide equivalent (CO₂e) and 1 Mt CO₂e respectively (MBIE, 2017b). From these estimates, including international transport, emissions would increase overall transport emissions by about 25%.

New Zealand's per person transport emissions are high

New Zealand's per person transport emissions are the fifth highest among OECD countries (Figure 11.3). Nearly all transport emissions are carbon dioxide (CO₂) that arise from the consumption of fossil fuels.¹⁰⁷

Figure 11.3 Transport emissions per person, OECD countries, 2014



Source: OECD (2018a); UN DESA (2018).

Notes:

1. Luxembourg is an extreme outlier and is therefore excluded. It has high transport emissions because around three quarters of fuel sold in Luxembourg is used outside of the country's borders (Donat et al., 2014).

Private road transport dominates New Zealand's transport system

The relative size of New Zealand's per person transport emissions is partly a result of the transport system's reliance on road transport and ownership of private vehicles. New Zealand has the second highest rate of vehicle ownership among OECD countries (RSNZ, 2016). Over 80% of trips are made by car, 90% of freight tonnes are carried via road, and use of public transport in main cities is relatively low (section 11.7). Its low-density geography and widely distributed population are both important factors.

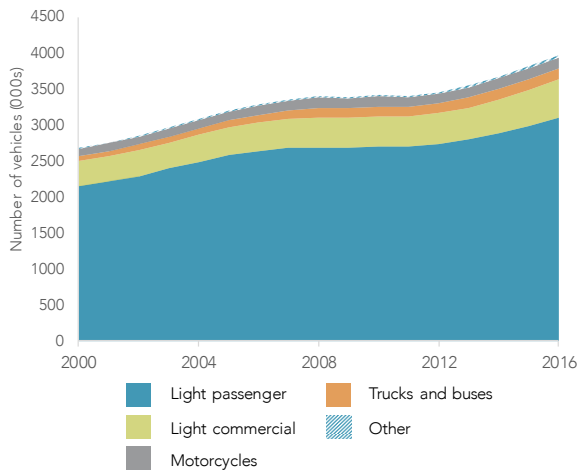
Decisions in the 1950s to focus on completing the motorway network instead of upgrading and electrifying Auckland's rail system, and to remove the tram networks, were also influential in shaping New Zealand's road-dominated system. More recently, the removal of tariffs on vehicle imports in the 1990s also played an important role in the increased use of private vehicles (through reducing the price of fossil-fuel vehicles), as did the relative low cost of fossil fuels (Transport and Industrial Relations Committee, 2017).

The vehicle fleet is growing – population is rising and people are owning more vehicles

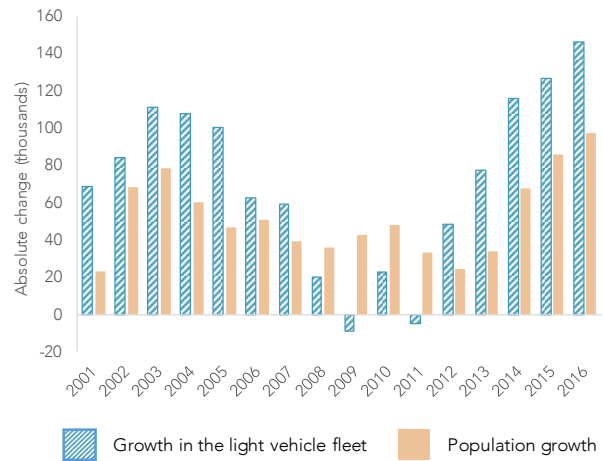
Roughly four million road vehicles are registered in New Zealand. The number of vehicles has grown by nearly 50% since 2000, with light vehicles dominating this growth (Figure 11.4). About 90% of the vehicle fleet are light vehicles. Trucks and buses make up 3.5% and 0.3% of New Zealand's total fleet respectively (MoT, 2016a).

New Zealand's growing population has been an important driver of growing transport emissions (Figure 11.5). The population grew by 36% between 1990 and 2015 (Chapter 2). A larger population has led to more people travelling and greater economic activity. The latter has required more vehicles and vehicle kilometres to transport goods and people across the country. Future population growth will provide a challenge in bringing down transport emissions.

¹⁰⁷ About 1% of transport emissions are methane and nitrous oxide emissions resulting from the use of transport fuels.

Figure 11.4 Vehicle fleet size by type, 2000–2016

Source: MoT (2016a); StatsNZ (2017b).

Figure 11.5 Growth in the light vehicle fleet and population growth, 2001–2016

New Zealand's road vehicles are comparatively old and emissions-intensive

New Zealand's vehicle fleet is old relative to comparable countries, and getting older. The average age of light vehicles in New Zealand increased from 11.8 years to 14.2 years between 2000 and 2016. This compares to Australia's average light vehicle age of 10.1 years and 11.5 years in the United States. Vehicles in New Zealand are scrapped on average after 19 years (MoT, 2016a). The slow turnover of the fleet implies that vehicles purchased in 2018 will likely stay in the fleet until well after 2030 (and potentially after 2040).

Vehicles entering New Zealand's fleet are more emissions-intensive (ie, have a poorer fuel economy) than in many other developed countries. The average vehicle entering New Zealand's light fleet in 2015 produced 181 grammes (g) of CO₂ per kilometre (km). In comparison, in Europe, cars and SUVs entering the fleet on average emit 119 g of CO_{2e} per km (and 168 g CO₂ for light commercial vehicles), and 115 g of CO₂ per km in Japan (ICCT, 2017). New Zealand is one of the few developed countries without any fuel economy standards. Its poor fuel economy also reflects a preference in New Zealand for larger, heavier vehicles, which has increased in recent years (MoT, 2017b).

Reliance on road transport has also led to significant external costs

In addition to producing GHG emissions, the use of road vehicles has led to several other costs not fully borne by the user (section 11.8). External costs from road transport include traffic congestion, air pollution from harmful exhaust gases (eg, carbon monoxide), noise pollution, and road fatalities and injuries.

11.2 Technological change and transport emissions

Due to advances in technology, transport patterns could look markedly different in a few decades time.

The transport sector is going through an unprecedented period of innovation in vehicle, infrastructure, and services. Transport could be at the forefront of a 'fourth industrial revolution' – a fusion of the physical and digital worlds that is transforming how people live and work. This is being driven by breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things..., and energy storage (MoT, 2017b, p. 20).

Already, road vehicles powered by low-emission fuels are rapidly developing and are likely to eventually replace the fossil fuel fleet. But this transition will likely be gradual given that New Zealand continues to import fossil-fuel vehicles that, based on current trends, will be retained in the fleet for decades. As such, the oil industry and those businesses with an interest in fossil-fuel vehicles will have time to adapt. How those industries respond to the rise of low-emissions vehicles is uncertain, but it will have important implications for New Zealand's transition to a low-emissions economy.

Improvements in digital technology are also enabling new business models to emerge that harness shared mobility (eg, ride sharing and vehicle sharing). The development of autonomous vehicles (AVs) has the

potential to fundamentally disrupt traditional models of transport, and transform New Zealand's transport system (Box 11.2).

Box 11.2 **The potential for autonomous vehicles to transform New Zealand's transport system**

Globally, vehicles capable of fully driving themselves are expected to be commercially available by the early 2020s (MoT, 2017b). The convergence of digital and AV technology advances could lead to a shift away from traditional individual vehicle ownership to an on-demand model of transport provided through driverless shared vehicle fleets. Z Energy (2017) predicts that this shift will happen, largely due to the potential for substantial cost savings.

Given the large proportion of time (roughly 96%) that vehicles are not used, a shift to such a model may mean fewer vehicles are needed in total to meet overall mobility needs. The use of driverless shared fleets could reduce transport costs for individuals, provide opportunities for new land uses due to reduced demand for parking (The Morgan Foundation, sub. 127), and improve road safety.

Recently, a US think tank predicted that by 2030, AVs will drive 90% of total vehicle kilometres (Arbib & Seba, 2017). MRCagney's (2017) report on the potential impact of AVs in New Zealand provides relatively more conservative predictions, suggesting that AV uptake will be small before 2040 and largely limited to commercial use (eg, taxis, deliveries). After 2040 though, they anticipate AVs will become more affordable, and be used for the bulk of private vehicle travel in cities after 2055.

The development and uptake of transport technologies is highly uncertain. For example, it is not yet known whether low-emission technologies for aviation, such as biofuels or electric engines, will emerge before 2050, or whether hydrogen-fuelled vehicles will become cost competitive with EVs. External factors, such as commodity prices and global innovation, will be pivotal in determining the pace and scale of future change. Additionally, future demand for personal travel and social attitudes towards mobility are uncertain.

It is also not clear how some changes in technology will influence emissions. For example, the impact of a large penetration of AVs on emissions would depend on the extent to which AVs are powered by low-emissions fuels. In the face of this technological uncertainty, it will be critical to effectively regulate the effects of vehicle use, to maximise the emissions reductions arising from technological change. The next two sections emphasise the importance of a strong emissions price, and other regulations for fossil-fuel vehicles, while section 11.8 looks at the current arrangements for pricing other negative externalities arising from vehicle use.

11.3 Pricing transport emissions

At current prices, the New Zealand Emissions Trading Scheme (NZ ETS) is likely to have a limited impact on transport emissions. This is primarily for two reasons: first, the emissions price is a relatively small component of fuel prices at current levels; second, fuel demand is relatively unresponsive to changes in price.

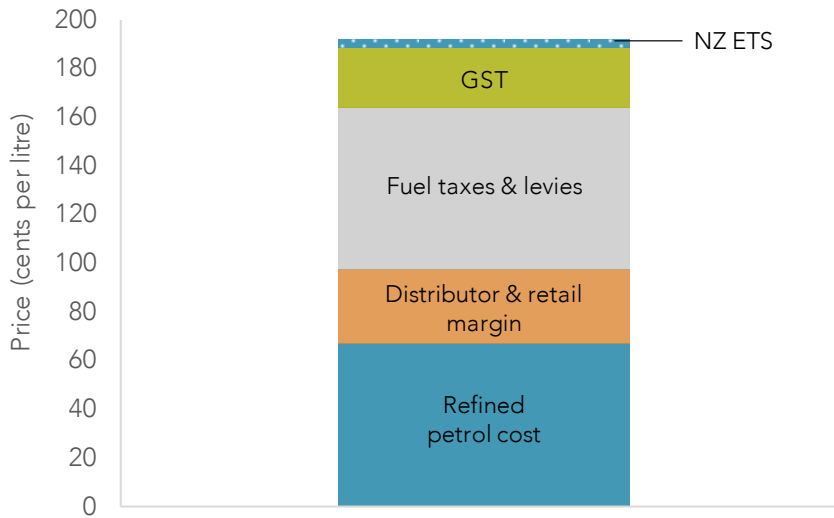
While the point of obligation for transport emissions sits with fuel importers and producers, the majority of the ETS cost is passed through to consumers. At the current New Zealand Unit (NZU) price of around \$20, the emissions component of fuel prices is just under 5 cents per litre for petrol and around 5.5 cents per litre for diesel (NZAA, 2018).¹⁰⁸ The small relative impact of the NZ ETS on fuel prices reflects the size of the emissions cost compared to the total costs of importing and distributing fuel and the total taxes on fuel (Figure 11.6).

Fuel demand tends to be highly price inelastic – in general, consumers are relatively unresponsive in the short-term to changes in fuel prices (although responsiveness will vary significantly depending on individual circumstances). The response tends to increase over time as individuals and businesses may have opportunities to choose more fuel-efficient vehicles and make other more significant adjustments to their behaviour or circumstances (eg, location choice). A 2007 study for Land Transport New Zealand estimated

¹⁰⁸ This assumes full surrender obligations.

that a 10% rise in petrol prices would reduce fuel consumption by 1.5% in the short term (within a year) and 3% in the medium term (over five years) (Kennedy & Wallis, 2007).¹⁰⁹ A 10% increase to the current petrol price would require the emissions price to rise to around \$100 per tonne.

Figure 11.6 Breakdown of the retail price of petrol, as at September 2017



Source: MBIE (2018), adapted from Scion (2018).

While this price inelasticity poses a challenge to the effectiveness of an emissions price in the transport sector, there are several reasons to believe that higher and sustained emissions prices could drive more meaningful changes.

- Evidence suggests that well-signalled taxes can elicit a significantly stronger demand response than other variations in fuel price (The Morgan Foundation, sub. 127, p. 8). Reforms to improve price certainty in the NZ ETS could lead to similar results.
- The emissions price could have a larger impact in other areas of transport, particularly aviation. Concept Consulting (2017a) estimates that a \$100 emissions price could reduce domestic air travel demand by up to 12%.
- Increased availability, and declining prices, of low-emissions vehicles (particularly EVs) would be expected to increase the responsiveness to an emissions price.
- A strong emissions price will make biofuel production more viable (section 11.5).
- Pricing emissions may have a sizeable indirect effect on transport demand. In recent modelling work, Infometrics (2017) estimates that a \$25 emissions price would reduce transport emissions by roughly 3% by 2030 (compared to no emissions price). Most of this response is an indirect effect of the emissions price raising the cost of emissions-intensive goods and services, which would reduce both household disposable income (and firm output) and fuel demand.

Even so, it seems clear that an emissions price, by itself, will not be sufficient to deliver a significant reduction in transport emissions, and complementary policies are required. While this demonstrates the relatively high value that New Zealanders place on private mobility, it does not necessarily imply that reducing transport emissions will come at a large cost. Rather, as discussed in Chapter 4, well-designed complementary measures can lower the emissions price that would otherwise be needed, and co-benefits (such as reduced air pollution) can increase the value to society of reducing emissions. Inadequate pricing of these co-benefits can work against an emissions price (section 11.8). Further, investment in quality alternative transport options, such as public transport and cycling infrastructure, should increase the responsiveness to an emissions price by improving choices available to people – particularly those on lower incomes (section

¹⁰⁹ This is a similar magnitude to earlier New Zealand and Australian studies, but significantly lower than what most studies in Europe and North America find. The Intergovernmental Panel on Climate Change (IPCC), for instance, reports a long-run impact on fuel demand of between 6% and 8% for a 10% change in price, based on an average across hundreds of studies (Somanathan et al., 2014).

11.9). Distributional policies (discussed in Chapter 9) can also help to support, and limit the impact of transport mitigation policies on, vulnerable households.

F11.1

At the current low-emissions price, the New Zealand Emissions Trading Scheme (NZ ETS) has a small effect on fuel prices, and accordingly, a small effect on consumer behaviour and transport emissions. A higher emissions price would have a greater impact. Yet, because consumers are relatively unresponsive to changes in fuel prices, additional measures will be required to achieve large emissions reductions.

11.4 Regulating vehicle emissions

As noted above, additional policies that complement a higher emissions price will be required to achieve a significant reduction in transport emissions. In the long term, one of New Zealand's most promising mitigation options is a full transition away from fossil-fuel powered vehicles. However, even with rapid development and adoption of alternative fuels, such a transition will take decades to achieve. This section examines regulatory measures to reduce emissions from vehicles entering the New Zealand fleet.

Vehicle CO₂ emissions standards

Regulated standards to improve fuel economy and reduce CO₂ emissions from light vehicles are now commonplace internationally. Coverage has increased significantly over the last decade to around 80% of the global light vehicle market today, including the United States, Canada, Japan, China and India (Yang & Bandivadekar, 2017). Differing in design detail, these regulations all require manufacturers to meet an overall average fuel economy or CO₂ emissions level, weighted across new vehicle sales within the country or region where the standard applies. New Zealand, Australia and Russia are currently the only developed countries without such standards.¹¹⁰ Australia is in the process of developing one (Commonwealth of Australia, 2016).

Many submitters,¹¹¹ including the Ministry of Transport (MoT, sub. 4), suggested or recommended introducing a vehicle CO₂ emissions standard in New Zealand.

Our vehicle fleet could be rapidly improved through raising fuel efficiency standards. NZ needs to set stringent emissions standards and tackle the issue of the impact of doing so on low-income vehicle owners – potentially by providing relief. (Guardians of NZ Superannuation, sub. 32, p. 11)

Changes in technology will see an increasing proportion of the vehicle fleet powered by electricity over the coming years. Nevertheless, Council recognises that a substantial proportion of the fleet will continue to be powered by fossil fuels for years to come. As such, we consider that vehicle emissions standards that require improved performance over time would be a useful tool in this transition. (Waikato Regional Council, sub. 48, p. 7).

Several countries have also implemented CO₂ emissions standards for heavy vehicles (Miller et al., 2017). Compared with light vehicles, the heavy vehicle market is significantly more complex, and standards in other jurisdictions are less mature. This section focuses on standards for light vehicles, which would be more straightforward to implement and capture around three-quarters of total road transport emissions (Figure 11.2). However, the Commission is interested in views on the potential role for standards and other policies to drive uptake of low-emissions heavy vehicles (question 11.2 in section 11.5).

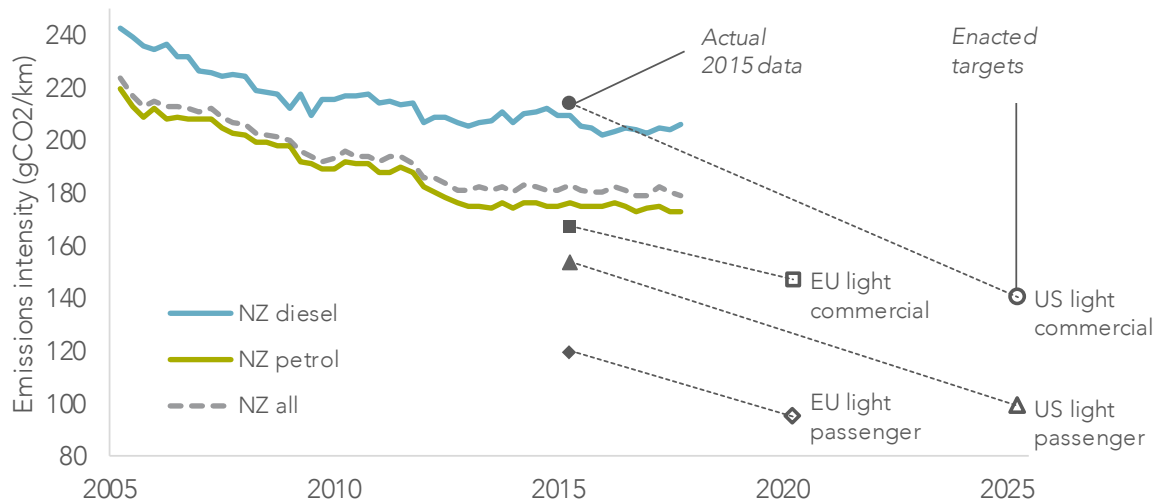
New Zealand's light vehicle fleet is more emissions-intensive compared to most developed countries (section 11.1), and evidence indicates that relative performance is worsening. The average fuel economy of vehicles entering the New Zealand fleet steadily improved from 2005 to 2013 but has plateaued since (Figure 11.7). Other countries have continued to improve fuel economy since 2013, though at a slower rate than in preceding years (European Environment Agency, 2017; IEA, 2017b; US EPA, 2018c). New Zealand's worsening performance reflects two key factors.

¹¹⁰ The *Land Transport Rule: Vehicle Exhaust Emissions 2007* sets minimum standards for emissions of substances directly harmful to human health: carbon monoxide, particulates, nitrogen oxides and hydrocarbons. It does not regulate CO₂ emissions (Barton & Schütte, 2015).

¹¹¹ Submissions 4, 9, 29, 32, 39, 43, 48, 70, 77, 78, 97, 102, 105, 121, 127, and 131.

4. Although efficiency is generally improving within vehicle weight classes as manufacturers introduce fuel-saving technologies, New Zealanders are increasingly choosing to purchase larger, heavier vehicles (MoT, 2017b).
5. Manufacturers are likely opting to provide less efficient model variants into the New Zealand vehicle market than to markets where standards apply. Australian research finds that the most efficient variants¹¹² of top-selling passenger vehicle models sold in Australia were about 27% worse on average than the most efficient model variants offered in the United Kingdom (Commonwealth of Australia, 2016). Similar results are likely to apply in New Zealand.

Figure 11.7 Average emissions intensity of vehicles entering the New Zealand fleet, compared with EU and US emissions standards



Source: ICCT (2017); MoT (2016a); US EPA (2018c).

Notes:

1. Values are calculated from laboratory test measurements normalised to the New European Driving Cycle.
2. In the United States, SUVs are included in the light commercial category rather than the light passenger category.
3. New Zealand vehicle emissions data is only available by fuel type, but most light commercial vehicles are diesel-powered and most light passenger vehicles are petrol-powered.

F11.2

Light vehicles entering New Zealand's fleet emit significantly more CO₂ than in most developed countries, and efficiency improvements have stalled since 2013. Evidence suggests vehicle manufacturers are opting to provide less efficient variants of vehicle models to the New Zealand market compared to markets where CO₂ emissions standards apply.

Standards address barriers to uptake of lower-emissions vehicles

Other governments have implemented CO₂ emissions standards to unlock cost-effective gains in fuel efficiency faster than market forces would be expected to deliver on their own. Even with much higher emissions prices, development and uptake of lower-emissions vehicles will very likely occur more slowly than optimal from a societal perspective, due to a misalignment between private and social valuation methods in vehicle purchases. Evidence suggests that buyers behave as if they heavily discount future fuel savings, and that uncertainty around future fuel (and emissions) prices may play a role in this (Commonwealth of Australia, 2016). While this may reflect rational decision-making from the individual perspective, such heavy discounting will lead to poor outcomes for society.

¹¹² Variants are vehicles of the same model (eg, Toyota Corolla). In some cases, the most efficient variants available in different markets differ in specification (eg, transmission type and engine size).

The New Zealand Government introduced mandatory fuel economy labelling in 2007 to increase the information available to vehicle buyers. However, buyers can only act on the choices available to them, and are very unlikely to be aware of more efficient model variants unavailable in the New Zealand market.

The majority of new vehicle purchases in New Zealand are by companies rather than individuals (Scott et al., 2012). While commercial fleet managers may be better informed and better equipped to evaluate options, heavy discounting of fuel savings is still likely to occur. For example, many businesses may only retain a vehicle for around three years before reselling it, and will likely require a corresponding short payback period on a more efficient vehicle. This ‘split incentive’ can limit uptake of more efficient vehicles that would deliver overall financial benefits to motorists but not to the first owner (Climate Change Authority, 2014).

Given New Zealand primarily imports vehicles from countries with standards in place, one could question whether it is necessary to adopt a similar standard here. However, as these standards operate as a sales-weighted average in the domestic market, they do not cover vehicles exported into other markets. The Australian research cited above indicates that New Zealand is not fully benefiting from standards in other countries. Manufacturers will choose to offer a selection of vehicles to the New Zealand market that will maximise their profit, and that will likely mean selecting less efficient vehicles from their global portfolio.

The case for standards is strengthened by the fact that vehicles imported today will continue to influence New Zealand’s emissions for decades. Assuming little change in vehicle ownership and patterns of use, the average new petrol or diesel light vehicle will stay in the fleet for around 20 years and lock in significant emissions over its lifetime. While EV market share is fast increasing, the number of fossil-fuel vehicles entering the New Zealand fleet has grown by a far greater amount in recent years. From 2015 to 2016, annual EV registrations increased by about 1 000, while total light vehicle registrations increased by over 20 000 (MoT, 2016a, 2018).

Several submitters described the risk of New Zealand becoming a “dumping ground” for high-emitting vehicles (Guardians of NZ Superannuation, sub. 32; Vector, sub. 63; the Morgan Foundation, sub. 127). A specific risk is that, as other countries move to implement bans or other policies to phase out fossil-fuel vehicles, the absence of emissions regulations could lead to New Zealand being targeted as a market for offloading fossil-fuel vehicles during the transition.

F11.3

Vehicle CO₂ emissions standards are warranted because buyers tend to discount future fuel savings at a much higher rate than is socially optimal. Domestic standards could also mitigate risks around “dumping” of high-emissions vehicles in New Zealand due to stringent standards and regulations adopted in other regions.

Fleet average standards provide flexibility and preserve choice

Countries that have introduced emissions standards have used *fleet average standards* (Figure 11.8). These operate very differently to minimum performance standards, such as those used to regulate energy efficiency in appliances.

1. The country sets a series of national average targets for the fuel economy or emissions rate (eg, in grams of CO₂ per kilometre) of vehicles entering the fleet.
2. The national average target is used to define a “limit curve”, which effectively sets different target emissions rates for different vehicles depending on their size (either weight or area footprint).¹¹³ For example, a weight-based limit curve might set a target of 100 g of CO₂ per km for a 1 500 kg vehicle and 130 g of CO₂ per km for a 2 000 kg vehicle.
3. Vehicle suppliers must ensure that the vehicles they sell are *on average* below the limit curve for a given year, weighted across all sales. They can still sell individual vehicles that are above the limit curve, so long as this is balanced by selling other vehicles below the limit curve (for example, a

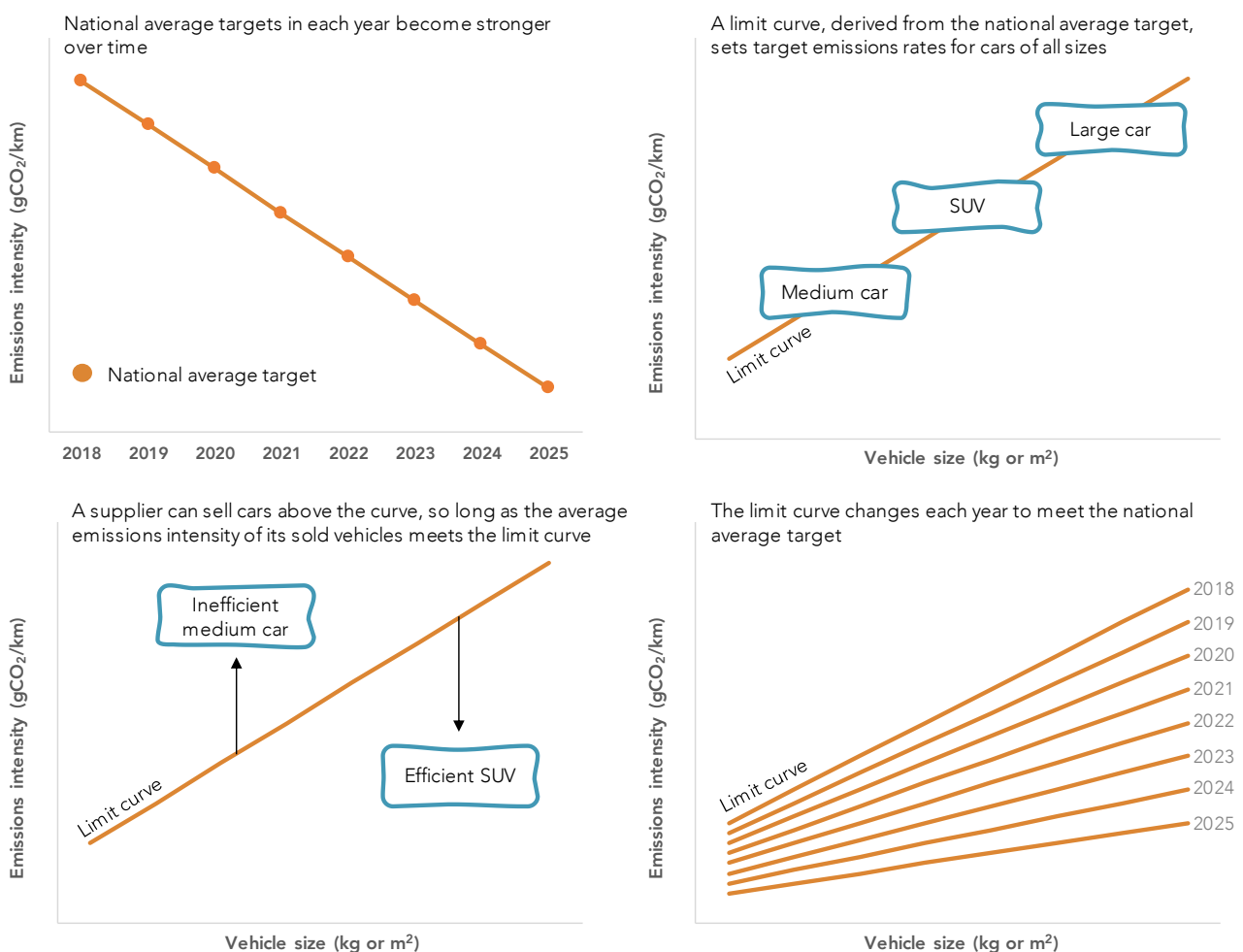
¹¹³ The Commission understands that Australia is likely to implement a weight-adjusted average standard harmonised with the European Union.

supplier that sells inefficient smaller cars could meet the standard by also selling efficient larger cars). Failure to meet the standard will attract a fee based on how far it is exceeded.

- The limit curve is adjusted downward each year in line with increasingly stringent national average targets.

This design aims to drive efficiency improvements across the full range of vehicles on offer, rather than to influence the mix of vehicles (classified by size) being purchased. Suppliers have a high degree of flexibility around how they meet the standard – for example, they could choose to improve the efficiency across their whole vehicle range, or to increase their sales of very low-emissions vehicles, such as EVs. Further flexibility can be provided by allowing for some banking or borrowing across years (ie, a supplier can compensate for underachieving the standard in one year by overachieving in the next year), and allowing suppliers to group together in a pool. In theory, it would be more efficient to allow for some form of permit trading between suppliers rather than requiring them to all meet a target individually. However, this would increase complexity and administrative costs.

Figure 11.8 How a fleet average emissions standard works



Source: Adapted from Climate Change Authority (2014).

Standards could deliver significant emissions reductions with net economic benefits

The Australian Government has modelled the impact of a light vehicle CO₂ emissions standard at different target levels (Commonwealth of Australia, 2016). The modelling found net economic benefits under all targets considered, primarily because fuel savings outweigh expected increases in vehicle costs. The strongest target delivered the largest net benefit, with a similar benefit–cost ratio to the weaker targets. As an emissions reduction policy, this translated to a negative “abatement cost” with a net saving of A\$48.7 per tonne of CO₂ avoided.

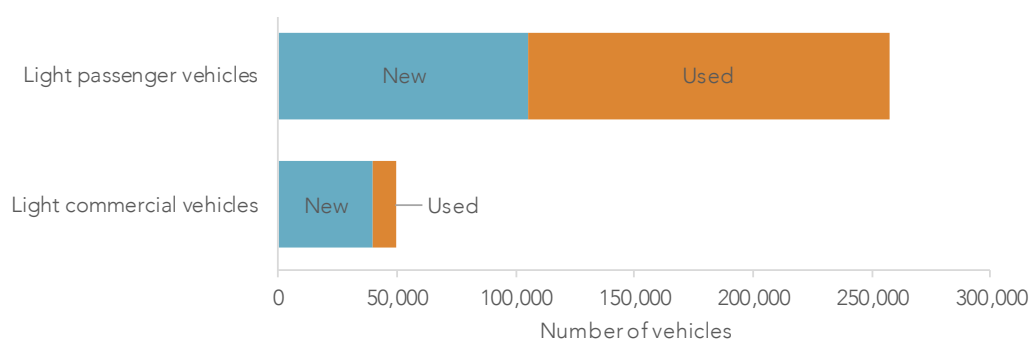
The current emissions intensity of New Zealand’s light vehicle fleet is very similar to Australia’s, so it is likely that similar results could be expected. However, a slower vehicle turnover rate would suggest a slower rate of emissions reductions. Further, as discussed below, characteristics of New Zealand’s vehicle market imply more complexity and higher administrative costs.

Designing a standard for light vehicles in New Zealand

Based on the arguments and research above, a strong case exists for the introduction of emissions standards for light vehicles in New Zealand. Yet further research is required to determine precise design-details that suit the New Zealand context.

New Zealand’s vehicle market has very different characteristics to other developed countries. Over half of the light vehicles entering the fleet are used imports (Figure 11.9). By comparison, used imports are estimated to account for less than 3% of vehicle sales in Australia (Climate Change Authority, 2014). Relatedly, New Zealand has a large number of small importers dealing mainly in used imports. These characteristics pose challenges to the implementation of an emissions standard.

Figure 11.9 Vehicles entering New Zealand’s light vehicle fleet in 2016



Source: MoT (2016a)

Two important design questions for New Zealand include whether a standard should cover used vehicle imports, and whether it should cover vehicle importers of all sizes.

The fact that used imports account for over half of all light vehicle purchases would suggest it is imperative for these to be included under a standard. Further, the “dumping ground” risks discussed above apply most strongly to the used vehicle market. However, no other CO₂ emissions standards currently apply to used imports (Climate Change Authority, 2014), so for New Zealand to do this would be novel.

The question of whether to cover vehicle importers of all sizes is particularly relevant when it comes to the highly fragmented used vehicle market. Provisional work by MoT indicates that over 400 traders imported between four and 20 used vehicles in 2017 (pers. com., MoT, 20 March 2018). For these small traders, compliance with a standard could involve significant administrative costs, and many may struggle to meet it due to their small, niche nature. This would likely result in some market consolidation. The net benefits of a comprehensive, well-functioning standard may outweigh the costs of including small traders. If not, this problem could be addressed through a liability threshold, as is common for standards in other countries.¹¹⁴

Introducing vehicle emissions standards is likely to raise average vehicle prices over time. Yet, the increase would be gradual, given that the standards only affect vehicles entering the fleet and most vehicles stay in the fleet for close to two decades. Even so, the effect of any price increase would be felt particularly strongly among low-income households (Chapter 9). The Government should monitor the impact of emission standards on vehicle prices over time.

¹¹⁴ The Australian Government suggested a potential threshold of 100 annual sales based on Australia’s market size relative to the European Union (Commonwealth of Australia, 2016).

R11.1

The Government should introduce CO₂ emissions standards for light vehicles entering the New Zealand fleet, subject to detailed consideration of design options (for example, including or excluding small traders).

Should New Zealand explicitly aim to phase out fossil-fuel vehicle imports?

A further option for New Zealand in signalling a transition to a low-emissions transport system is to explicitly commit to phasing out importing of fossil-fuel vehicles by some specified future date. Several submitters supported this policy (Christchurch City Council, sub. 13; Rick Blazeley, sub. 12; Graham Townsend, sub. 15). Other countries have made commitments of this sort, with target years ranging from 2040 to as soon as 2025.

- Norway has set a goal, through parliament, for all new cars to be low emissions (ie, battery EV, plug-in hybrid EV or hydrogen) by 2025 (Norsk Elbilforening, 2018).
- The United Kingdom has committed to ban the sales of petrol and diesel cars (excluding plug-in hybrids) by 2040 (MacLellan & Faulconbridge, 2017).
- France has signalled a ban on the sale of petrol and diesel cars by 2040, without specifying whether any form of hybrid vehicles will be permitted (M. Ewing, 2017).

Table 11.1 sets out some of the key reasons for and against making a commitment to phase out the importing of (both new and used) fossil vehicles in New Zealand. The Commission is interested in views on whether New Zealand should pursue this policy.

Table 11.1 Reasons for and against explicitly aiming to phase out fossil-fuel vehicles

For	Against
As other major countries phase out the sale of fossil-fuel vehicles, a real risk is that New Zealand will inherit their leftover fossil-fuel vehicles if an explicit policy of phasing out fossil-fuel vehicles is not pursued.	There is significant uncertainty around the development and costs of low-emission vehicles in the future, especially for heavy vehicles. Therefore, a specific target may end up being unrealistic.
It could send a strong signal to the public about future policy direction, discourage investment in fossil-fuel vehicles and improve awareness of low-emission vehicles.	A long-term target year for phasing out fossil-fuel vehicles may be perceived as lacking credibility and have little effect on behaviour change.
It could help to attract low-emission vehicles suppliers to import to New Zealand, increasing the stock of vehicles available.	Continued reduction in the price of low-emission vehicles could mean that fossil-fuel vehicles will phase out without the need for an explicit target.
It could help to make the public more aware of the reality and urgency of a low-emissions transition, and foster broader support for action.	Eliminating the option to purchase fossil-fuel vehicles could, depending on future vehicle and commodity prices, increase vehicle costs. This would be felt most heavily by low-income households as they tend to spend a greater share of income on transport (Chapter 9).
It could enhance the credibility of New Zealand's mitigation efforts internationally.	Failing to achieve New Zealand's phase-out commitment could hurt its credibility.
Successfully phasing out fossil-fuel vehicle imports would go a long way to helping New Zealand meet its long-term emissions-reduction goals.	

One consideration in deciding whether to set a target to phase out fossil-fuel vehicles is how to treat low-emissions vehicles that still rely on some fossil fuels, such as plug-in hybrids or conventional hybrids. A decision would also be needed about how to treat alternative low-emission fuels that can be used to power internal combustion engine vehicles. Biofuels are currently blended with petrol and diesel in relatively low

volumes. However future advances may result in the development of biofuels that can be blended at much higher ratios, or substitute completely for petrol or diesel (section 11.6).

A further consideration is whether to include heavy vehicles as part of any target, given that a limited number of low-emissions alternatives currently exist. The targets set by Norway, the United Kingdom and France all reference “cars” and so do not appear to include heavy vehicles.

A rapid uptake in EVs is likely required to transition to a low-emissions economy (section 11.5). As such, there is merit in government clearly signalling a commitment to a widespread transition away from fossil-fuel vehicles. The Commission seeks feedback on how this message would be most effectively signalled.

Q11.1

How could New Zealand signal a commitment to a widespread transition away from fossil-fuel vehicles? For example, should New Zealand explicitly aim to phase out the importing of fossil-fuel vehicles by some specified future date?

11.5 Increasing the uptake of low-emission vehicles

This section looks at the opportunities for increasing the uptake of low-emission vehicles, including electric and hydrogen-powered vehicles.

Globally, momentum for low-emission vehicles is growing rapidly. Major vehicle manufacturers are shifting their business models, with many committed to ramping up production of low-emission vehicles, particularly EVs, over the next decade. Volvo, for instance, recently announced that all vehicles it sells will be electric by 2019, while Toyota announced it will release all its vehicles in electric form by 2025 (Toyota, 2017; Volvo Car Group, 2017).

Electric vehicles are one of New Zealand’s most promising mitigation opportunities

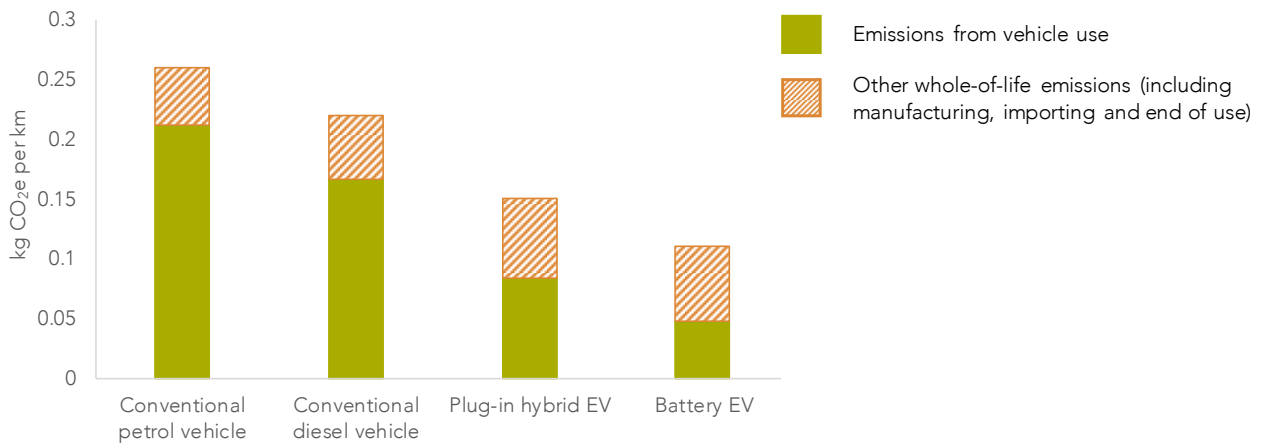
Using electricity to power an EV produces zero tailpipe emissions (GHGs and other harmful gases). The only direct emissions that arise from using battery EVs comes from generating the electricity to charge the battery. The process of manufacturing and importing EVs can also produce emissions, though these do not occur in New Zealand.

Several submitters consider EVs to be one of New Zealand’s most promising mitigation opportunities. Mercury (sub. 49, p. 2) summarises the range of benefits from EVs:

Electrification of transport is one of the largest areas of opportunity if significant reductions in New Zealand’s emissions is to be considered. New Zealand is well suited to Electric Vehicles (EVs) due to our abundance of renewable electricity, off-street parking and low-average commuting distances. The cost of electricity is far lower than petrol at the equivalent of 30c/litre and the running costs of EVs are lower due to fewer moving parts. EVs also have no tailpipe emissions and therefore have the potential to significantly improve air quality and reduce healthcare costs.

New Zealand is especially well-placed to achieve substantial emissions reductions from adopting EVs because most of its electricity is generated using low-emissions sources. ARUP and Verdant Vision (2015) estimate that driving a battery EV produces 80% fewer emissions compared to a petrol vehicle, while a plug-in hybrid EV produces 60% fewer emissions (Figure 11.10). Reductions will likely increase as New Zealand continues to decarbonise its electricity system (Concept Consulting, 2016).

Some submitters (Wiremu Thomson, sub. 78; Wise Response Society, sub. 103) pointed out that manufacturing EVs tends to produce more emissions compared to fossil-fuel vehicles. However, as shown in Figure 11.10, EVs still produce fewer emissions compared to fossil-fuel vehicles when applying a whole-of-life perspective.

Figure 11.10 Estimates of emissions across light vehicle types in New Zealand

Source: ARUP and Verdant Vision (2015).

Notes:

1. Emissions from manufacturing and importing EVs occur outside of New Zealand.
2. For the purposes of their analysis, ARUP & Verdant Vision assumed that each vehicle drove 210 000 km throughout its lifetime.

F11.4

The use of electric vehicles (EVs) leads to substantial emissions reductions compared to fossil-fuel vehicles, due to New Zealand's low-emissions sources of electricity generation. EVs also contribute to reduced air and noise pollution, and involve lower fuel and maintenance costs.

At present, the total cost of ownership (including purchase, fuel and maintenance costs) for a new EV is typically greater than for a 'comparable' fossil-fuel vehicle, due to the upfront cost premium (Concept Consulting, 2017a). Yet, the recent growing EV uptake in New Zealand (see below) suggests that, for some, EVs already offer a cost-effective investment. EV prices have also fallen dramatically. Since 2010, the cost of EV batteries has dropped by about 80% (IEA, 2016c). Prices are expected to continue to fall; Bloomberg New Energy Finance (2017) predicts the lifetime costs of light EVs will reach parity with fossil-fuel vehicles in the United States in the mid-2020s.

The scope for electrifying the heavy fleet, particularly in the freight industry, is more limited at present (Box 11.3). While heavy EV technology is developing, other mitigation options, such as hydrogen fuel-cell vehicles (HFVs), biofuels (section 11.6), and mode-shifting (section 11.7), will also likely need to play a role in reducing heavy vehicle emissions.

Box 11.3 Opportunities for adopting electric heavy vehicles

EVs currently have little penetration in the heavy vehicle fleet, due primarily to the higher cost and weight of battery packs for heavy vehicles, and their limited travel range (Vivid Economics, 2017a).

However, as with light vehicles, technology is developing rapidly, and numerous heavy EVs are already commercially available or under development. For example, Shenzhen City's entire fleet of over 16 000 buses are now electric (Hanley, 2018), while in the United States, over 500 reservations have been placed for the *Tesla Semi*, an all-electric, semi-trailer truck being developed by Tesla (Lambert, 2017).

While the development of batteries suitable for heavy vehicles is difficult, the way some heavy vehicles are used makes them particularly suited to electrification. For example, charging infrastructure for some heavy vehicles may be relatively straightforward due to the predictability and repeated nature of driving patterns, and the ability to recharge vehicles while they are being unloaded (Heid et al., 2017).

Reflecting this, many early adopters of electric trucks in the United States are companies with their own fleets that can deploy charging infrastructure within their distribution networks (Lambert, 2017).

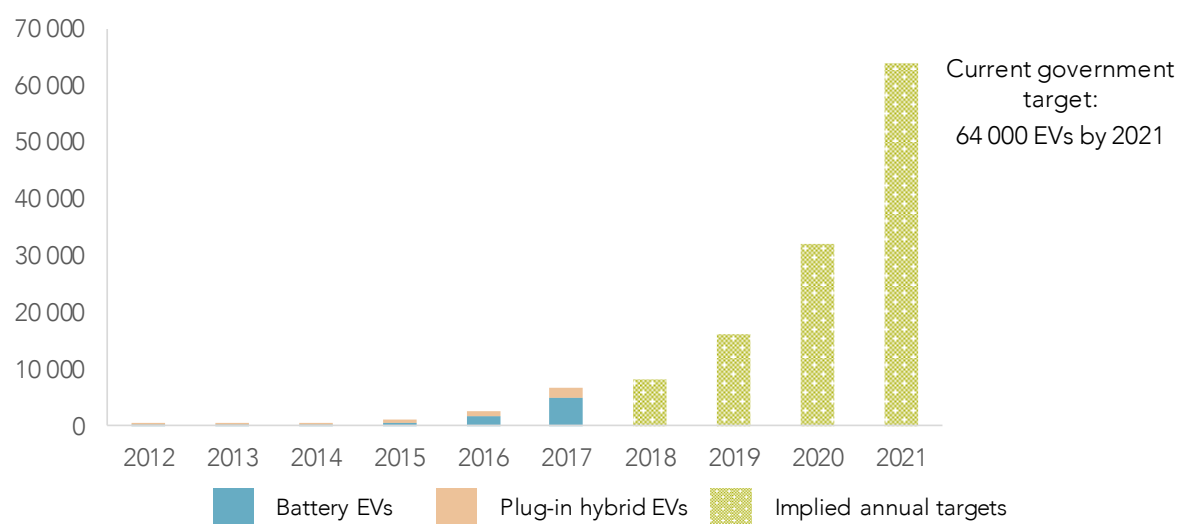
Similarly, the stop–start nature of some heavy vehicle tasks (eg, rubbish trucks or buses with frequent stops – is compatible with regenerative braking. New Zealand company Waste Management has converted a handful of their collection trucks to full electric (Barry, 2018).

Heid et al. (2017) suggest that the point at which the total cost of ownership for commercial EVs will achieve parity with conventional fossil-fuel vehicle models varies depending on the application. The authors find that, in Europe, some light trucks have already reached parity, while long-distance heavy freight may be ten years away from parity.

New Zealand’s EV fleet is small, but is growing quickly

New Zealand’s EV fleet is small, but it has been rising exponentially in recent years. As at January 2018, New Zealand had about 6 500 registered EVs. The previous Government set a target of doubling uptake each year, reaching 64 000 registered EVs by 2021. Uptake has so far been faster than the pace needed to achieve this target, though a substantial increase is still required (Figure 11.11).

Figure 11.11 Size of New Zealand’s EV fleet, 2013–2017, and current government targets



Source: MoT (2018).

Notes:

1. The implied annual targets are calculated from a baseline of 1 000 EVs in 2016, doubling each year to 64 000 in 2021.

What EV uptake is needed to achieve a low-emissions economy?

The Commission’s modelling shows that a rapid uptake of EVs will likely be critical for achieving a low-emissions economy (Chapter 3). Under the three scenarios modelled, estimates for the size of EVs as a share of the total light fleet needed by 2050 to reach net-zero emissions range from about 40% to 80%. The lower-uptake scenario assumes, among other things, large reductions in the emissions intensity of fossil fuel vehicles (eg, through the uptake of biofuels), and slow reductions in the cost of EV batteries. The high-uptake scenario assumes very fast reductions in the cost of EVs (Concept Consulting et al., 2018b).

To electrify the bulk of the light vehicle fleet by 2050, nearly all newly registered vehicles (including used imports) would need to be electric by the early 2030s (Concept Consulting, 2018). The importance of early uptake reflects the long period that vehicles stay in the fleet. The earlier that uptake accelerates, the greater the proportion of the light fleet will be electric in 2050.

If we could wave a wand and magically replace the light vehicle fleet (private and commercial) with electric vehicles, annual emissions would fall by about 11 million tonnes of carbon dioxide... But no such magic wand exists. Even though electric vehicle technology costs are projected to fall, the transition to electric vehicles will take several decades because New Zealand cars are typically not scrapped until they are 20 years old (PCE, sub. 54, p. 7).

In addition to light EVs, steady electrification of the heavy fleet will also be important. With slow uptake of heavy EVs, combined with low uptake of biofuels and hydrogen fuelled vehicles, it is possible that heavy vehicle emissions could continue to rise (Concept Consulting et al., 2018b).

F11.5

A rapid uptake of light EVs will likely be a critical part of achieving a low-emissions economy. To electrify the bulk of the light vehicle fleet by 2050, nearly all newly registered vehicles would need to be electric by the early 2030s.

Barriers to the uptake of EVs

Several important barriers currently inhibit the uptake of EVs. These include:

- *The upfront cost of purchasing EVs:* The Energy Efficiency and Conservation Authority (EECA)'s recent quarterly consumer survey indicated that the unaffordable cost of purchasing EVs was the most important reason for deciding not to buy one (pers. com., EECA, February 2018).
- *Limited travel range, and associated range anxiety:* Current models of battery EVs typically can travel between 100 km and 300 km on a full charge (S. Magnusson, 2017). Commonly known as range anxiety, the fear that EVs will run out of power due to lack of charging infrastructure deters people from investing in EVs (NZ Automobile Association, sub. 43).
- *The lack of public awareness, and inadequate understanding of, EVs:* EECA's survey suggests that only 52% of consumers agree that EVs are cheaper to run than fossil-fuel vehicles, and only 35% agree that they are cheaper to maintain. Only 10% of those surveyed said they were familiar with EVs.

Other issues raised by submitters include the limited range of models currently available in New Zealand, fast depreciation of EV values over time as technologies improve (NZ Wind Energy Association, sub. 40, EMANZ, sub. 70), and difficulties in sourcing EVs (Waikato Regional Council, sub. 48).

Another key barrier frustrating EV uptake is the lack of cost-reflective electricity pricing (Chapter 12). The flat pricing structure means consumers face little incentive to actively charge their vehicle at off-peak periods when the actual cost of supplying electricity is much lower. Concept Consulting (2018) estimates that emissions from the light vehicle fleet will be 37% higher in 2050 under a continuation of non-cost-reflective prices, due to delayed uptake of EVs and higher electricity emissions (with more charging at peak times).

Further, a large penetration of EVs would add significant load to the electricity grid and, depending on the time at which vehicles are charged, could lead to much higher emissions from electricity generation. Also, high uptake combined with greater use of fast chargers (as the size of EV batteries rise) could put substantial pressure on electricity networks, and require large investment in network capacity (Vector, 2018). Discussed in Chapter 12, smart metering and more cost-reflecting pricing of electricity will be essential for maximising the emissions-reduction benefits and reducing the network impacts from EV uptake.

F11.6

The most significant barriers inhibiting the uptake of EVs in New Zealand are:

- the upfront cost premium compared to petrol and diesel vehicles;
- limited travel range, and associated range anxiety;
- the lack of public awareness and understanding of EVs; and
- the lack of cost-reflective pricing of electricity.

F11.7

A large uptake of EVs would add significant load to the electricity grid. Without measures to encourage off-peak charging, such as cost-reflective pricing and smart metering, electricity emissions could rise significantly. The additional electricity load

could also put significant pressure on the existing network, and require large investments to provide additional capacity.

Current measures for supporting EV uptake

Two main policies underpin the Government's current programme for supporting uptake of EVs:

- road-user charge exemptions for EVs; and
- a Low Emission Vehicles Contestable Fund.

To reduce the cost barrier to EV uptake, the Government exempts light and heavy EVs from road-user charges (RUCs).¹¹⁵ The exemption is due to be removed at the end of 2020, or when light and heavy EVs reach 2% share of their respective fleets. The exemption saves owners of light EVs around \$600 per year (MoT, 2017c). Savings for heavy EVs can range from around \$3 000 (eg, for a medium-sized delivery truck) to over \$6 000 (eg, for a trolley bus) depending on vehicle weight and distance travelled (MoT, 2016b).

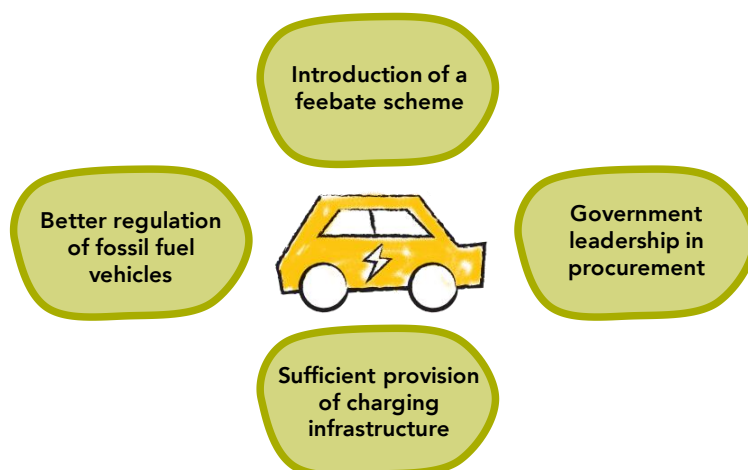
The Low Emission Vehicles Contestable Fund provides up to \$6 million each year to co-fund projects that encourage "innovation and investment to accelerate uptake of electric and other low emission vehicles" (EECA, 2018a). The only projects considered for assistance are those not commercially viable without funding assistance. So far, three rounds of funding have been completed, with over \$10 million of funding provided. The fund has not been evaluated to determine whether it is achieving its objectives.

Other policies in place to encourage EV uptake include enabling local authorities and the New Zealand Transport Agency (NZTA) to create bylaws allowing EVs to travel in special vehicle lanes, and a nationwide EV information campaign. Local government and businesses also play a role in promoting EV uptake, primarily by improving public awareness. For instance, Mercury and Air New Zealand have electrified their light fleets, while Wellington City Council is trialling the deployment of residential, public charging stations.

An EV policy package to support the low-emissions transition

The Commission has identified four key components of a policy package to achieve a level of uptake consistent with a low-emissions economy (Figure 11.12). An important element is improving the regulation of fossil-fuel vehicles (including the pricing of GHG emissions), discussed in sections 11.3, 11.4 and 11.8.

Figure 11.12 Key components of an effective policy package to support EV uptake



But the biggest driver of EV uptake will very likely be a continued reduction in price. Indeed, achieving parity with fossil-fuel vehicles, in terms of lifetime costs, could be a crucial tipping point in stimulating uptake.

¹¹⁵ Plug-in hybrid electric vehicles are subject to RUCs for the portion of their travel that is fuelled by petrol.

The case for price incentives for EVs

Policies to address the price barrier are likely necessary to achieve accelerated uptake of EVs, until the price gap disappears, in order to incentivise the uptake required to transition to a low-emissions economy.

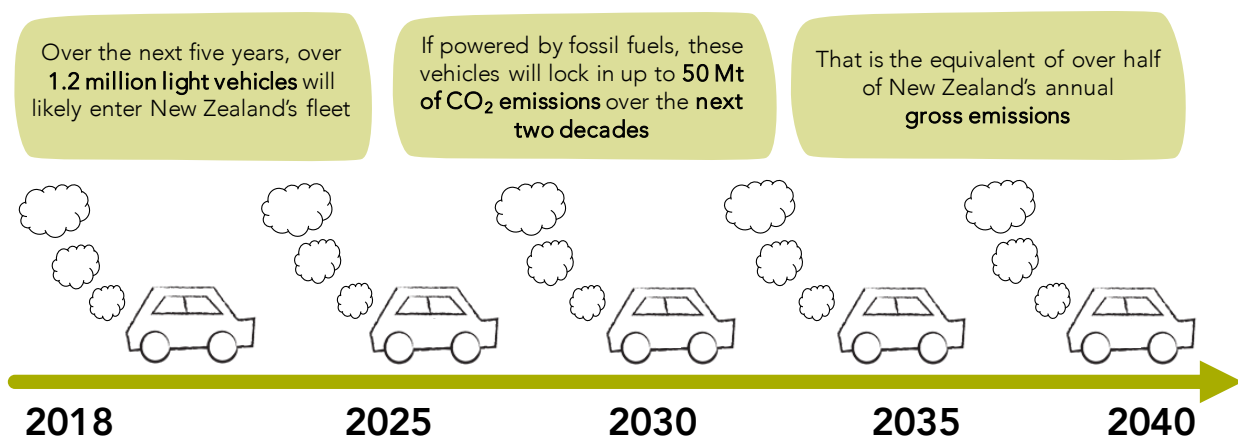
A key rationale for providing price incentives for EVs is that the actual cost of using EVs is currently greater than the wider social cost, relative to fossil-fuel vehicles. Identified earlier as a barrier to uptake, a lack of cost-reflective pricing for electricity means that EV users typically pay much more for charging overnight than the true cost of supplying the electricity during off-peak periods. Also, consumers do not fully benefit from reducing social costs when switching from a fossil-fuel vehicle to an EV, due to the currently low emissions price and the lack of pricing for air pollution (section 11.8).

Consequently, EVs are not on a level playing field with fossil-fuel vehicles. Modelling from Concept Consulting (2017a) suggests that reducing the gap between the actual cost and the true social cost of EVs would make EVs a much more viable option. Concept Consulting demonstrated that with an emissions price of just \$9, EVs with a price premium of \$12 500 would be a viable option for consumers if the full public benefits of EVs were taken into account (including reduced negative externalities).¹¹⁶ This analysis assumed the true cost of supplying electricity at the time most EVs are likely to be charged.

Instead of providing price support for EVs, an obvious option to incentivise EV uptake is to directly resolve the issues related to electricity pricing and the specific negative externalities. However, policies to address these issues (including adjusting the emissions price) will likely take time to implement and to take effect. In the meantime, a significant number of fossil-fuel vehicles would likely enter the fleet. Some form of support is therefore likely to be required as a transitional measure.

The emissions lock-in effect of fossil-fuel vehicles provides a further rationale for EV price incentives. Fossil-fuel vehicles emit a significant volume of cumulative emissions over their lifetime (Figure 11.13). The more fossil-fuel vehicles entering the fleet, the smaller New Zealand's remaining emissions budgets will be over the next ten to twenty years, and the higher the future emissions price across the economy.

Figure 11.13 Lock-in effect of fossil-fuel vehicles on emissions



Source: Based on MoT (2016a) and MfE (2017i) data.

In principle, the existence of an emissions price would encourage consumers to consider the impact of their future emissions when choosing what vehicle to purchase. However, in practice, future emissions prices are highly uncertain and unclear to vehicle purchasers. This provides a case for encouraging EV uptake in the short term to insure against a high emissions price-path and lock-in. Also, consumers tend to heavily discount future vehicle-related costs when purchasing vehicles (Section 11.4). So, even if the price path of the NZ ETS was clear, vehicle choices would likely still under-value the social cost of future emissions.

¹¹⁶ Modelling assumes a capital cost premium (the average upfront cost difference between an EV and a comparable fossil-fuel vehicle) of \$12 500 excluding GST, and annual vehicle kilometres of 14 000 km.

Finally, early price support could also help to facilitate ‘technology learning’ and achieve greater acceptance of EV technology among consumers. That is, there are spill-over benefits from early uptake of EVs that justify transitional price incentives.

F11.8

Overpricing of off-peak electricity and under-pricing of CO₂ emissions and air pollution from fossil-fuel vehicles means that the running costs of EVs (relative to fossil-fuel vehicles) are higher than they should be. In choosing a vehicle, consumers are also likely to under-value the large emissions that are locked in over the vehicle’s lifetime (eg, due to high discounting of future running costs). This provides a case for Government to provide some form of transitional price support to incentivise EV uptake.

Currently, the Government already provides some price support for EVs in the form of RUC exemptions. These exemptions are poorly targeted. As the The Treasury (2016b, p. 15) explains:

If a subsidy is to be given it is unlikely that a RUC exemption is the most effective approach. EVs use the roads in the same way as other cars so should be exposed to RUC. An expanded RUC exemption would also increase expectations about support of this form, which could drive inefficient long-term decisions on whether to purchase EVs. Explicit subsidies focused on purchase costs would be less likely to drive perverse outcomes and would target the apparent issue of up-front costs.

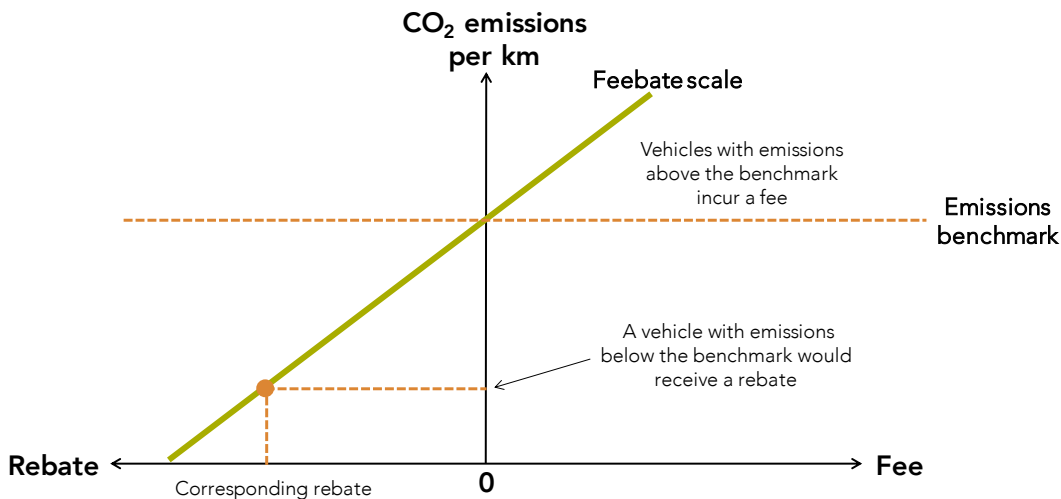
It is reasonable that EVs should be subject to RUCs, given that funds are used to maintain roading infrastructure that all vehicles, including EVs, benefit from.

A few submitters suggested that price support for EVs should take the form of direct subsidies, for example by subsidising the purchase of EVs (NZAA, sub. 43; John Clark, sub. 31; Vision Kerikeri, sub. 116), or by exempting EVs from GST (Genesis Energy, sub. 118). The Commission does not favour price subsidies that target EVs rather than low-emission vehicles more generally (ie, hydrogen vehicles). In any case, subsidising low-emission vehicles without imposing an additional cost on fossil-fuel vehicles effectively subsidises vehicle ownership, which would lead to more inefficient levels of vehicle use.

A price feebate scheme

A more effective approach to a direct subsidy is a price ‘feebate’ scheme. Under a feebate scheme, a vehicle would be assessed for its GHG emissions potential. Essentially, high-emission vehicles would incur a fee, while low-emission vehicles would receive a rebate (hence the name feebate). The feebate could be a one-off transaction at the point of importing a vehicle, a component of a vehicle’s annual registration fee, or a combination of the two. As Figure 11.14 illustrates, the difference between a given vehicle’s emissions and an emissions ‘benchmark’ would determine the size of the vehicle’s feebate.

Figure 11.14 Stylised structure of a feebate scheme



The New Zealand Automobile Association (NZAA) (sub. 43), Z Energy (sub. 110), Conrad Healy (sub. 113), and the Morgan Foundation (sub. 127) recommended that the Commission investigate the merits of a feebate scheme for New Zealand.

A big advantage of a feebate scheme is that it would not only encourage consumers to switch to EVs; it would also encourage the purchase of lower-emitting (more fuel efficient), fossil-fuel vehicles until such point that EVs or other low-emissions vehicles become cost-competitive. In the case that early EV uptake is slow, improving the efficiency of fossil-fuel vehicles would become hugely important. A feebate would also be technology neutral, so that low-emission vehicles across fuel types would be equally incentivised.

Another advantage is that the scheme could be designed to be revenue-neutral for the Government, so that total revenue from fees offsets the cost of providing rebates. To maintain revenue neutrality, the emissions benchmark would need to be monitored and adjusted over time as technologies and consumer vehicle choices change.

Given these advantages, feebate schemes can be highly cost-effective. In modelling pricing policies for vehicles in the United Kingdom, Brand et al. (2013) found feebates to be the most cost-effective in reducing emissions and accelerating the market share of EVs. Element Energy (2013, p. 97), in their report for the UK Committee on Climate Change explicitly recommended that “feebates should be explored for future application in the UK”. Barton and Schütte (2015, p. iii) identify a feebate scheme as a policy that has “credibility”, “a proven record of success internationally”, and is “suitable to New Zealand conditions”.

Other countries, including France and Singapore, have implemented feebates or similar schemes. France introduced their *Bonus-Malus* feebate system for new vehicles entering the fleet in 2008 to reduce CO₂ emissions. The system offers rebates of up to €7 000 to the purchase price of the lowest emitting vehicles, and charges fees of up to €6 000 for the highest. The scheme has been largely successful. Average emissions from newly registered vehicles fell from 149 g of CO₂ per km to 114 g of CO₂ per km between 2007 and 2014. One adverse outcome of the scheme was an increased demand for diesel vehicles (since diesel vehicles are often more fuel efficient), worsening air pollution (OECD, 2016b).

In section 11.4, the Commission recommended introducing vehicle emissions standards. Both a feebate scheme and vehicle emissions standards aim to reduce the overall emissions of the vehicle fleet. Yet, the two policies can complement each other. Barton and Schütte (2015, p. 31) explain:

A feebate provides a continuous long-term incentive to improve the performance of cars bought or manufactured. It is therefore different from a performance-based standard, which provides no incentive after minimum compliance, but it can readily co-exist with standards and complement them.

F11.9

A well-designed price feebate scheme based on the GHG emissions of light vehicles entering the fleet would provide the most cost-effective approach to incentivising the uptake of low-emission vehicles. The approach:

- provides a continuous incentive for purchasing lower-emitting vehicles (including fossil-fuel vehicles);
- is technology neutral; and
- can be designed to be revenue neutral.

Effective design of a feebate scheme is critical to achieving its desired objective, and to avoid unintended costs from the scheme. As an example, setting excessively high rebates could lead to adverse outcomes (eg, higher overall vehicle demand). On the other hand, insufficient rebates could result in the scheme effectively subsidising those who would have otherwise still purchased an EV, without having any real impact.

One important design consideration is whether to apply the feebate on a one-off basis, an annual basis or a combination of the two. The Commission favours applying a one-off feebate when the vehicle enters the fleet (ie, vehicles already in the fleet are unaffected). In principle, all three approaches could provide the

same monetary incentive for consumers. An annual feebate would increase the ongoing cost (or benefit) from owning a vehicle, while a one-off feebate would affect a vehicle's purchase price. However, a one-off feebate would be more effective in addressing the upfront price barrier and affecting purchase decisions, given consumers high discounting of future vehicle costs. Also, if a feebate scheme is introduced as a transitional policy for a limited period, then an annual charge would provide weaker financial incentives.

Table 11.2 outlines some other design features of a feebate scheme, and specific issues to consider.

Table 11.2 Key design features of a feebate scheme, and issues to consider

Design feature	Issues to consider
The scale of the feebate incentives	The greater the feebate, the stronger the incentives for purchasing lower-emitting vehicles, but the larger the financial costs for consumers.
The level of the emission benchmark	The emission benchmark determines which vehicles receive rebates and which receive fees. A high emission benchmark, with rebates for lower-emitting, fossil-fuel vehicles, could increase overall vehicle demand. A low emission benchmark, could lead to excessive costs for consumers.
The coverage and treatment of different vehicle types	A scheme that treats all vehicles the same (eg, family vehicles versus commercial vans) would be more efficient, in terms of emissions. However, such a scheme may be less equitable for those with few low-emission alternatives. Another option is to have separate schemes for different vehicle classes.
Use of a linear or non-linear feebate scale	A linear feebate scale (like in Figure 11.14) provides a pure continuous incentive to improve the emissions of a vehicle. Yet, a non-linear scale (ie, a scale where the gradient changes at certain points) provides greater flexibility for setting incentives.
Revenue neutrality	A revenue neutral scheme may be more politically acceptable than the alternative. However, ensuring the scheme stays revenue neutral entails frequent changes to incentives. Such frequent changes could induce greater uncertainty.

The scheme will effectively raise prices for high-emitting vehicles newly imported into New Zealand. Given current prices for EVs and the limited models available, lower-income households and users of larger vehicles (eg, vans and utes) may disproportionately bear the costs of the scheme. Chapter 9 discusses appropriate measures to deal with the distributional impacts of transport policies.

F11.10

The effective design of a feebate scheme is critical for its success. Excessively high or low feebates can lead to adverse outcomes. Applying a one-off feebate when a vehicle enters the fleet provides stronger incentives than an annual charge over time.

R11.2

The Government should introduce a price feebate scheme for vehicles entering the fleet, subject to identifying the most suitable design features for the New Zealand context. The feebate scheme should replace the existing road-user charge exemptions for light EVs.

The Commission is not aware of any international examples of feebate schemes that cover heavy vehicles. Applying a feebate to these vehicles could be more complex and difficult, due to the greater range of vehicle classes. There are also fewer options for purchasing low-emission heavy vehicles compared to light vehicles. A different form of price support may therefore be appropriate.

Q11.2

Should a price feebate scheme cover vehicles within the heavy vehicle fleet? What other policies are appropriate for incentivising the uptake of low-emission heavy vehicles?

Ensuring sufficient provision of charging infrastructure

Providing sufficient charging infrastructure is important for encouraging households to invest in EVs, especially because of their limited range. While about 85% of New Zealanders have access to off-street parking (The Morgan Foundation, sub. 127), public charging infrastructure is still needed to enhance accessibility within urban areas and throughout the country.

The Government has so far had a fairly limited role in facilitating the development of charging infrastructure. The contribution it has made has been through the Low Emission Vehicles Contestable Fund – around \$3.5 million of the \$10 million of funding provided has gone to charging-related projects (EECA, 2018b).

Several submitters recommended that Government invest more in public charging infrastructure (Christchurch City Council, sub. 13; Robert McLachlan, sub. 9; Tauranga City Council, sub. 126; LGNZ, sub. 36; Waikato Regional Council, sub. 48). Conversely, Vector (sub. 63), one of the main investors in charging infrastructure, considers that a misperception exists that charging infrastructure is inadequate, and that existing infrastructure is capable of supporting EV uptake at least in the short term.

Available information suggests that the provision of charging infrastructure has been relatively strong with the current level of government support. At present, New Zealand has over 170 purpose-built charging stations installed, including 85 rapid charging stations (Vector, sub. 63). NZTA expects that by July 2018, 88% of New Zealand's state highways will be within charging coverage (within 75 km of a rapid charger). That said, specific gaps do exist – particularly in sparsely populated regions. Provision of slow chargers within urban areas has also been relatively slow (pers. com., NZTA, March 2018).

Continuing to extend the charging network and resolving the existing gaps, however, may be difficult given the current small size of the EV fleet. Vector noted that “while it is necessary to continue expanding and developing... infrastructure to enable further EV uptake, there is currently limited incentive for the private sector to do so” (sub. 63, p. 7). This highlights the potential for coordination problems. For example, firms may not invest in charging infrastructure until there is sufficient EV uptake, but uptake of EVs might not occur until sufficient infrastructure is in place (The Treasury, 2016b).

Chapter 6 concludes that where a lack of coordination creates a barrier to investing in low-emissions infrastructure, there may be a good case for Government to provide financial assistance. In the context of EVs, the Commission considers that Government should continue to provide financial support for charging infrastructure projects to support the development of the network. In particular, the Government should consider addressing specific gaps in the charging network that are commercially unattractive to the private sector (eg, charging stations in lowly populated regions), yet are important for completing the network. Conversely, it should avoid providing funding for charging projects that would likely be profitable without government support.

F11.11

The provision of EV charging infrastructure in New Zealand, especially fast charging stations, has been relatively strong with the current level of government support. Yet, some gaps appear to exist in specific regions, and for slow chargers within urban areas.

R11.3

The Government should provide financial support for charging infrastructure projects to support the uptake of EVs. Support should be limited to specific gaps in the charging network that are not commercially attractive to the private sector (eg, charging stations in lowly populated regions).

The role of government leadership in procuring low-emission vehicles

Many submitters called for the Government to play a greater leadership role in promoting EV uptake. Z Energy (sub. 110) commented that the Government should be far more “bullish” in supporting uptake, specifically through procuring EVs. Federated Farmers of New Zealand (sub. 39, p. 8) suggested that “the Government can best encourage uptake in this country through influencing its agencies’ purchasing decisions and through information and promotion”. Four submitters proposed that the Government commit

to electrifying its fleet (Rick Blazeley, sub. 12; Graham Townsend, sub. 15; Guardians of NZ Superannuation, sub. 32; Morgan Foundation, sub. 127). Vector (sub. 63, p. 9) stressed in the context of transport, “if the government does not take an active and visible role in promoting carbon reduction..., the urgency and desire to move to a low-emissions economy will be less likely recognised by the public”.

Encouraging the procurement of EVs by government agencies is one way of signalling future policy direction to the public, and addressing the barrier to uptake around the lack of public awareness of EVs. A further benefit of doing so is that it would increase the second-hand stock of EVs available for purchasing over the next decade. Adoption of EVs may not be practical in all cases, for example where fleets are parked in locations where it is costly to install charging capability.

R11.4

The Government should encourage government agencies where practical to procure low-emission vehicles.

The role of other low-emission vehicles

Hydrogen fuel-cell vehicles

Hydrogen fuel-cell vehicles (HFVs) offer another vehicle option that could play an important role in decarbonising the transport fleet. An HFV uses hydrogen gas to power its motor by converting the hydrogen to electricity. This conversion process produces only water and heat meaning HFVs produce zero tailpipe emissions. HFVs reduce emissions per vehicle km by less than battery EVs, since they are less energy efficient (RSNZ, 2016). Several submitters identified the potential benefits from adopting hydrogen technology in New Zealand (Contact Energy, sub. 29; Hera, sub. 96; Sustainable Business Council, sub. 131).

HFVs have some significant advantages over EVs that make the technology especially suited to heavy commercial vehicles. The travel range of HFVs is more similar to a fossil-fuel vehicle and therefore much greater than EVs. Recharging HFVs is also considerably faster than for EVs. Both these advantages help to reduce the time a vehicle spends charging, and thus achieve much higher asset utilisation. In addition, the lower weight of hydrogen fuel cells compared to EV batteries means that HFVs can carry greater additional weight.

The biggest challenge with HFVs is the substantial infrastructure investment needed to produce and transport the hydrogen and for refuelling vehicles. Producing hydrogen (in a low-emissions way) in New Zealand would likely involve using electrolysis of water in power plants (Vivid Economics, 2017b).¹¹⁷ With abundant sources of renewable energy, New Zealand could potentially produce significant quantities of hydrogen (Concept Consulting, 2017a). Once produced, the hydrogen then needs to be distributed to support a hydrogen refuelling network. Unlike EVs that can be charged anywhere that is connected to the electricity grid, HFVs require some form of a hydrogen refuelling station.

The significant costs of infrastructure combined with the high cost of purchasing HFVs (compared to fossil-fuel vehicles and EVs) makes HFVs, at present, a less viable option. While currently uneconomic (requiring emission prices of about \$100 to \$250 per tonne of CO₂), Concept Consulting (2017a) notes the technical potential for HFVs to be used for return-to-base transport.¹¹⁸ Even without any HFV uptake in New Zealand, another potentially lucrative opportunity could be producing hydrogen locally using low-emissions sources and exporting it to countries that use HFVs.

Ensuring policies to support low-emission vehicle uptake are technology-neutral where possible is especially important given the important part of the mitigation mix that HFVs could play.

¹¹⁷ Less likely, hydrogen could be produced through thermal gasification accompanied with carbon capture and storage.

¹¹⁸ Vehicles that carry out services and regularly return to a base location, such as rubbish trucks and local bus services, are examples of return-to-base transport.

F11.12

Several advantages of hydrogen fuel-cell vehicles, including the lower weight and greater travel range, make them especially suited to reducing emissions from road freight. The biggest challenge for achieving uptake in New Zealand is the significant investment needed in new infrastructure.

Natural-gas fuelled vehicles

A few submitters (NZ Oil and Gas Ltd, sub. 56; PEPANZ, sub. 65; First Gas Ltd, sub. 47) identified natural gas fuelled vehicles as a mitigation option worth considering for replacing heavy fossil-fuel vehicles. Currently, just under 2 000 vehicles in New Zealand are fuelled by natural gas. These vehicles do not fit the Commission's working definition of 'low-emission vehicles', because of their significant tailpipe emissions.

Analyses of whole-of-life emissions for vehicles fuelled by natural gas generally suggest that, at best, the overall reductions are minor (Tong et al., 2015; US Department of Energy, n.d.). This is because the modest reductions in tailpipe emissions from using these vehicles are largely eroded by the fugitive emissions involved in generating the gas. Concept Consulting (2015, p. 33) concludes that "[n]atural-gas based vehicles are not materially different in terms of carbon dioxide emissions" compared to fossil-fuel vehicles, and some vehicles result in higher emissions.

11.6 Using biofuels to reduce transport emissions

This section explores the contribution that biofuels can make to reducing New Zealand's transport emissions. Biofuels are fuels made from plant-based material, also known as biomass. The most commonly used biofuels in New Zealand are bioethanol (an alternative to petrol) and biodiesel (an alternative to diesel). Only about 0.1% of total transport fuels consumed in New Zealand are biofuels compared to 4% globally (Scion, 2018).

The combined process of producing and consuming biofuels is often referred to as being "carbon-neutral", since the CO₂ emitted when combusting the fuel is equal to the CO₂ that plants absorb as they grow. In reality, growing the plant feedstock and converting the feedstock into biofuel typically involves some emissions, for example through the production and application of fertiliser used to grow feedstock (PCE, 2010).

Biofuels can help to mitigate more challenging transport emissions

Biofuels are better placed to reduce emissions in the heavy fleet and aviation and shipping fleets, due to the challenges in electrifying these modes.

Electric vehicles have positive attributes for short cycle use but long cycle and heavy load use will probably be a challenge for a number of years. This is where liquid and gaseous biofuels will have a decided advantage over electric as liquid and gaseous biofuels require minimal modification of vehicles, and infrastructure additions for heavy road transport can be modest. Heavy grade liquid biofuels for marine and rail applications are technically available today but market demand is necessary to get them to the stage of commercialization. (The Bioenergy Association, sub. 37, pp. 6–7)

Given that vehicles remain in the New Zealand fleet for around 20 years, biofuels present a potential mitigation option for emissions that are "locked-in" over the future lifespan of fossil-fuel vehicles.

The total emissions reductions depend on the portion of biofuel contained in a fuel source. Due to technical limitations, biofuels currently available in New Zealand (such as bioethanol and biodiesel) are blended with petrol and diesel in relatively small proportions (5% to 10% of a fuel) (EECA, 2017a) As such, emissions reductions from these fuels are relatively small. For instance, it is estimated that a typical blend of 10% bioethanol and 90% petroleum results in approximately a 5%–6.5% reduction in emissions (MBIE, 2016). However, more advanced "drop-in" biofuels – fuels functionally equivalent to fossil fuels – are rapidly developing (Scion, 2018). These drop-in fuels can be used in much higher proportions than current fuels.

The attractiveness of biofuels as a mitigation option for heavy vehicles is closely linked to the development and relative cost-competitiveness of low-emission vehicles. For shipping and aviation, few other significant

mitigation options appear on the horizon. In 2016, the International Air Transport Association set a target of reducing net global aviation emissions by 50%, with biofuels expected to feature prominently (Z Energy, sub. 110).

Scope for producing biofuels in New Zealand

Historically, New Zealand has produced biofuels on a small scale, mostly using agricultural by-products such as whey and tallow. Z Energy has established New Zealand's first industrial-scale biodiesel plant in Auckland and plans for the plant to produce up to 20 million litres of biodiesel each year from tallow, equivalent to over 33 times the biodiesel produced nationwide in 2015.

The supply of biofuel is physically limited by the volume of feedstock available. Total suitable feedstocks currently available in New Zealand would deliver about 8% of total liquid fuel demand (Scion, 2018). Significant research is taking place globally and in New Zealand into producing advanced biofuels from non-food based feedstocks, such as wood residues. Yet advanced biofuels are much less technologically mature and therefore come with significant technical risk (Z Energy, sub. 110). Increased production of feedstocks – for instance, through greater afforestation – could enable more large-scale production. With other businesses seeking to decarbonise their processes, the limited supply of feedstock may be in high demand.

Recently, Scion (2018) undertook a *Biofuels Roadmap Study* modelling scenarios of expanding biofuel production in New Zealand up until 2050. The report found that substituting 30% of liquid fuels with domestically produced biofuels in 2050 could reduce annual emissions by roughly 5 Mt of CO₂e – about one-third of current transport emissions. This level of substitution could be achieved in New Zealand using mature technologies (biodiesel from canola plus a little tallow, and ethanol from sugar beet). However, this approach has a number of significant negative implications, including the need for engine modifications and a dramatic increase in cropping land (1.7 times that of all current cropping and horticultural land in New Zealand) to grow canola and sugar beet.

Scion concluded that the biofuel technologies most suited for large-scale uptake in the New Zealand context are not yet commercially viable.

Although rapid developments are occurring internationally, many of the biofuel technologies of interest are not yet commercially proven. This is particularly so for drop-in fuel production from lignocellulosic feedstocks... Before large-scale deployment of these new technologies can occur they will need to be proven to operate reliably at large scale and to produce fuels that meet required fuel quality standards. (Scion, 2018, p. 48)

In addition to the technical challenges, several other barriers prevent a significant increase in the production of biofuels in New Zealand. Most prominent is the low emissions price in the NZ ETS, which provides little commercial advantage in producing lower emissions fuels.

The current low oil price and carbon price make the competitiveness of biofuels very poor relative to fossil fuels. Z has modelled that an order of magnitude carbon price in excess of 100 NZD/T would be required to make biofuels commercially viable in New Zealand, based on prevailing oil prices. (Z Energy, sub. 110, p. 6)

In addition, emissions from international aviation and shipping lie outside national GHG emission obligations. Accordingly, use of biofuels in aviation and shipping is only incentivised for domestic application.

Scion (2018) also notes that biofuel production would require coordination across the value chain. For instance, learning how to plant new feedstocks and the process of growing crops takes time. The timing of growing feedstock must match the timing of future biofuel demand. The time needed to prove the feasibility of new biofuel conversion technologies provides an added uncertainty.

F11.13

Biofuels can potentially deliver considerable reductions in emissions, especially for transport modes that are more challenging to electrify (eg, heavy vehicles, aviation and shipping). New Zealand's current production of biofuels is relatively small. A higher emissions price in the NZ ETS would create a greater incentive to develop and switch to biofuels. However, the biofuel technologies with the greatest promise for New Zealand's context are not yet commercially proven.

Policies to support biofuel production

Few current government incentives are in place to encourage the production of biofuel. Currently, bioethanol is exempt from the fuel excise duty. This provides an incentive of \$0.59 a litre for its use. For a 5% blend, the exemption reduces the excise duty by about 2.5 cents. Also, the ETS does not affect the biofuel component of any transport fuel, though low emissions prices have considerably weakened any incentive this provides. A significant increase in the emissions price in the NZ ETS is an important first step in encouraging greater investment in the production of alternatives to fossil fuels, including biofuels.

Scion's *Biofuels Roadmap Study* (2018) presents a sensible set of broad principles around how to approach the development of biofuel in New Zealand. These include:

- producing liquid biofuels to replace fossil fuels where few decarbonisation options exist (for example, heavy vehicles and shipping);
- focusing on drop-in biofuels that existing vehicles, ships and planes can use;
- reducing future market risks by focusing on feedstocks grown on non-arable land; and
- concentrating on developing biofuel based on plantation forest feedstocks, as such feedstock is New Zealand's best long-term, large-scale biofuel production option.

The report also argues that national leadership is needed to make a meaningful transition to biofuels:

Government policy support will be required in the short to medium term to enable large-scale biofuel production to occur. Market forces alone will not be sufficient to initiate large-scale production. (p. 8)

However, Scion provides few details about the role for government in supporting the development of biofuel. The Roadmap notes that biofuels are an area of "intense global research and rapid development, so viable technologies are expected within the required timeframes" (p. 8). However, the same can be said of other low-emissions technology, and the Roadmap provides little evidence for a targeted government intervention to support this specific technology.

Some submitters suggested that greater innovation support (The Morgan Foundation, sub. 127) and incentives for developing biofuels (Air New Zealand, sub. 130; Hera, sub. 96) could be beneficial. Z Energy (sub. 110) commented that advanced biofuel technologies are typically emerging in markets where government funding or mandates are in place.

Chapter 5 examines the role that innovation should play in supporting New Zealand's transition to a low-emissions economy and recommends that Government should provide major public backing and funding support for innovation. In areas relevant to New Zealand's emissions profile, and areas of existing research strength in climate mitigation, the country should invest in the full range of basic and applied research, commercialisation, infrastructure and skills. In other areas New Zealand will be a technology taker, and in these cases should seek to develop capacity and resourcing to identify, absorb, adapt and deploy a wide range of technologies from offshore.

If researchers and firms with an interest in biofuels are able to demonstrate a comparative advantage in developing a fuel that can generate significant emissions reductions, then these entities should be well positioned to take advantage of any increase in R&D funding available for emissions-reduction research. However, it is also likely that areas of biofuel research exist where New Zealand has no comparative

advantage. In these instances, New Zealand would be better placed to monitor international developments and seek to absorb and adopt technologies developed offshore.

11.7 Shifting modes, and improving system efficiency

While the adoption of low-emission vehicles will provide the bulk of transport emissions reductions in the medium term, other mitigation options can contribute to more immediate emissions reductions, and provide valuable non-emissions benefits. This section identifies some of these opportunities including:

- shifting modes from private vehicles to public transport, cycling and walking, and from road freight to rail and shipping; and
- improving the efficiency of the transport system (eg, through lowering traffic congestion).

Given that the non-emissions benefits from these opportunities largely come from avoiding the negative externalities of private vehicle use, efficiently pricing these externalities is crucial. Section 11.8 looks at the arrangements for pricing transport services and negative externalities.

Section 11.9 then assesses whether New Zealand's funding system for land transport adequately supports investment in infrastructure for low-emission transport modes, so as to enable mode-shifting.

Increasing the use of public transport, cycling and walking

Public transport, cycling and walking respectively make up about 3%, 1% and 17% of trips in New Zealand. Over the last decade use of public transport has significantly grown, while cycling and walking trips have been falling (MoT, 2014, 2017b). Per person, Auckland's public transport patronage rose by over 25% between 2003 and 2017 (Auckland Transport, 2017). Yet, given its relative high density, Auckland's public transport patronage is low compared to other Australasian cities (Nunns, 2014).

Mode shifting offers small emissions reductions but potentially significant wider benefits

The emissions reduction benefits from increased public transport, cycling and walking are relatively small. Modelling from Concept Consulting (2017b) estimates that an increase in the number of per person public transport trips (by 30%), cycling trips (by 30%) and walking trips (by 100%) over the next 20 years would achieve approximately a 1% reduction in private vehicle emissions. The small size of this reduction reflects the small potential for mode shift relative to the overall vehicle fleet, and that these modes tend to replace vehicle trips of a shorter distance.

Yet other benefits from shifting modes can be significant. Greater use of low-emission transport modes can improve road safety and accessibility, relieve congestion, and provide gains in productivity (NZTA, 2013). The *2017 National Land Transport Fund Annual Report* shows that investments in public transport had the highest benefit–cost ratio of all activity classes in 2015/16 and 2016/17 (NZTA, 2017). City Rail Link (2018) considers that the City Rail Link currently being developed will lead to over \$1.4 billion of travel time savings for public transport and road users. Increased cycling and walking can also lead to improved health outcomes.

A five percent increase in cycling and walking for trips of 2km or less in Auckland would bring health benefits of \$225 million per year, as well as reduce traffic... About half of regular public transport users walk for more than 10 minutes per day, compared with just 13 percent of people who do not use public transport. (MoT, 2017b, p. 25)

A large number of submitters emphasised the role of public and active transport in providing wider benefits from New Zealand's low-emissions transition. For instance, Guardians of NZ Superannuation (sub. 32, p. 10) argued "the first priority of a credible climate change strategy in any country is improved public transport and a modern rail network for passengers and freight".

F11.14

Increasing the use of public transport, and cycling and walking provide relatively small emissions reductions benefits. On the other hand, shifting to these modes can achieve significant other benefits, including reduced congestion, better health outcomes and overall productivity gains.

Opportunities for shifting from road freight to rail and coastal shipping

Roughly 90% of the more than 200 million tonnes of freight transported throughout New Zealand each year is carried on roads. In terms of freight kilometres, road transport satisfies about 70% of demand, while rail and coastal shipping each satisfy about 15%. Over recent decades, a gradual shift has occurred towards road transport and away from rail and coastal shipping (Deloitte, 2014; MoT, 2017b).

Some submitters viewed mode-shift towards rail and shipping as a large emissions reduction opportunity (Rangitikei District Council, sub. 35; Waikato Regional Council, sub. 48; Oji Fibre Solutions, sub. 71).

Rail and shipping offer low-emission modes of freight transport...

In general, rail and coastal shipping are less emissions-intensive modes of freight transport compared to road. One study estimates that road freight is about twice as emissions intensive as rail and shipping (Cenek et al., 2012). KiwiRail (sub. 124) estimates that moving a tonne of freight using rail produces 66% fewer emissions compared to road. However, these estimates assume that the freight load is delivered directly from its origin to its destination. In reality, both rail and shipping rely on heavy vehicles to transport goods at both ends.

... but the volume of freight contestable across modes is limited

Often, certain types of freight are inherently suited to particular modes. Road freight has the advantage of providing faster, responsive, point-to-point service, so businesses often prefer using road, especially for time sensitive loads (Deloitte, 2016). Where speed of delivery is less important, rail and shipping can be more cost-effective (Cenek et al., 2012). For instance, these modes are suited to bulk products such as meat (Asuncion et al., 2012). However, lack of access to effective rail and shipping networks can rule out using low-emission modes (NZ Steel, sub. 64).

The distance of travel is an especially important factor in choosing a freight mode. Over short distances, rail and coastal shipping tend to be uneconomic (MoT, sub. 4). As such, road transport satisfies over 97% of freight demand within regions, while rail or coastal shipping is more competitive for inter-regional freight. Rail and shipping move about 30% of this freight load. However, the majority (nearly 80%) of New Zealand's total freight load, in terms of weight, is transported within regions (Figure 11.15).

Figure 11.15 Volume of freight transported across modes, 2012



Source: MoT Freight Information Gathering System, Deloitte (2014).

As a result, the volume of freight that is contestable across modes is limited. MoT and Federated Farmers of New Zealand expressed this point in their submission, and a 2006 study concluded it is "unlikely that rail could transport more than 20% of the current freight task without revolutionary changes to the way freight is transported" (Mackie et al., 2006). This compares to 15% currently.

The case for electrifying rail

Emissions reductions achieved from moving freight from road to rail, are increased when trains are powered by low-emissions fuels such as electricity. However, the upfront cost of electrifying existing rail lines is significant. KiwiRail (2016b) estimates a cost of \$2.5 million to electrify one kilometre of track. The section of the North Island Main Trunk Line between Hamilton and Palmerston North is the one of the few currently electrified. In December 2016, KiwiRail announced its plans to replace the electric fleet operating on the line with new diesel locomotives. The internal business case that underpinned this decision noted that replacing the fleet with diesel trains would increase CO₂ emissions on the NIMT by about 12 000 tonnes (equivalent to 0.08% of annual transport emissions) (KiwiRail, 2016a). KiwiRail (2016b) also consider that electrifying the rest the North Island Main Trunk Line could require capital expenditure of over \$1 billion.

F11.15

Moving freight via rail and coastal shipping is less emissions intensive than road transport. However, because a large proportion of freight carried by road is not economically contestable, the potential to reduce emissions from shifting modes of freight is limited. Electrifying rail would enhance the emissions reductions from shifting to rail, but would require significant capital expenditure.

Barriers to mode shift for private travel and freight

Providing good access to quality low-emissions transport infrastructure and services is important for encouraging modal shifts. In the context of private travel, MoT (2017b, p. 24) notes that, “travel habits can change when alternatives become more attractive”. Yet, over the last decade, investment in public transport and rail infrastructure has grown much slower than for roading (section 11.8).

Strengthening the regulation of the adverse effects of road vehicle use would also make shifting modes more attractive (section 11.8). This is especially important for public transport, cycling and walking. At present, the lack of cost-reflective pricing of vehicle externalities, such as congestion and parking, all work against these modes of transport.

Improving the efficiency of the transport system

Improving the transport system’s efficiency means meeting society’s mobility needs while reducing the number of vehicle kilometres driven or litres of fuel consumed. Any improvement in the system’s efficiency should reduce emissions. One way to achieve greater efficiency, as described above, is to increase the use of public transport.

Yet other options exist, such as exploiting new technologies to manage transport demand, and make better use of freight modes. Vehicles that frequently stop and start in traffic consume more fuel and therefore produce more emissions than when in free flow. One study suggested emissions reductions of almost 20% were achievable in California by adopting a range of measures to mitigate congestion (Barth & Boriboonsomsin, 2008). Adopting intelligent transport systems to better plan, optimise, and adjust freight movements can potentially improve freight efficiency by up to 10% and reduce emissions (Deloitte, 2018).

Reduced demand for travel would also directly lower emissions. Such a trend could occur, for instance, through advances in digital technology that reduce demand for face-to-face communication, increased consumption of goods online, and reduced vehicle ownership rates. A higher emissions price would also bring about reduced vehicle use and air travel (section 11.3).

F11.16

Developing demand management and intelligent transport systems provides new opportunities to make the transport system more efficient. A more efficient system can reduce emissions and achieve wider benefits such as lower congestion.

11.8 Pricing transport services and externalities

While providing large economic and social benefits, vehicle use also entails significant costs in terms of the development and maintenance of transport infrastructure and the negative externalities that affect the wider public (in addition to GHG emissions). The way these costs are priced directly influences the transport choices that households and business make, and therefore affects overall transport emissions.

Pricing of transport services

Current pricing and funding arrangements for transport involve a combination of cost-recovery approaches. Most costs are recovered through price mechanisms on road users, reflecting a “user pays” principle. However, a significant share of the costs is borne by the general population, reflecting a view that some benefits from the transport system are shared even by those who do not use a vehicle.

The government imposes the following charges on those who own and operate motor vehicles.

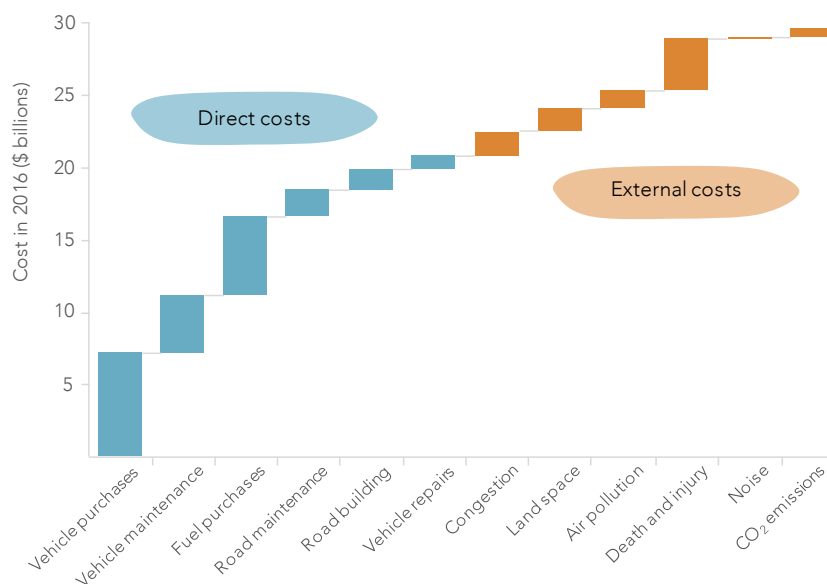
- *Fuel excise duty on petrol:* This is a charge on petrol that is passed on to consumers at the pump. The current excise rate is 59.52 cents a litre.
- *Road user charges (RUCs) on heavy vehicles and light diesel vehicles:* RUCs are distance-based charges with the rate varying by vehicle weight and type, reflecting the fact that heavier vehicles contribute disproportionately to road wear. EVs are currently exempt from paying RUCs (section 11.5). New Zealand is unique in its use of a distance-based charging system for diesel vehicles instead of an excise tax. The reason for this different system is to avoid diesel that is used off-road (eg, on farms and in machinery) being charged to fund the transport system.
- *Licensing and registration:* These are fixed fees paid when registering a vehicle and obtaining licences.

All revenue raised from these charges is hypothecated for investment in the land transport system through the National Land Transport Fund (NLTF). This covers road maintenance, building of new roads, public transport operations, road policing, and some other related expenditure. In addition to the charges listed above, rates revenue and general taxation revenue also contribute to transport funding.

Pricing externalities

A feature of current transport pricing arrangements is that they are designed to recover the costs of providing transport infrastructure and services. They are not designed to reflect negative externalities associated with the use of private vehicles such as air and noise pollution.

Concept Consulting (2017a) has estimated the total annual costs arising from land transport in New Zealand (Figure 11.16). External costs add up to around 40% of the total. Particularly striking is the comparison between the total external costs (\$8.8 billion) and the costs of road building and maintenance (\$3.3 billion), which roughly reflect the total charges imposed on road users at present. This suggests that if the government were to fully price all adverse effects, total charges on road users would increase to almost four times the current level on average (the distribution of these costs would vary widely by location, timing and vehicle type). This increase would clearly have significant impacts on the behaviour and vehicle choices of road users.

Figure 11.16 Estimated costs of land transport in New Zealand in 2016

Source: Concept Consulting (2017a).

Notes:

1. The estimate of the cost of CO₂ emissions assumes an emissions price of \$40 per tonne of CO_{2e}.
2. Obesity and private travel time costs and the cost of providing public transport and cycling facilities are excluded.

Despite methodological differences,¹¹⁹ this overall picture of costs is broadly in line with an earlier study referenced by the South Island Regional Transport Committee Chairs Group (sub. 14), which compared different transport modes and vehicle types:

A 2005 study by the Ministry of Transport found that cars directly pay 64% of their costs, trucks directly pay 56% of their costs, and buses directly pay 68% of their costs. (p. 3)

As noted above, a wide range of externalities from land transport are not priced. Box 11.4 examines two examples of how road pricing could be adjusted to better account for externalities.

Box 11.4 Pricing transport externalities: congestion and air pollution

Congestion

Traffic congestion is detrimental to productivity and quality of life and causes higher vehicle emissions due to more stop-start travel. While those driving in congested conditions experience some costs directly, particularly from slower travel times, this does not account for the costs their trip is imposing on other road users. Cost estimates vary significantly depending on how congestion is defined and measured. For example, Wallis and Lupton (2013) estimate that congestion in Auckland costs between \$250 million and \$1.25 billion each year, depending on the measure used.¹²⁰

Congestion pricing, or road pricing, seeks to direct these costs onto the road user so that they are accounted for in private choices of if, when and how to travel. Many submitters, (eg, Contact Energy, sub. 29; LGNZ, sub. 36; NZAA, sub. 43; and Z Energy, sub. 110) suggested introducing congestion or road pricing.

Well-designed road pricing could deliver multiple benefits such as more efficient use of road infrastructure and a reduction in investment in new road capacity. It could incentivise people who currently travel at peak times to pursue alternative options such as carpooling, shifting to public or

¹¹⁹ In particular, the MoT (2005) study excluded vehicle purchasing and maintenance costs but included private travel time costs.

¹²⁰ The amount of \$250 million a year measured the difference between the observed cost of travel and the cost of travel when the network is at capacity. The amount of \$1.25 billion a year measured the difference between the observed cost and travel and zero traffic ("free flow"). Both measures include the costs of travel time delay, schedule costs (ie, those who stagger or delay their trip times), crash costs, vehicle operating costs and environmental costs.

active transport, or travelling at less busy times. Such actions would reduce emissions and other externalities.

Legislative changes are required to enable the use of road pricing tools. Under current legislation, tolls and congestion charges cannot be placed on existing roads, and tolling schemes on new roads can only be introduced under Order in Council.

Air pollution

In addition to CO₂, vehicle emissions include particulates, carbon monoxide, nitrogen dioxide, sulphur dioxide and benzene. The most harmful to human health are particulates and carbon monoxide.

- Particulates are very fine particles associated mainly with diesel vehicles. They can settle in the bronchial pathways and lungs causing respiratory problems such as asthma and bronchitis.
- Carbon monoxide is mainly associated with petrol vehicles. It makes heart disease worse, causes drowsiness and has been linked with learning difficulties. The effects of carbon monoxide are greater in cities due to high traffic and congestion rates (MoT, 2017a).

The Government's primary tool for reducing harmful vehicle emissions is the Land Transport Rule: Vehicle Exhaust Emissions 2007. The Rule sets emissions standards that new and used vehicles must meet when entering the New Zealand fleet. However, no pricing mechanisms are in place to internalise the costs associated with air pollution.

A good case exists to adjust the pricing arrangements for transport so that they more fully reflect the range of negative externalities associated with different modes of transport. In addition to improving wellbeing by creating a financial incentive to avoid travel that creates the externality, pricing externalities incentivises behavioural change consistent with lower transport emissions. Such changes include more efficient travel choices (for example, avoiding travel when roads are likely to be congested), and the adoption of more efficient vehicles. In addition, alternative modes of travel (such as public transport) are likely to become relatively more appealing if consumers face the full costs of private vehicle travel.

R11.5

The Government should take steps to amend the pricing system for transport so that a greater share of the external costs associated with private vehicle use are internalised. For example, Government should work with councils to enable and encourage the use of road pricing tools to reduce congestion and emissions in main urban centres.

11.9 Efficient investment in infrastructure for low-emissions transport

The previous sections discussed the potential to reduce emissions while achieving other co-benefits by shifting passenger and freight movements to lower emissions modes. Transport infrastructure dictates the travel options available and their relative attractiveness to individuals and businesses. Investment in low-emissions transport infrastructure is therefore a key determinant of the potential for mode shift to occur.

Past transport investment in New Zealand has focused on roading

As mentioned in section 11.1, choices to focus investment on the motorway network rather than public transport networks date back to the 1950s. The post-war road-building boom saw roading expenditure, as a percentage of gross domestic product (GDP), increase to around 2.5% before declining to around 1% through the 1980s and 1990s (MoT, 2014). Investment in public transport and dedicated cycling facilities was very limited throughout this period.

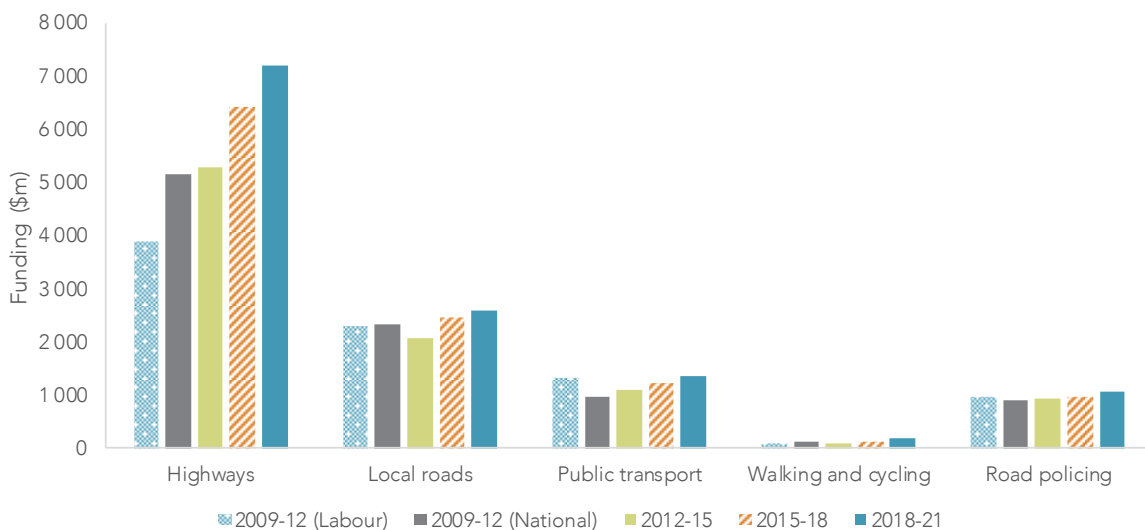
A pronounced increase in investment across most transport activities began around 2004. Total annual transport expenditure has roughly doubled as a percentage of GDP since the early 2000s (MoT, 2017). Significant developments for low-emissions transport in this period include electrification of the Auckland rail network (2011–2015); upgrades to the Wellington metro rail network (2011–); the Urban Cycleways Programme (2014–); and construction of the Auckland City Rail Link (2017–).

However, investment in roading has increased significantly more than investment in alternative transport modes (Figure 11.17). The previous Government’s Roads of National Significance (RoNS) programme committed an estimated \$12 billion to seven large motorway projects (Bridges, 2017). NZTA states that the RoNS projects represent a “lead infrastructure” approach to encourage economic growth rather than wait until the network is under strain (NZTA, n.d.). This approach has not been applied consistently to investment in public transport and rail infrastructure. Under the assessment framework developed by NZTA for prioritising and allocating funding under the National Land Transport Programme (NLTP), any project that the government labelled a RoNS would receive a “high” rating for strategic fit — effectively guaranteeing funding — despite several of the RoNS projects being assessed with low benefit–cost ratios (Pickford, 2013).

Many submitters¹²¹ called for adjustment of funding settings to provide greater emphasis on public and active transport and rail freight. The Guardians of NZ Superannuation (sub. 32, p. 10) noted that “a key barrier to a low-emission mass-transit system is the lack of a long-term, government-led mass-transit infrastructure investment strategy”.

The Government released a new draft Government Policy Statement (GPS) in April 2018, which proposes a marked shift in funding priorities away from state highway improvements and towards public and active transport (New Zealand Government, 2018).¹²²

Figure 11.17 Recent National Land Transport Programme funding by activity



Source: Government Policy Statements on Land Transport.

Notes:

1. The graph shows the upper limit of funding ranges.
2. Two sets of figures are shown for the 2009–12 period, as new funding ranges were introduced following the change of government.
3. Additional investment outside the NLTP is not shown. This includes around \$200 million a year in capital injections for KiwiRail and other Crown funding for rail projects, including the City Rail Link.

The current system can inhibit efficient investment in low-emissions transport options

New Zealand’s land transport investment system is set out in the Land Transport Management Act 2003. Every three years, central government issues a GPS on Land Transport. The GPS sets the overall objectives

¹²¹ Submissions 12, 13, 14, 26, 36, 57, 74, 97, 99, 105, 119, 121 and 126.

¹²² Direct comparison between funding ranges in the current and prior draft GPS is problematic due to the introduction of new activity classes and the inclusion of funding previously excluded in the document (eg, funding for the Auckland City Rail Link).

and long-term results sought for land transport over a 10-year period, as well as the national funding ranges for each class of transport activity (eg, new state highways, local road maintenance, public transport, road policing). Regional authorities develop Regional Land Transport Plans which set out the regions' own objectives and intended activities. NZTA then develops a three-year NLTP, which gives effect to the GPS and outlines the activities and projects that will receive funding from the NLTF.

Several submitters referred to the current transport planning, funding and investment system – beyond simply the current settings – as a barrier to reducing transport emissions.

[E]xisting transport planning and policy settings, investment models, and forecasting methods, inhibit the development of innovative multi-modal transport solutions that could deliver emissions reductions in the transport sector. [...] The existing transport funding model incentivises councils to focus exclusively on road transport solutions, and regions are unable to adopt the best solution to transport issues, whether it be road, rail, air or sea. (South Island Regional Transport Committee Chairs Group, sub. 14, p. 1 & p. 3)

The Commission has identified the following five issues within the current system.

Restrictions on which transport activities can receive funding from the NLTF introduce a bias towards road transport solutions and create inefficiencies

Despite its name, the NLTP does not encompass all investment in the land transport system – only those activities approved or managed by NZTA. Most notably, this excludes investment in rail track facilities.¹²³ Investment in rail infrastructure, managed by KiwiRail, is not covered in the current GPS. Instead, KiwiRail has relied on Crown appropriations through the annual Budget process. For example, investments in Auckland and Wellington's metropolitan rail networks over the last decade received supplementary Crown funding. Coastal shipping facilities and inter-regional public transport services are also excluded from NLTF funding. A council or the NZTA may identify a preferred or more cost-effective investment involving these activities, but be forced to pursue a roading project instead unless they can successfully lobby for funding through other political processes. Box 11.5 presents two case studies that illustrate this issue.

Different assessment methods are used for investments in the road and rail networks

This is a further consequence of the current segregation in funding processes. Investments in the rail freight network are typically assessed as a business case for KiwiRail, preventing consideration of wider social benefits such as reductions in emissions,¹²⁴ congestion, accidents and road maintenance requirements. Roothing projects, on the other hand, are assessed using a full social cost-benefit analysis along with other non-financial criteria set out in the GPS.

Funding levels can restrict the ability for projects to compete based on their merits

The government sets out NLTF funding ranges for different transport activity classes in the GPS. The funding settings reflect the Government's view on how to best deliver on its stated priorities and objectives, but it is not clear how evidence is used to inform these decisions. While flexibility is provided by having funding ranges (which NZTA is tasked with optimising across), this is limited in practice, especially when dealing with large, one-off infrastructure projects. For example, even if the Auckland City Rail Link construction could be funded from the NLTF in principle, the scale of investment required would dwarf the typical annual funding range for public transport activities. The activity class structure would prevent the project from competing with large roading projects in the Auckland region (or elsewhere) for funding.

In an analysis undertaken as part of the development of the draft GPS 2018, MoT (2017d, p. 86) received feedback from local government stakeholders that

[a]most all regions sought greater opportunity to use multi-modal approaches and/or flexibility in the GPS. Some regions felt that activity classes interfered with the overall story and objectives of the GPS. The regions felt that multi-modal solutions were less achievable under the current GPS structure.

¹²³ Only passenger rail services and associated above-track infrastructure (such as train stations) can be funded through the NLTF.

¹²⁴ KiwiRail's business case would presumably include the projected cost it will face through the Emissions Trading Scheme, but exclude the social benefit of reductions in emissions from road freight due to its operations.

Similar calls for greater multi-modal flexibility were made in submissions on this inquiry from the South Island Regional Transport Chairs Forum (sub. 32), Environment Canterbury (sub. 26) and Auckland Council (sub. 97).

Differences in the funding assistance rates for different activities incentivise councils to favour state highway projects

Funding assistance rates (the percentage of total project funding contributed by central government) for local roads, public transport and walking and cycling activities vary by region with a nationwide average of 53% at present (NZTA, 2014). State highway projects are fully funded by central government. In urban areas where choices exist between expanding the state highway network or improving public transport networks, councils and ratepayers will be biased towards expanding the state highway network since it will not involve any direct financial contribution.

Restrictions on revenue-raising tools limit councils' autonomy in a system that is already highly centralised

Current legislation inhibits councils from using alternative revenue-raising tools such as congestion pricing, value capture and regional fuel taxes. This increases a council's dependence on central government funding sources and restricts their ability to determine their own transport priorities. These tools could help to overcome political and financial barriers to public transport investment by giving councils alternative options to raising rates. The Commission's 2017 report *Better Urban Planning* discussed the use of these funding tools and recommended that councils be enabled to implement road pricing and value capture mechanisms (NZPC, 2017a). The Government is currently amending the Land Transport Management Act to enable councils to levy a regional fuel tax.

The issues listed above work individually and in concert to create a bias towards investment in roading projects. This creates potential for poor outcomes that will lead to higher emissions, though it is unclear to what extent it has affected recent investment decisions in practice. However, evidence from submissions indicates that councils generally want to be able to invest more in public and active transport and alternatives to road freight, and favour a shift in central government funding priorities and processes.

Box 11.5 Examples of how restrictions on NLTF funding can inhibit low-emissions investments

Third Main Line from Wiri to Westfield

The Wiri to Westfield section of the North Island Main Truck railway in South Auckland is a key link for both freight and passenger services. The current twin track configuration is operating at maximum capacity. NZTA, KiwiRail and Auckland Transport collaborated to produce a case for investment which recommended building a Third Main Line (WSP and Parsons Brinckerhoff, 2016). This served as the basis for a 2017 Budget bid by KiwiRail, which was unsuccessful. The economic assessment gave an expected cost of \$60 million and benefit–cost ratio of between 1.5 and 2.3. While relatively low, this ratio is in a similar range to many roading projects funded under the current NLTP. Given NZTA's support for the investment case, it seems likely that if the Third Main Line could compete for funding through the NLTP process it would be successful.

Log cartage options in Marlborough

The South Island Regional Transport Committee Chairs Group's submission provided the following example where an investment in coastal shipping facilities would be considerably cheaper than a road upgrade, but is ineligible for funding.

The Marlborough RTC has been dealing with the issue of log cartage from the Pelorus and Kenepuru Sound areas. Significant commercial forestry was established in these areas in the 1980s and 1990s, supported by government subsidy. These forests are now ready for harvest but the required infrastructure is not in place. The cost of upgrading the Kenepuru Road to an appropriate standard is around \$6.1 million. In contrast, the cost of establishing a barging facility and upgrading roads to that facility is estimated at \$930 000. Barging the logs would also lead to less wear and tear on roads. Barging is also the cheaper option for forestry companies; although it requires double handling, the cost can be weighed against the distance trucks need to travel. The

current GPS does not permit the funding of a barging solution. (South Island Regional Transport Committee Chairs Group, sub. 14, p. 3)

Levelling the playing field for transport investment

In principle, an efficient transport investment system will be designed to minimise biases and siloes, and to guide investment to deliver the highest value to society when all costs and benefits are considered.

Transport planning and funding should consider the most cost-effective modes of transport for each location, taking into account the full costs, including social, economic, and environmental. (Transport and Industrial Relations Committee, 2017, p. 26)

In practice, the economic impacts of transport projects – particularly large, transformative ones – are difficult to predict and quantify. Any assessment method will involve important values judgements. Transport infrastructure can have a strong effect on location choice for people and businesses over time, which poses a challenge to conventional economic assessment methods that focus on short-run impacts and put heavy emphasis on travel time savings (NZIER, 2013). Uncertainty around the rate of uptake and the effects of new transport technologies such as autonomous vehicles (section 11.2) adds further complexity.

Nonetheless, the Government should strive for neutrality as a guiding principle in the investment system. The previous Government signalled possible moves in this direction in May 2017 when it announced a review of KiwiRail’s operating structure (Burr, 2017). The review was stated to be focused on ensuring that KiwiRail is “on an even footing when it comes to funding”, with options suggested including allowing KiwiRail to bid for funding from the NLTF, and removing the requirement for the company to return a profit.

In the new draft GPS 2018, the current Government has introduced a theme of “a mode neutral approach to transport planning and investment decisions” (New Zealand Government, 2018, p. 23). The draft GPS suggests that this approach “will mean that the scope of the GPS is likely to expand to include aspects of rail freight and coastal shipping” (p. 48). As such, a second stage GPS is likely to be required following the conclusion of the rail review. Other relevant policy work (including possible input from the Climate Commission once established) might also be required. In the meantime, the draft GPS includes a transitional rail activity class to provide immediate scope for funding passenger rail projects. It also proposes a new approach that will see results linked to objectives rather than activity classes, so that a single project may receive funding from multiple activity classes.

F11.17

New Zealand’s current transport investment system is biased towards investment in roading. An efficient transition to a low-emissions transport future requires an investment system that is:

- better integrated across modes;
- more flexible, with greater competition for funding across different transport modes and activities, and greater autonomy for councils;
- more neutral, by removing distortions and biases that favour particular modes or activities, and fully accounting for social, economic and environmental costs and benefits.

Addressing path dependence

Removing biases in the transport investment system and improving the efficiency of transport pricing have the potential to drive significant change to travel choices and investment decisions in the direction of low-emissions mobility. However, the transport system is subject to strong path dependence. Past investment decisions and policy settings have shaped New Zealand’s present land use, travel patterns and social norms. Future choices will continue to be shaped by the past focus on roading and private vehicle travel.

Path dependence also affects the political economy of making beneficial policy changes. For example, a lack of quality alternatives to car travel due to past under-investment poses a barrier to implementing a congestion price in Auckland. Over time, congestion pricing should enable a reduction in subsidies for public transport trips due to more people using such transport, but increased investment in infrastructure and services may be needed to smooth the transition, limit distributional impacts and “lean against the past”. This provides a case for some explicit prioritisation of low-emissions modes in the transition to a neutral system.

Providing a stronger focus on emissions reductions

The previous Government amended the purpose of the Land Transport Management Act in 2013 to “contribute to an effective, efficient, and safe land transport system in the public interest”.

While the current legislation does not limit the Government’s ability to focus on reducing emissions from transport, nor does it provide any explicit steer in this direction. The extent to which reducing emissions is a consideration in transport investment is left to be determined by the GPS.

The previous Government’s draft GPS 2018 largely represented a continuation from the current GPS 2015, renewing the same three strategic priorities – economic growth and productivity, road safety, and value for money – and six objectives. One objective was for a

land transport system that increasingly mitigates the effects of land transport on the environment. (New Zealand Government, 2017a, p. 12)

However, this objective was to explicitly receive less focus than others (p. 12), implying only weak emphasis on reducing emissions. Notably, the previous draft GPS did not refer to any national emissions targets, even though it would span most of the period of New Zealand’s first Nationally Determined Contribution under the Paris Agreement.

The new draft GPS 2018 promotes “environment” as one of four new strategic priorities, with a corresponding objective for a

land transport system that reduces the adverse effects on the climate, local environment and public health. (New Zealand Government, 2018, p. 7)

The Commission believes a stronger emphasis on emissions reductions in the GPS is necessary and appropriate.

R11.6

The Government should make emissions reductions a stronger strategic focus in transport investment. This should include changes to the Government Policy Statement on Land Transport to broaden its scope to cover the whole land transport system and make the transition to a low-emissions economy a strategic priority.

11.10 Conclusion

Transport has been the biggest contributor to New Zealand’s rising emissions over the last thirty years. Yet, the wide range of mitigation options already available for transport means it can play a greater role than other emitting sources in achieving a low-emissions economy.

Raising the emissions price in the NZ ETS is an important step in reducing transport emissions. However, because fuel demand is relatively unresponsive to changes in price, additional measures are needed to achieve large emissions reductions.

With New Zealand’s low-emissions electricity grid, EVs provide a huge mitigation opportunity. Modelling suggests that EVs can contribute a significant portion of emissions reductions across the economy. As costs continue to fall, EVs can also provide cost savings for consumers, though price is still among the key barriers to faster EV uptake. Further, New Zealand’s vehicles stay in the fleet for a long time, so electrification of the whole fleet will take decades. To achieve an ambitious long-term emissions target, additional policies are

needed to support and accelerate uptake of EVs. The Commission recommends that MoT takes steps towards introducing a price feebate scheme to provide stronger incentives to purchase low-emission vehicles.

While EVs will play a substantial part of the transport mitigation mix, other mitigation options should also play a role. New Zealand is one of the very few developed countries without vehicle emissions standards. New Zealand should introduce standards so that it avoids becoming a dumping ground of high-emitting vehicles from other countries decarbonising their fleets. Options such as shifting to low-emission transport modes (eg, public transport and rail freight) and reducing congestion, result in relatively minor emission reductions. Even so, such options can provide valuable health, environmental, and productivity benefits.

More broadly, investment skewed towards roading and a failure to price negative externalities from private vehicle use has led to high private vehicle travel and inefficient vehicle choices. More cost-reflective pricing of vehicle externalities would lead to more efficient and lower emission outcomes. Finally, with a level playing field for investment in infrastructure, the transport system would better support rather than stifle shifts towards low-emission modes.

12 Electricity

Key points

- New Zealand already has a low-emissions electricity system (emitting around 5 megatonnes of carbon dioxide equivalent a year), with up to 85% of electricity generated from renewable sources. Remaining thermal generation mostly serves, when required, as a currently vital resource to meet demand at daily and seasonal peaks and during dry years.
- The demand for electricity will increase greatly as other parts of the economy, particularly transport and process heat, replace fossil fuels with cleaner electricity. Expanding the supply of electricity could increase the challenge of reducing electricity emissions.
- New Zealand has abundant unused sources of renewable energy, particularly wind power (the cost of which has been falling rapidly) and geothermal (which still produces some emissions). Rapid technological development is allowing more responsive management of electricity demand and integration of distributed energy resources (such as solar power and batteries) into the system. These developments will complement grid-scale renewable energy generation to contain the need for thermal generation.
- Under current technology and prices, no options exist to completely eliminate greenhouse gas emissions from electricity generation, without greatly increasing wholesale electricity prices. Yet technology is changing rapidly and by 2050 economic options, such as tidal or biomass generation and carbon capture and storage, may have emerged. The price of wind power may also fall to the point where holding surplus renewable generating capacity is an efficient option for reducing the need for thermal generation.
- Given technological uncertainty and the importance of electricity prices for the adoption of low-emissions technologies in other parts of the economy, the Government should not favour particular electricity-generation technologies. The Government should, instead, through the New Zealand Emissions Trading Scheme, rely mostly on effective emissions pricing to guide new investment and decommissioning of existing plant.
- Integration of flexible demand response and distributed energy resources into a future electricity system will require ongoing adjustment to the regulation of electricity distribution. The Electricity Authority (EA) has a programme of work to address these issues. Yet the capability of the electricity distribution sector may not match the scope and speed of the required regulatory change. The EA should review the capabilities of the electricity distribution businesses to ensure they can fully support innovation that will benefit consumers and help reduce emissions.
- The electricity market is complex and has been evolving over time as participants and regulators learn from experience with regulatory adjustments; and respond to changing technology, weather patterns and economic conditions. The Government should consider the risk of unintended and expensive consequences of any new interventions in the electricity system. An efficient and well-functioning electricity system will play a central part in the transition to a low-emissions economy.

New Zealand already has an electricity system with a high proportion of renewable generation and relatively low greenhouse gas (GHG) emissions. Electrification of transport and process heat will play a big role in New Zealand's path to a very low-emissions economy (see Chapters 3, 11 and 13). This implies a large expansion in electricity generation in the years to 2050. In turn, this puts a premium on reducing electricity emissions, without raising electricity prices to a point where they dissuade electrification in other parts of the economy.

This chapter looks at the challenges in reducing electricity emissions efficiently, while ensuring that electricity supply meets demand at all times. Particularly important is the need to provide for dry years when hydro energy supply is limited. Based on current technologies, almost all the scenarios considered in this chapter envisage some thermal (emissions-producing) generation remaining in 2050 to meet this need. They also all involve additional emissions from geothermal generation. Yet technology is changing at a rapid pace and it is likely that over the next 30 years further options to reduce electricity emissions will emerge.

12.1 Low-emissions electricity will help reduce transport and process heat emissions

By international standards, New Zealand already generates a high proportion (85%) of electricity from renewable energy. Hydro generates more than 50% of New Zealand's electricity (in some years up to 65%). Electricity generation from fossil fuels produces around 4 megatonnes (Mt) of carbon dioxide equivalent (CO₂e) or around 5% of all New Zealand's emissions, while geothermal generation produces almost an additional 0.9 Mt CO₂e. The electricity and waste sectors produce a comparable level of emissions.

The path to a very-low-emissions electricity system requires decommissioning and not replacing existing thermal plants. Two major gas plants were closed in 2015. Yet thermal plant currently plays a crucial role in covering both daily peak demand and the risk of a dry year (section 12.2). As the proportion of electricity generated from intermittent renewable sources rises, ensuring that supply meets demand at all times may be more challenging (section 12.3).

Electricity is a significant input into other parts of the economy. Electrification of light vehicles and of process heat will play a central role on a pathway to a low-emissions economy (see Chapter 11 and Chapter 13). Light vehicles currently emit over 12% of all emissions, while using fossil fuels to produce heat for industry produces over 11% of all emissions. If reducing emissions from electricity generation significantly increases the cost of electricity, this could delay the electrification of other sectors where the reductions are potentially larger. The cost of reducing electricity emissions is therefore material not only for the effects on electricity consumers, but also for effects on the overall efficiency of emissions reductions across the economy (Mercury, sub. 49; Meridian, sub. 55; Transpower, sub. 81; Genesis, sub. 118).

The New Zealand Emissions Trading Scheme includes electricity generators. The Scheme requires them to surrender New Zealand Units covering their thermal and geothermal emissions. Section 12.4 investigates the emissions prices that are needed to incentivise very-low emissions generation and the flow-on effects on electricity prices.

12.2 Security of supply and resource adequacy

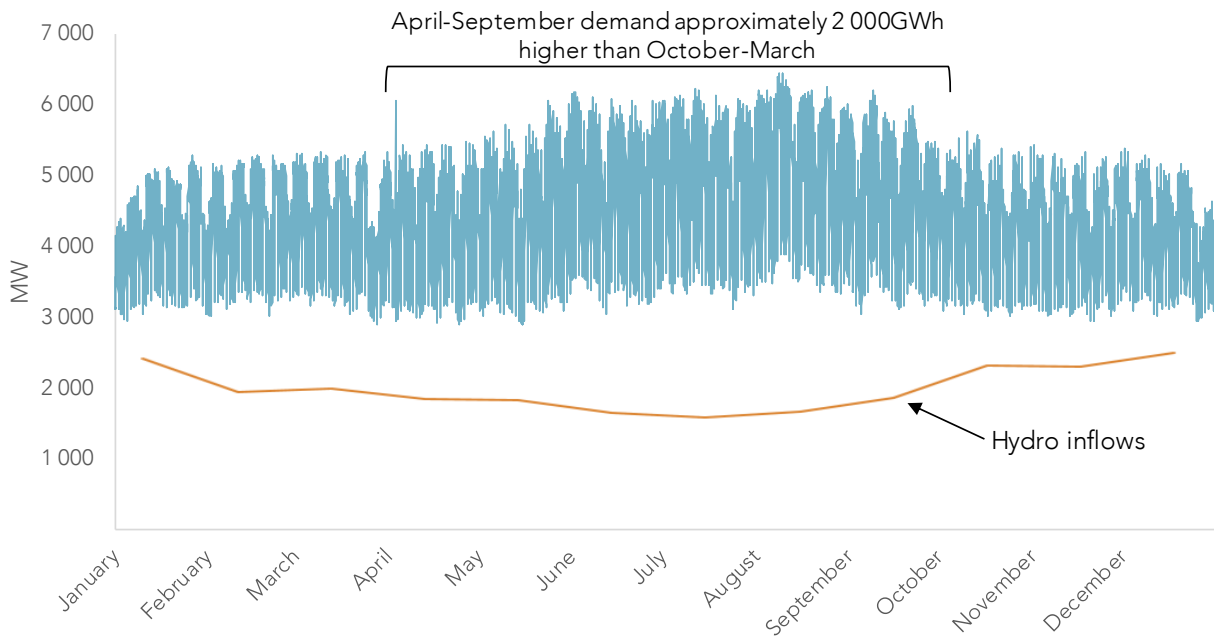
The biggest challenge for New Zealand in moving to a very-low emissions electricity system is providing for resource adequacy, particularly in dry years.

Resource adequacy

Resource adequacy has two broad dimensions:

- meeting the highest instantaneous demand from the system (capacity adequacy); and
- the ability to meet demand over a period of time (energy adequacy).

Demand varies by time of day, and by seasonal weather patterns (Figure 12.1). In 2016 demand peaked at over 6 000 megawatts (MW) and fell below 3 000 MW at its lowest. Some generation needs to be flexible to provide energy adequacy from one period to the next, as generation from intermittent fuels and demand varies over time. In the short term wind and solar generation vary, while in the medium term hydro, wind and solar energy inflows are uncertain and, on average, anti-correlated with demand. Heavy reliance on hydro energy means that seasonal changes in the weather potentially have a strong impact on energy adequacy in New Zealand.

Figure 12.1 Electricity half-hourly demand and monthly hydro inflows, 2016

Source: Stevenson et al. (2018).

Flexible fuel contracts (eg, for coal and gas) and storage of fuel in gas and hydro reservoirs and coal stockpiles have historically been important for supporting flexible generation. In the future, batteries and demand response (DR) will play significant roles in providing this flexibility; yet both are likely to provide only short-term flexibility. They are unlikely to provide the flexibility to deal with the confluence of seasonal changes in demand and seasonal changes in inflows, particularly during dry years.

Capacity and energy adequacy have a time dimension. The energy a plant can supply on average over a prolonged period is different to what it could supply in any given half hour. As a result, intermittent fuels, such as wind, contribute more to energy adequacy than to capacity adequacy. Wind is relatively dependable over extended periods, but cannot be relied on to supply energy in a particular half hour. On the other hand, gas plants, if required, can run at near capacity at any time, providing they have fuel on hand.

Solar, without accompanying battery storage, does not provide any capacity adequacy as peak demand in New Zealand occurs during winter nights. Without battery storage, a system with a large solar capacity will experience substantial hour-to-hour swings in output that need to be matched by some other flexible, responsive capacity.

Resource adequacy in “dry years”

Inflows to hydro lakes in particular years do not generally reflect the pattern of “average” inflows shown in Figure 12.1. Inflows can be quite volatile from month to month and season to season. Generators collectively manage this volatility currently by using a combination of:

- hydro reservoirs to “shift” some of the summer inflows to winter; and
- discretionary (thermal) plant to supplement supply in winter (sometimes referred to as hydro firming).

Figure 12.1 shows that in an average year, a significant amount of storage will be required to shift enough energy from periods of low demand and high inflows to periods of high demand and low inflows. New Zealand currently has around 4 000 gigawatt hours (GWh) of national storage, which provides an ample buffer in an average year.¹²⁵ Even so other factors increase the need for discretionary generation:

¹²⁵ Mercury (sub. 49) advised that a typical dry year shortfall in hydro generation is equivalent to around 4 terawatt hours (TWh). Mercury points out that meeting this shortfall through battery storage, even at 5% of the current cost of batteries, would be prohibitively expensive.

- weather patterns are not predictable and hydro inflows do not reliably match the averages depicted in Figure 12.1; and
- reservoir managers consider the risk of a dry year when deciding how much water to store before each winter (for instance, if rainfall is low in November, generators may then use thermal plant to meet current demand so as to preserve water in hydro reservoirs).

The electricity market coordinates generators' expectations and choices through the wholesale electricity price. In addition, Transpower currently conveys information to the market on seasonal resource adequacy through two measures – the Winter Capacity Margin (WCM) and Winter Energy Margin (WEM).¹²⁶

The energy margin... assess[es] whether it is likely there will be an adequate level of generation and HVDC [high-voltage direct current] south transmission capacity to meet expected electricity demand in extended dry periods. The capacity margin assesses whether it is likely there will be adequate generation and HVDC north transmission capacity to meet peak North Island demand. (Transpower, 2018, p. 4)

A future increase in demand for electricity (due for instance to electrification of the vehicle fleet and industrial heat) may increase the amount of energy required to be shifted across seasons through hydro storage. Current storage capacity may need to be further supplemented from other flexible sources of generation (such as thermal) or demand management (section 12.4) or changes to hydro resource consents.

Quality of supply and system stability

A well-functioning electricity system needs to reliably supply electricity of suitable quality to meet demand at all times. The system needs a stable, resilient grid that can adjust rapidly to sudden fluctuations in demand and supply, including unplanned breakdowns of major system components. The System Operator (a unit within Transpower) commissions ancillary services to maintain quality of supply. These services keep frequency and voltage within specified ranges and restore operation in the event of a major outage. A system with a high percentage of intermittent renewable generation poses challenges for maintaining system stability (section 12.6).

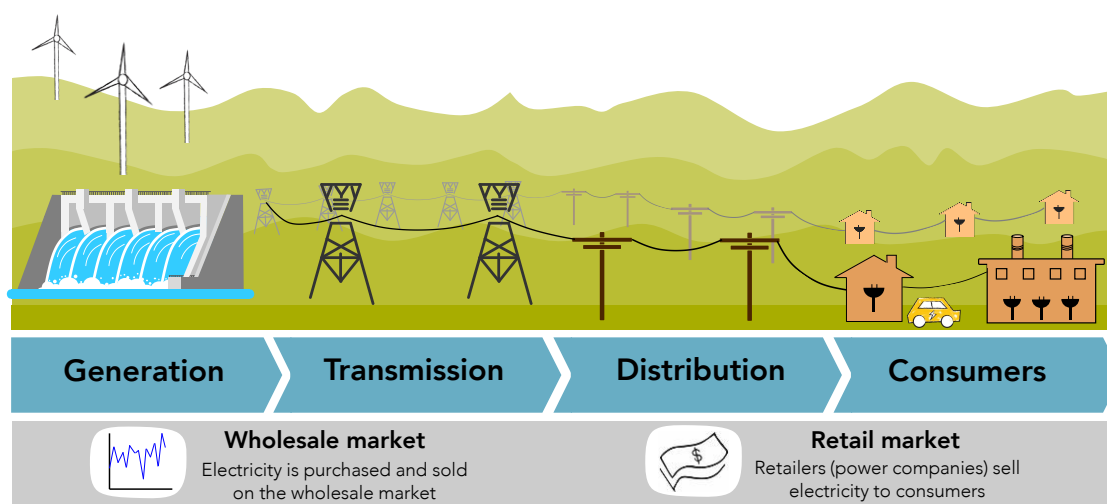
12.3 Decision making in the New Zealand electricity sector

Five large generation companies operate 179 power stations to produce the majority of New Zealand's electricity. Transpower, a state-owned enterprise, owns and operates the national transmission grid, while 29 electricity distribution businesses (EDBs) transport electricity from the grid to homes and businesses.¹²⁷ Consumers buy their electricity from one of more than 30 retailers. Some generators also operate retail businesses (see Figure 12.2 on the next page).

Transpower, as the contracted system operator, coordinates electricity supply and demand to ensure a continuous balance both in real time and for future periods. The Electricity Authority (EA) oversees the operation of the wholesale electricity market.

¹²⁶ Transpower also publishes daily hydro lake levels relative to hydro risk curves.

¹²⁷ New Zealand has an unusually large number of EDBs for its size — Australia has 16 and the United Kingdom has 13 (IEA, 2017a).

Figure 12.2 Electricity supply in New Zealand

Institutions and regulation of the electricity sector

The EA, an independent Crown entity is the primary electricity market regulator, responsible for the efficient operation of the New Zealand electricity market. Section 15 of the Electricity Industry Act 2010 specifies the EA's objective as being "to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers". The EA sets the framework for the operation of the sector, including provisions for "security of supply" (or resource adequacy). In particular, it establishes rules for the sector through the Electricity Industry Participation Code (the Code). The EA also guides the methodologies for allocating transmission and distribution network costs between different network users.

Under Part 4 of the Commerce Act 1986, the Commerce Commission regulates Transpower and EDBs because they operate in environments with little or no competition.

The Commission applies price-quality regulation to Transpower and 17 of the 29 EDBs. The Commission sets:

- the maximum prices/revenues that are allowed at the start of the regulatory period;
- the yearly rate at which maximum allowed prices can increase; and
- the minimum service quality standards that must be met.

Twelve mostly small trust-owned EDBs are subject only to information-disclosure requirements.

In addition, Transpower must obtain Commerce Commission approval for investment in transmission grid upgrades above a certain size and for base capital expenditure.

How the New Zealand electricity market operates

The International Energy Agency (IEA) notes:

New Zealand's electricity system is unique. New Zealand was among the first IEA members to introduce unbundling and competition in its electricity market. The country has an effective energy-only market based on financial transmission rights and locational nodal pricing – it is a leading example of a well-functioning electricity market design among IEA member countries, and continues to work effectively, thanks to appropriately targeted Government intervention. (IEA, 2017a, pp. 101-102)

Since the 1990s, the main features of New Zealand electricity market have been:

- an energy-only electricity market (meaning generators are paid only for electricity they supply and no payments are made simply for supplying capacity or energy adequacy);

- financial contracting for risk management (whether over the counter or through an organised exchange in financial instruments);
- separation between lines and retail businesses (although this was relaxed in 2010, the extent of retailing activity by lines companies remains minor);
- open or equal access arrangements to transmission and distribution networks; and
- full retail contestability.

Retail tariffs are not generally regulated, but are subject to the Low Fixed Charge (LFC) Tariff Option regulations (2004) (section 12.6).

The “energy only market” establishes the wholesale price of the lowest-cost supply of electricity at the margin to meet demand in all conditions. Generators only receive payment if and when they run. No payment is made for available but unused capacity.

As electricity demand rises and falls, the System Operator calls additional generators on to the system or dispatches them off based on their offer prices and so supply meets demand. Wholesale prices are published every 30 minutes for a number of locations around the grid, while indicative spot prices are published every five minutes. All generation that runs generally receives the price of the highest-priced, dispatched generator’s offer, adjusted to each generator’s (and load’s) location. Discretionary plant (such as hydro and thermal) generally set the wholesale price as such plant can operate “at the margin”, while other less-flexible plant is a “price taker”.

The Code provides for scarcity pricing in the form of a price band between \$10 000 and \$20 000 megawatts an hour (MWh), which is introduced into the market when an electricity supply emergency forces power cuts (called emergency load shedding). This provides an incentive for retailers to hedge wholesale purchases and to take other steps to avoid exposure to high wholesale prices.

As noted, there are also markets for ancillary services to manage the security and quality of electricity supply. Ancillary services are available

to keep the frequency of the grid within its normal band; to provide additional electricity in the event of failure; to reduce injection of electricity to stop an unplanned rise in system frequency; to inject power into the system to boost voltage; and to restore operation in the event of a major power outage. (Electricity Authority, 2016, p. 21)

Investors decide on the location and type of generation after considering the prospective profits and risks from selling electricity and ancillary services. Two such risks are operating in fewer periods than expected and volatile income streams. Generators must meet technical requirements for connection to the grid (administered by Transpower) and comply with market rules, including prudential requirements.

Domestic-scale consumers, who have a choice of retailers, usually receive an invoice with all of the costs of supply bundled together. Costs include distribution, transmission, energy, an emissions price, risk, retail overheads, metering, market administration and Goods and Services Tax (GST).

Consumers are able to install their own generation and batteries “behind the meter”. Distribution charges may take this into account. Some retailers offer incentives to consume at times of the day that will reduce the costs to both the EDB and the retailer. Increasing numbers of consumers are taking up these options.

A market for firm energy is developing

Stevenson et al. (2018) raise the issue of the strength of incentives to retain plant purely to manage extreme hydro shortfalls (known as firm energy) in a system with a high proportion of renewables. They argue that investors in such plant would have to be rewarded with very high prices when it did operate, given the infrequency of use. They question whether, at some time in the future, New Zealand will require a market for firm energy (alongside the market for energy) to address this issue.

Yet a useful market for firm energy already exists, though it mostly operates among the large generators and gentailers. In particular, Genesis has retained the Huntly Rankine plants for use under a voluntary “swaption” agreement with Meridian (which runs hydro and wind generation) (New Zealand Herald, 2016). Meridian also has demand response (DR) arrangements with the Tiwai Point aluminium smelter that effectively provides it with firm energy in the event of a dry year. In addition, Huntly provides Genesis with firm-energy cover for its retail base.

The EA has been working to get financial products that cap electricity prices listed and traded on the Australian Stock Exchange. These products will further facilitate the development of voluntary markets for firm energy in New Zealand. The initiative seeks to bring greater transparency and robustness to pricing of capacity and dry year risks. It will provide a means for any electricity retailer or consumer to insure against large spikes in wholesale prices. The trading of these products will reward investors for holding plant to provide firm energy when required.

The EA anticipates undertaking further initiatives to encourage demand-side participation in the market for firm energy (section 12.5 and section 12.6). The EA expects that this approach, by starting early, will provide time for market participants to learn from events and evolve their risk management practices (pers. comm., 13 April, 2018).¹²⁸

12.4 Future low-emissions electricity supply pathways

This section looks at possible pathways to a very-low-emissions electricity system, the emissions prices that might be needed to incentivise those pathways, and the effect on electricity prices. It mostly assumes current technology and technology prices. In reality, technology and prices are changing rapidly and will certainly continue to do so over the next thirty years. As a result, the analysis in this section is only a starting point for thinking about how to achieve very-low-emissions electricity generation. Even so, current prices and technologies will likely influence some long-lived investments in generating plant that will need to be made in the next decade.

Current emissions

Current electricity emissions come mainly from five sources:

- fossil fuel co-generation (electricity generated in conjunction with an industrial process, such as the gas turbines operated by Contact at Fonterra’s Te Rapa dairy factory);
- coal- and gas-fired generation from the Huntly Rankine station (HLYR);
- generation from combined-cycle gas turbines (CCGTs) at Huntly (HLY5) and in Taranaki (TCC);
- gas generation from flexible peaking turbines in Taranaki and Huntly; and
- geothermal generation (Box 12.1).

Box 12.1 Emissions from geothermal generation

Geothermal energy, a renewable source, generates a significant and growing proportion of New Zealand’s electricity. Yet using geothermal fluids to generate energy causes “fugitive” CO₂ and CH₄ emissions. The emissions depend both on the technology used and on field chemistry. The emissions intensity of New Zealand’s most intensely emitting geothermal plant (Ngawha) is higher than that of a low-efficiency gas plant. Even so, six of New Zealand’s seven plants have substantially lower emissions than high-efficiency gas plants. The volume-weighted average emissions intensity across all plants is approximately a quarter of that of gas.

¹²⁸ A market for firm energy is viable because consumers place a high value on security of supply and are prepared to pay high spot prices or a high “insurance premium” for cap products. This in turn means generators will be well-remunerated for having resources available. (See Electricity Authority (2013) for data on the value that consumers place on security of supply.)

Geothermal technology is currently chosen for its efficiency. Binary units (which use a second fluid in a heat exchanger) are more efficient in low-energy-intensity fields and can reinject nearly all extracted fluids back into the field (including potential GHG emissions). Double or triple flash plants (which flash off the dry steam from the geothermal fluid, to drive the turbines) are more efficient in other circumstances, but release GHG emissions along with dry steam. It is feasible to use heat exchangers in high-energy intensity fields, but, with current technology, this causes efficiency losses. A rising emissions price may shift the advantage towards binary units, new heat-exchange technology and lower emissions in the future. This would be reinforced by pricing actual emissions rather than using average emissions factors for geothermal generation.

Economic cost-effective carbon capture and storage (CCS) methods for geothermal fields may also emerge in the future (Chapter 13). Iceland is already demonstrating such a method, though it requires the location of geothermal plant near large basalt formations and an ample source of water.

Source: Stevenson et al. (2018); Orkuveita Reykjavíkur (2018); Contact Energy, sub. 29; New Zealand Geothermal Association (2018).

Most of current electricity emissions (with the exception of geothermal) result from the use of thermal plant to provide resource adequacy (section 12.1). Annual emissions depend on the extent to which plant is used in this way, which in turn mostly depends on weather patterns.

Future pathways

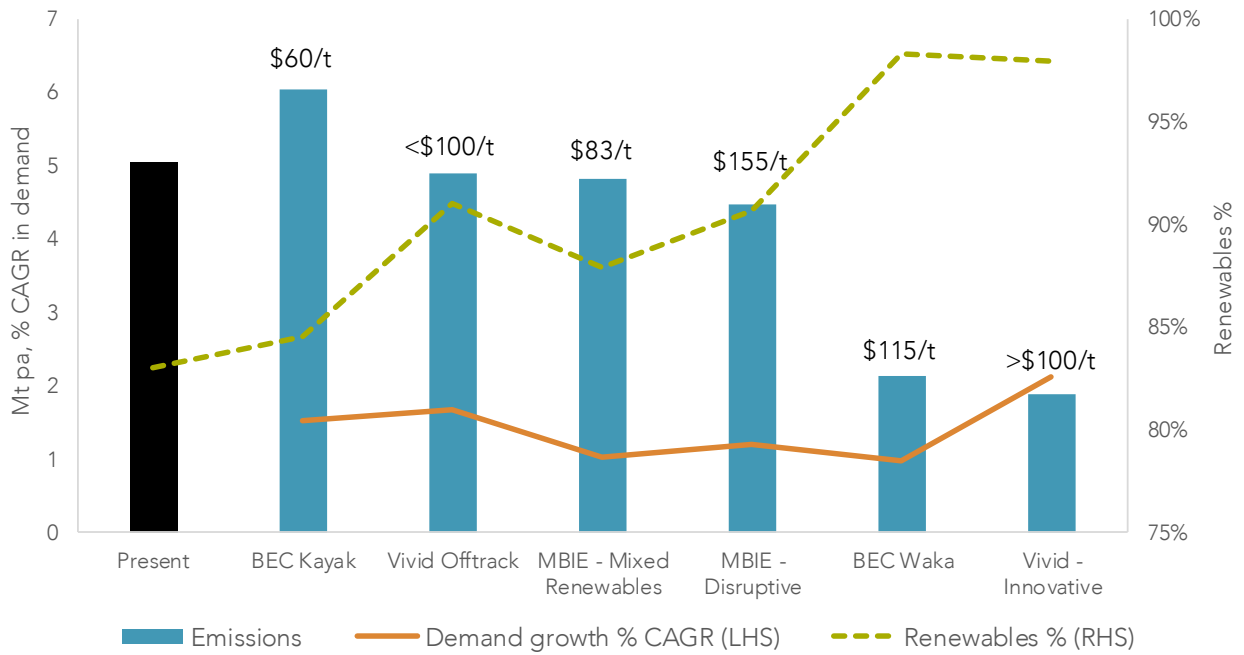
The Commission engaged electricity system analysts from consulting firm Sapere to identify the opportunities and risks for electricity supply in New Zealand that arise from moving to a very low-emissions electricity system. Sapere analysed different electricity supply and demand scenarios that had been developed over the last several years to look at possible future electricity system outcomes (Stevenson et al., 2018). Separately, the Commission also engaged a consortium led by Vivid Economics to model pathways to a low-emissions economy, which included an electricity system module developed by Concept Consulting (see Chapter 3). This section draws primarily on the Sapere analysis, but also briefly covers the Concept Consulting model.

Sapere chose six scenarios for analysis. Two, “BEC Kayak” and “BEC Waka”, were developed for the Business New Zealand Energy Council (Business New Zealand Energy Council, 2015). The Ministry of Business, Innovation and Employment (MBIE) developed a further two – “MBIE Mixed Renewables” and “MBIE Disruptive”. Vivid Economics developed the remaining two – “Vivid Offtrack” and “Vivid Innovative” (Vivid Economics, 2017a). The BEC and MBIE scenarios are produced from models that explicitly build in investment decisions motivated by minimising lifetime costs.

Stevenson et al. (2018) note that the scenarios served different objectives, yet all incorporated an emissions price. They used this diversity to analyse the relationship between cost and emissions outcomes under different assumptions. They also tested four of the scenarios (but not the two Vivid scenarios) to see if, irrespective of emissions and cost, they would satisfy current market objectives for energy adequacy and capacity adequacy (expressed in the WEM and the WCM).

Figure 12.3 shows the relationship between emissions, the percent of generation from renewable sources, demand growth and carbon prices as at 2050 for each of the scenarios.

Figure 12.3 Electricity sector emissions, renewable %, demand growth, and emissions prices in 2050



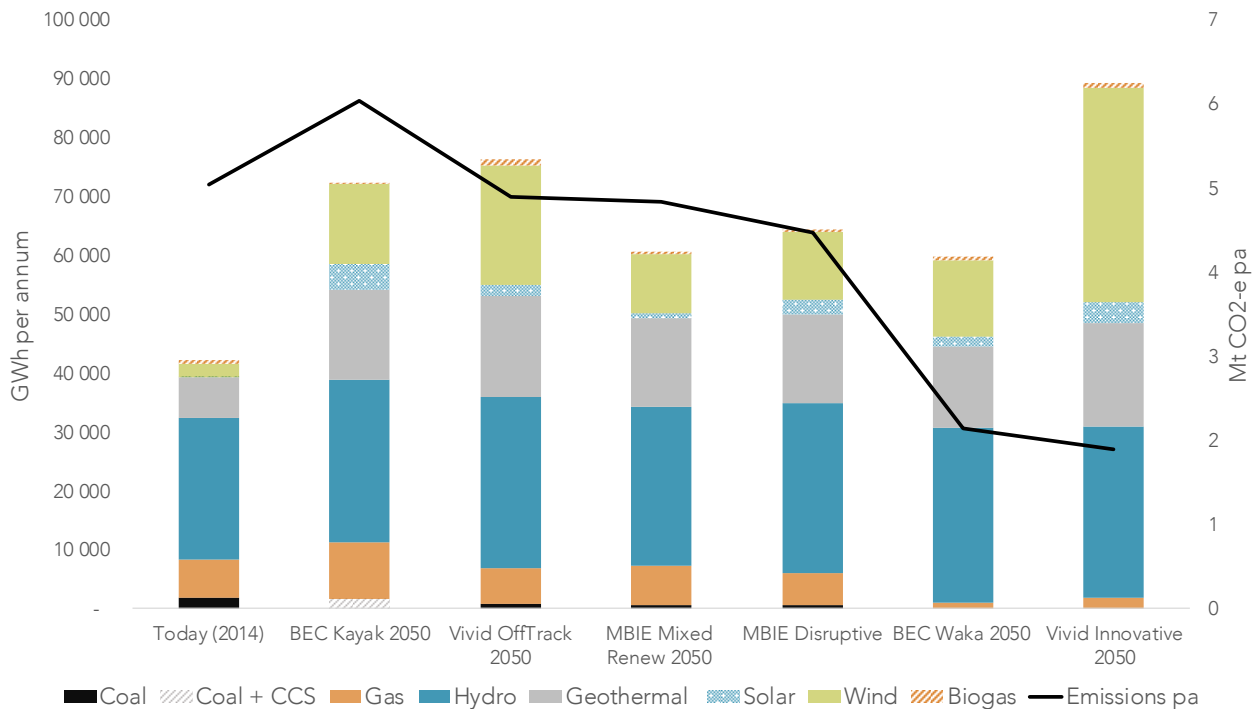
Source: Stevenson et al. (2018).

Notes:

1. CAGR refers to compound annual growth rates.

The percentage of renewable generation and the level of carbon emissions is broadly related, but growth in demand and the mix of generation, particularly the proportion of geothermal, have an influence on emissions (Figure 12.4). Each scenario assumes particular drivers of demand in 2050 (Box 12.2).

Figure 12.4 Breakdown of total generation by fuel and emissions, 2050



Source: Stevenson et al. (2018).

Notes:

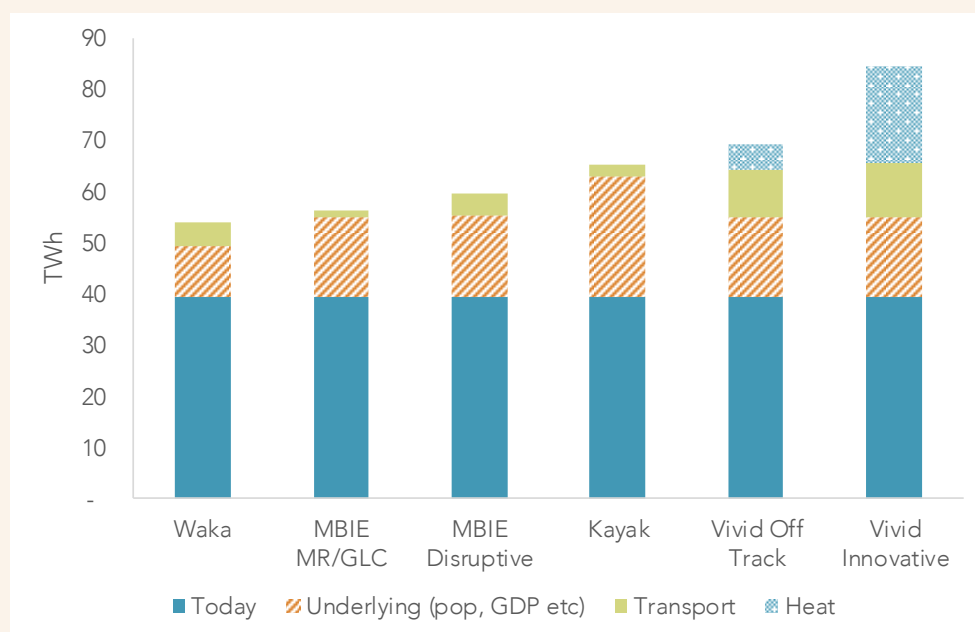
1. MBIE Mixed Renewables and MBIE Disruptive scenarios both include very small amounts of generation and emissions from wood – these are too small to be visible in the figure.
2. Though Vivid Innovative employs more thermal and geothermal generation than BEC Waka, it has lower emissions. This is because Vivid Innovative assumes that new technology will be employed to reduce the intensity of geothermal emissions.

Box 12.2 Drivers of future demand for electricity

Population growth, rising incomes, the uptake of electric vehicles and electrification of process heat in industry will be the main drivers of future demand for electricity (see Chapters 3, 11 and 13). Each of the six scenarios examined in the modelling for this chapter has different assumptions about the drivers of future demand (Figure 12.5).

As a result, the projected growth in demand for electricity varies from a 0.9% compound annual growth rate (CAGR) in the BEC Waka scenario to 2.1% CAGR in the Vivid Innovative scenario. By 2050 this difference represents 30 terrawatt hours (TWh) or 75% of today's total annual demand. The differences across scenarios have potentially significant impacts on the profile of demand over a day or year and, as a result, on the mix of generating capacity required to ensure resource adequacy.¹²⁹

Figure 12.5 Components of demand for electricity in 2050



Notes:

1. The two MBIE scenarios incorporate assumptions about the electrification of heat into their underlying growth assumptions.

Improving energy efficiency, particularly in the design and operation of buildings (see Chapter 15) and in the use of energy in industry will play a role in tempering demand (see Chapter 13). Average household demand for electricity has already been falling substantially since 2007, roughly offsetting the effect on electricity demand of the increasing number of households.

The future of the Tiwai Point aluminium smelter (the largest single user of electricity in New Zealand, consuming nearly 5 TWh each year) creates further uncertainty (Mercury, sub. 49; Transpower, sub. 81). All the scenarios examined for this chapter assumed the continued operation of Tiwai Point.

Demand-side technology (distributed-energy resources and demand response) will also offset a rise in demand from a growing population and electrification of transport and process heat (section 12.5).

Source: Stevenson et al. (2018).

Reductions in emissions are mostly due to the retirement of thermal plant, motivated by a rising emissions price and the availability of more economic alternatives such as wind and geothermal. Scenarios vary on

¹²⁹ The models reported in Chapter 3 all assume that demand for electricity will grow by at least 45% over the period 2015 to 2050. This is similar to the rate of growth in demand assumed in the Vivid Innovative model.

when, and the extent to which, retirement of thermal plant happens. All scenarios close the Huntly Rankine plant in the early to mid-2020s. The BEC Waka scenario closes the Taranaki and Huntly combined cycle plants and coal co-generation around 2030, while MBIE Disruptive retires the Taranaki combined cycle plant a few years later. The Vivid Innovative scenario also assumes that new technology reduces emissions from geothermal generation. All six scenarios retain flexible gas-peaking turbines in Taranaki and Huntly, to provide resource adequacy, falling to as low as 1.0 TWh in the BEC Waka scenario (Figure 12.4).

All scenarios involve substantial increases in wind and geothermal generation, modest additional investments in hydro and a modest-to-moderate increase in solar generation. The Vivid Innovative scenario anticipates a very large 34 TWh increase in wind generation. Only the MBIE scenarios explicitly included the potential for better management of demand to reduce the need for thermal generation to cover resource adequacy (section 12.2).

I. G. Mason et al. (2013) investigate the technical feasibility of eliminating all thermal plant from New Zealand's electricity system, while maintaining resource adequacy under conditions that pertained in recent years. Their full model uses a combination of wind, pumped hydro and over 600 MW of geothermal generation, which is switched on and off to manage the variation in generating inflows (and, implicitly, in demand). Without the use of pumped hydro, which has a high capital cost and is probably environmentally and economically infeasible, Mason et al.'s model achieves 99.8% renewable generation.

Switchable geothermal is technically feasible, but its lower utilisation rate (60%) drives up the unit cost of energy generated. Stevenson et al. (2018) calculate that the Long Run Marginal Cost of geothermal power would rise by at least \$40 a MWh if the plant is used flexibly (this compares with the current yearly average wholesale price of around \$80 a MWh). For flexible geothermal generation to compete with a CCGT plant, the emissions price would have to reach at least \$130 over the investment period. Even so, under current technologies, geothermal emissions would still be in the order of 1.2Mt CO_{2e}.

Climate change itself is another factor that will influence New Zealand's path to a very low-emissions electricity system (Box 12.3).

Box 12.3 **Climate change and future electricity generation and demand in New Zealand**

Changing rainfall, wind and temperature patterns caused by climate change will affect future electricity generation and demand in New Zealand.

While estimates are very uncertain, temperatures are predicted to rise across the country, with relatively more warming in the north. Overall, rainfall is predicted to fall in the north and east of the North Island and to increase everywhere else, especially on the west coast of the South Island. There will be more rainfall in the South Island hydro catchments in the winter and less snowfall. There will also be, on average, stronger westerly winds in winter over central and southern New Zealand.

If these changes eventuate, they may reduce seasonal demand peaks (particularly through milder winters in Auckland) and increase winter hydro flows, potentially making the problem of providing for winter and dry years less severe than at present. Yet hydro reservoir operators will still face uncertainty about weather patterns in particular years and will need to conserve water accordingly. This uncertainty could be made worse by more frequent and longer droughts. Wind generation is likely to increase, but severe storms may challenge the resilience of generation, transmission and distribution.

Source: MfE (2016a); Stevenson et al. (2018); Meridian Energy, sub. 55; Vector, sub. 63; Auckland Council, sub. 97; Wise Response Society, sub. 102.

New investments in transmission and distribution line capacity

All of the identified pathways to a low-emissions electricity system involve a large expansion of wind generation in the lower North Island. A future system would require transmission upgrades to transport this energy to load centres, particularly Auckland. Stevenson et al. (2018) estimate that the cost of this investment could be as high as \$5 billion, with flow-on effects to consumer electricity prices of \$5 a MWh.

In one scenario (for which they estimate the cost), Stevenson et al. (2018) envisage wind energy from the lower North Island and geothermal from the central North Island replacing thermal energy from Taranaki and Huntly. Under certain conditions, large amounts of wind energy would need to be exported northwards and southwards. This would require significant upgrades and extensions of the current HVDC infrastructure, with new terminals. Uncertainty around new transmission technology suggests delaying this investment. Stevenson et al. (2018) consider that if extra geothermal generation was built before most of the extra wind generation was installed, a decision to upgrade transmission could be delayed until the 2030s (as the location of geothermal generation will be closer to centres of demand in the upper North Island).

Transpower (sub. 81, p. 8) notes the “challenges around coordinating commitment to investment across multiple parties in the supply chain.” It refers specifically to proposals to install wind farms with a combined capacity of 1 gigawatt (GW) in the Wairarapa. The required initial investment in transmission would impose high per unit costs on new generation for years to come as the wind farms are progressively developed. Transpower notes “[u]nder current industry arrangements there is no clear path to resolution of this, or similar, investment coordination challenges.” Contact (sub. 29) and the NZ Wind Energy Association (sub. 40) also identified issues around how the costs of transmission and distribution for newly connected users should be allocated.¹³⁰

Some EDBs consider that charging large numbers of electric vehicles (EVs) could require substantial and costly increases in the capacity of distribution lines serving households (Vector, 2018). This would depend on the size of car batteries and chargers, the number of EVs in a particular locality and the time of charging. Yet other companies consider that they are able to accommodate a large increase in charging off-peak, consistent with their customers’ preferences for their off-peak EV tariff (Mercury, 2017). The Nordic countries should provide a useful guide on problems for the distribution grid resulting from high EV uptake. Norway, with a current EV penetration of 40%, has experienced some issues, but these may ease as its electricity system moves to smart metering and dynamic electricity pricing (IEA, 2018).

Emissions, resource adequacy and cost in a future low-emissions electricity system

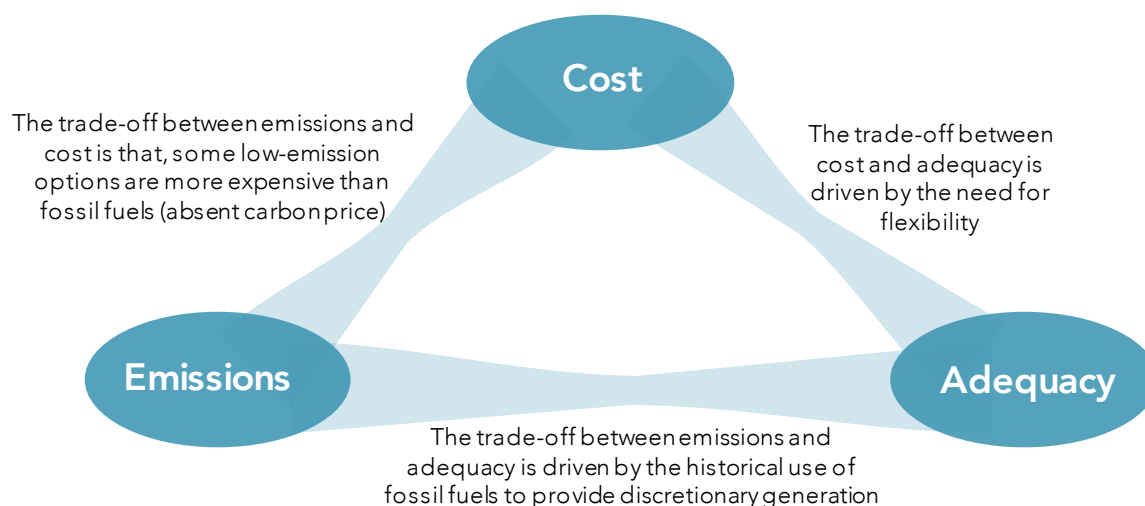
A trade-off exists between resource adequacy, cost and emissions in a future low-emissions electricity system (Figure 12.6 on the next page).

An electricity system cannot rely only on intermittent renewable energy sources while maintaining resource adequacy at all times. New Zealand faces the added difficulty of having to provide for dry years (section 12.2). Yet, with currently available technology, providing resource adequacy through low-emissions sources operated flexibly (such as on-call geothermal) greatly increases unit energy costs.

As a result, all six scenarios analysed by Stevenson et al. (2018) retain at least some thermal generation in 2050 (ranging from 1.0 TWh in the BEC waka scenario, to 11.2 TWh in the BEC kayak scenario). The Vivid Innovative scenario assumes technological improvements to reduce geothermal emissions. As a result total emissions range from 1.9 MtCO_{2e} in the Vivid innovative scenario to 6.0 MtCO_{2e} in the BEC kayak scenario (Figure 12.3). The emissions prices required to achieve these emissions levels range from \$60/tCO_{2e} under the BEC kayak scenario to \$155/tCO_{2e} in the MBIE Waka scenario (Figure 12.4).

In comparison, Chapter 3 reports the early results of new pathway models. Like the Vivid innovative scenario, all the new scenarios modelled involve substantial growth in electricity demand, which is provided mainly by wind and geothermal. Even so, thermal plant (particularly gas peakers and CCGT) continues to contribute an important resource adequacy role. By 2050, emissions from electricity generation will range from 2.1 MtCO_{2e} to 3.1 MtCO_{2e} and the emissions prices required to achieve these emissions levels will range from \$75/tCO_{2e} to \$250/tCO_{2e} depending on the stringency of the economy-wide emissions reduction target.

¹³⁰ A number of submitters also identified uncertainties around transmission and distribution pricing methodologies as a dampener on investment (Contact Energy, sub. 29; IEGA, sub. 58; NZ Wind Energy Association, sub. 40; Major Electricity Users Group, sub. 45; Transpower, sub. 81).

Figure 12.6 The cost-emissions-adequacy trade-off

Source: Stevenson et al. (2018).

One feature of the models described in Chapter 3 is that the large amount of wind generation employed leads to “spill” (either from wind or from hydro). This is commercially viable because the models assume that the cost of wind generation for each MWh will continue to fall (though at a slower rate than in the past). In contrast, Stevenson et al. (2018) assume that the cost of wind generation will rise over time, as more favourable wind generation sites are used first, and remaining sites raise the cost, because of some combination of less reliable wind, lower wind speeds and higher construction costs (pers. comm. 27 April 2018).

Even the Mason et al. (2013) model, which entirely dispenses with thermal generation, still entails geothermal emissions. As previously noted, under current technology and demand conditions, total emissions would amount to around 1.2 MtCO_{2e} and an emissions price of at least \$130/tCO_{2e} would be required to make this commercially viable (Stevenson et al., 2018).

Stevenson et al. (2018) use their analysis of the four scenarios that consider resource adequacy and the Mason et al. (2013) model to assess the impact of reducing electricity emissions on wholesale electricity prices and the emissions prices that will incentivise the adoption of low-emissions technology. They use their data on the generation mix, the lifetime costs of investments in generating capacity, fuel costs and emissions profiles to do so.

Under current technology and costs, reducing emissions appears to increase wholesale electricity prices. For instance, in 2050, a 3 MtCO_{2e} reduction in emissions from today’s level under the BEC waka scenario requires an emissions price of \$115/tCO_{2e}. In turn, this entails an increase of more than 35% in the average annual wholesale electricity price over today’s levels. In contrast, with their assumption of falling costs in wind generation, and other costs spread over a greater total amount of generation, the Chapter 3 models envisage wholesale electricity prices remaining stable or increasing slightly.

This analysis requires strong qualifications. The assumption that today’s technologies and technology prices will remain unchanged is not consistent with recent and anticipated experience. For instance, prices for wind turbines and solar panels have fallen rapidly over the last several decades. While uncertain, new technologies, for instance in tidal and biomass generation, CCS, and grid-scale batteries and demand response, are developing rapidly (Box 12.4). In addition, the medium- and long-term future volume and mix of generation needed to meet demand, consumer responses to prices, and investors’ choices of technology are all highly uncertain.

F12.1

The future mix of electricity generation by 2050 in a low-emissions electricity system and its effect on wholesale prices are both very uncertain. For example, different models envisage different paths for the cost of wind generation for each megawatt hour of electricity produced. This, in turn, leads to a different role for wind versus geothermal

generation in the system, and different effects on wholesale electricity prices. In the most favourable scenarios, prices fall; while in other scenarios they rise.

Box 12.4 Future generation, demand response and storage possibilities

Current technology and technology prices are a very imperfect guide to the best available technology for low-emissions generation in future decades. For instance, the cost of wind and solar generation has been falling rapidly and both are now commercially competitive with thermal generation in New Zealand (see Chapter 5, Box 5.1). Importantly, new generating and electricity storage technology continues to be explored, developed and trialled, and will almost certainly be commercially available within a decade or two. With higher emissions prices, some existing possibilities may become economic.

- Some coal-fired plants in the United Kingdom are already being partly or fully converted to use biomass. Biomass may become economic here as peaking plants. Even so, continuity and guarantee of feedstock supply would need to be solved; and other uses will compete with electricity generation for this feedstock.
- Battery storage capacity is improving and prices falling. As a result, grid-scale batteries and behind-the-meter batteries (including in EVs) will likely play a role in smoothing the daily electric demand profile and compete with gas for the peaking role. In the more distant future, batteries may become suitable for managing resource adequacy in dry years.
- Additional hydro storage in Lake Pukaki could be made available with some re-engineering and changes to resource consent conditions. This would improve the capacity to shift fuel storage from summer to winter and reduce the need for on-call thermal generation.
- Hydrogen can be produced by electrolysis of water when electricity prices are low, stored and used to generate electricity, either through a gas turbine or using fuel-cell technology, when demand peaks. The fuel efficiency of this process, though, is only around 25% to 35%, and it would require very large storage capacity to make a significant contribution. Resource consents would likely be needed for the water used.
- While costs are currently high, tidal generation could develop to a point where it plays a similar role to geothermal in the generation mix. The Scottish Government is partnering with Atlantis Resources to install commercial-scale tidal power generators near the Orkney Islands. Later phases will explore new technologies to reduce the costs of generated electricity.
- Buffering technology is in development that, if successful, would allow an aluminium smelter pot-line to operate with lower electricity consumption (up to 30% lower) for periods of up to 48 hours. The Tiwai Point smelter could then be incentivised to help smooth demand peaks and reduce the need for on-call thermal generation.
- Low-cost wind generation could be installed at a high-level of redundancy, and, for instance, paired with hydrogen manufacture (or some other discretionary use) when electricity demand and prices are low. This would increase the availability of low-emissions capacity to meet peaks and to reduce the need for hydro storage to provide for dry years.

Source: Stevenson et al. (2018); The Guardian (2016); Atlantis Resources (2018); Power Project Limited (2008); Rhodes et al. (2017); Dorreen et al. (2017); Contact Energy, sub. 29; Matheson (2017); NERI, sub. 53; Transpower, sub. 81; Auckland Council, sub. 97; Wise Response Society, sub. 102.

The experience of the United Kingdom suggests that, given rapid changes in technology and prices, governments should be cautious about favouring particular technologies as a route to a very low-emissions electricity system (Box 12.5). Using subsidies and other policies to encourage early commercial adoption at

scale of particular technologies may lock in unnecessarily high prices for years to come (Mercury, sub. 49; Meridian Energy, sub. 55).

Box 12.5 **Subsidies for renewable technologies in the United Kingdom**

Many European countries and the United Kingdom have provided incentives to increase the proportion of renewable electricity generation. The United Kingdom introduced a “renewables obligation” in 2002 to provide a market-based incentive to build renewable generation. The obligation required suppliers to supply, each year, a specified and increasing proportion of electricity from renewables. Ofgem, the market regulator, issued tradable certificates for the renewable electricity generated. The scheme is now closed to new generating capacity.

The United Kingdom government also introduced feed-in tariffs for micro-generation from 2010 that encouraged a large increase in photovoltaic installations to over 11.5 GW by the end of 2016. More recently, contract-for-difference feed-in tariffs have been introduced to set a fixed-price tariff for energy generated from low-emissions sources. The contract-for-difference is funded from levies imposed on electricity suppliers and intended to increase investor confidence in low-emissions technology. Meanwhile, the cost of renewable generation options has fallen to the point where they are now similar to those for fossil-fuel generators (Rhodes et al., 2017).

A recent review of the cost of energy in the United Kingdom (Helm, 2017) looked at the growing legacy costs of financial support for renewable technology. Helm estimated that the accumulated cost will exceed £100 billion by 2030. He noted that, despite the falling costs of renewables, these legacy costs still need to be met, and recommended that the relevant contracts be grouped into a legacy bank (so that current costs are transparent).

The United Kingdom Climate Change Committee put forward an alternative view on the high legacy costs of renewables. It argued that early subsidies for then high-cost investment in renewables has stimulated the technological advances and scale economies that have led to current falling costs. Even so, they agreed with Helm’s advocacy for letting the various technologies compete, and to rely on an emissions price to guide low-emissions choices both within the electricity sector and across the economy (Thompson, 2017).

F12.2

Technologies that generate low-emissions electricity are advancing rapidly with falling costs, changing design and new options emerging. If governments favour particular current technologies (for instance through subsidies), they risk locking in higher electricity costs without commensurate benefits in reducing emissions.

While financial support for renewables may have some benefits (such as stimulating technology development, economies of scale in production and falling prices), New Zealand is likely, for the most part, to be a technology follower in technologies that generate low-emissions electricity.¹³¹

Recent and prospective developments suggest that technology will develop to enable very low-emissions generation in the future. Yet, in the short term, two factors together have weight:

- large-scale generating capacity is long-lived and decisions to replace some existing capacity and increase capacity will need to be made over the next decade (so, locking in emissions profiles and costs into the future); and

¹³¹ Support for innovation in geothermal generation technology is one possible exception. New Zealand has been an early adopter of geothermal electricity generation and relies, to a greater extent than most other countries, on geothermal generating capacity. GNS Science has an active research programme on the sustainable utilisation of geothermal resources (GNS Science, 2018). New Zealand may also have advantages in innovating in other energy technologies such as biomass. Chapter 5 argues that direct Government support for research and development is the best way to stimulate innovation in technologies in which New Zealand may have an advantage.

- electricity prices will affect incentives to adopt emissions-reducing technology elsewhere in the economy, especially in process heat and transport. Reducing emissions in electricity at the expense of larger gains elsewhere would be inefficient.

F12.3

Under current technology and technology costs, reducing emissions from electricity generation will likely entail an increase in wholesale electricity prices. Rising electricity prices, if substantial, could dissuade adoption of emissions-reducing technology in process heat and in transport, as well as increasing costs throughout the economy. Yet rapid advances in, and falling prices for, low-emission electricity technology may make this trade-off less acute in the future. An effective emissions price will help weigh the efficiency of reducing emissions in electricity against possibly lower-cost options to do so in other sectors.

R12.1

Given rapid changes in electricity-generation technology and potential effects of rising electricity prices on adoption of low-emissions technology in other parts of the economy, the Government should not use subsidies or regulation to favour particular technologies that generate low-emissions electricity.

R12.2

The Government should rely on an effective emissions-pricing system as the main instrument to achieve an efficient trade-off between emissions reductions in electricity and emissions reductions in other parts of the economy. The Government should be cautious in specifying targets for emissions within the electricity sector, and make sure that technology is available to meet them without significantly increasing wholesale electricity prices above the levels achieved with current technology.

National Policy Statement for Renewable Electricity Generation 2011

The Government issued the National Policy Statement for Renewable Electricity Generation (NPS-REG) in 2011 to

drive a consistent approach to planning for renewable electricity generation in New Zealand [in particular by giving] clear government direction on the benefits of renewable electricity generation and requir[ing] all councils to make provision for it in their plans. (MfE, 2011)

The NPS-REG recognises the proportion of New Zealand's electricity generated from renewable energy sources as a matter of national significance within the ambit of the Resource Management Act 1991 (RMA). It explicitly recognises the benefits of reducing greenhouse gas emissions (New Zealand Government, 2011b). Under the NPS, councils have to provide for renewable electricity generation activities in their regional and district plans and regional policy statements, and recognise their national significance when making resource management decisions.

A number of submitters considered that the NPS-REG needs to send clearer signals to local government and the Environment Court about the significance of renewable electricity – particularly wind, but also hydro (NZ Wind Energy Association, sub. 40; Trustpower, sub. 59). Meridian Energy (sub. 55) submitted:

In Meridian's experience there is a pressing need for decision-makers within that framework to be provided with clear direction as to how to encourage low-emission land uses, such as renewable energy generation. It is not sufficient for any direction to simply identify the benefits of renewable energy generation or to highlight a preference towards low-emission land uses. Instead, decision-makers need unequivocal guidance as to how they should treat the benefits of renewable generation projects that will set the platform for a low-emissions economy. Meridian encounters a variety of different approaches to this issue depending on where a proposed renewable energy development will take place. (p. 4)

Meridian refers in particular to the Environment Court decision on the proposal for a community wind turbine at Blueskin Bay north of Dunedin.¹³² The court was not satisfied that the landscape's values (also recognised under the RMA) should stand aside for the benefits of the proposal. Meridian considers that there is a need for more guidance on the relative importance of renewable energy compared to other matters of national significance or importance under Part 2 of the RMA.

Trustpower makes similar points in relation to consent decisions for hydro power. Decisions involve ramp rates,¹³³ minimum river flows, water allocation, minimum and maximum lake levels, flushing requirements for water quality purposes, and flushing for sediment removal or flood management. Trustpower notes that these decisions have the potential to reduce hydro resilience and flexibility, and that it is important that these are not undermined by the framework for regulatory decision making.

The Commission is unsure how much the RMA constrains development of new renewable electricity generation. The IEA reports that new wind projects with a combined capacity of 2 500 MW have already been consented, but that the current balance between returns on investment and risks has made installation of new capacity unattractive (IEA, 2017a). Yet, the NZ Wind Energy Association (sub. 40) points to the regulatory barriers to development of small community-scale wind farms, in particular, and their potential importance in New Zealand's renewable energy mix.

Q12.1

Does decision making under the Resource Management Act 1991 unduly constrain investment in renewable electricity generation, particularly wind and hydro generation? In what ways could the National Policy Statement on Renewable Electricity Generation 2011 be strengthened to give clearer direction to regional, district and unitary councils to make provision for renewable electricity generation in their regional and district plans, regional policy statements and resource management decisions?

12.5 Demand-side options

Demand response (DR) and distributed energy resources (DER) will play an important role in reducing the need for thermal peaking in a future electricity market. First, DER and DR have the potential to add to grid-scale wind generation to reduce the need to use hydro to balance demand at peaks or when wind is unavailable. This will make it easier to store water and reduce the need to use thermal generation to meet dry-year resource adequacy needs (section 12.5). Second, increasing the contribution of DER and DR will reduce the need for investment in additional grid-scale generation and transmission capacity, and so lower costs for consumers.

The technology to support DR and DER is changing rapidly, and is being implemented or trialled in many jurisdictions.

A future electricity system will need to find the right balance between:

- flexibility and openness to new technology and market players;
- establishing technology and service standards for platforms to support multidirectional interconnections between consumers, other distributed generators and large-scale generators (section 12.6); and
- providing a stable and predictable regulatory environment to encourage investment.

Demand response

The United States Federal Energy Regulatory Commission (2017) defines "demand response" as:

¹³² *Blueskin Energy Limited v Dunedin City Council* [2017] NZEnvC 150.

¹³³ The increase or reduction in output per minute usually expressed as megawatts per minute. Hydro plant, unlike thermal plant, can ramp almost instantaneously.

Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

DR can work in different ways and serve different purposes.

- In *scheduled demand response*, consumers can contract to reduce or drop their load for a pre-determined time under defined circumstances. In New Zealand, for example, EDBs regularly used ripple control of hot water heating to manage peaks in demand. Currently, large consumers (such as industrial users of electricity) can offer, into the wholesale market, the capability to reduce load.
- *Frequency-armed demand response* (or “*interruptible load*”) is an ancillary service to protect the stability of the system when frequency falls to critically low levels, for instance as a result of a generator or the HVDC failing.
- *Voluntary demand response* is based on price signals. Consumers exposed to high transmission, distribution or energy prices may drop load if the price is sufficiently high and the inconvenience is correspondingly low. The extensive rollout of smart meters in New Zealand facilitates this sort of DR, which can include full exposure of household consumers to half-hourly wholesale prices. Third-party aggregators may manage this type of DR for consumers, potentially using automated responses to price changes.

By dampening demand at peaks, DR has the potential to reduce the use of on-call thermal generation. Yet none of these types of DR, by themselves, are suited to dealing with energy shortages in dry years (though they could help conserve hydro resources when the risk of a dry year is high). Conservation campaigns have, in the past, been a response to dry-year energy shortages in New Zealand, most recently in 2001, 2003 and 2008. As a result of concerns about how these campaigns unfolded, the EA amended the Electricity Industry Participation Code to provide for conservation campaigns based on pre-defined hydro storage levels. In the event of a campaign, retailers must compensate each residential or other small consumer (but not those already paying spot prices) at the rate of \$10.50 a week. No campaign has been required since these measures came into force despite a number of dry years occurring, indicating that the Code incentives have been effective.

Distributed energy resources

DER includes behind-the-meter solar panels and battery storage and distributed grid-scale wind and solar energy sources and batteries. Behind-the-meter DER could include using EV batteries as a source of energy during peak demand (Vector, 2018). Utilities, businesses or households can use batteries to store electricity when demand and prices are low; and use them as an energy source when demand and prices are high. Only two of the scenarios of New Zealand’s future electricity system summarised in section 12.4 (the MBIE scenarios) explicitly assume an increased contribution from DER to electricity generation.

Distribution-network-scale DER (such as community wind farms) would likely be more efficient than behind-the-meter DER because it would allow a group of consumers to:

- share the benefits of common batteries and associated electronic equipment;
- coordinate and optimise injections of DER into the system, coordinate DR systems; and
- trade energy surpluses and shortages within the group.

Even so, the economics and physics of battery storage are only suited to transferring energy intra-day or across a few days at most. Solar power is intermittent and is not directly available during nightly peak demand and is less available during periods of higher demand in winter. While DER can reduce the need for thermal or other on-call generation at daily or seasonal peaks and help conserve hydro resources, it cannot directly solve the dry-year problem. If not well managed, an increase in DER can also cause instability in the operation of an electricity system – for instance through high-voltage problems and the lack of inertia (Box 12.6).

The role and capability of power electronics

The three important types of power electronics for connecting DER to networks are:

- rectifiers (that convert alternating current (AC) to direct current (DC));
- converters (that convert one DC voltage to another); and
- inverters (that convert DC to AC, or one specification of AC to another).

Inverters are essential for connecting photovoltaics and batteries to the grid, and vary considerably in their specification and capabilities. High-specification inverters can manage frequency and voltage, smooth power flow, and (in combination with batteries) provide active stabilisation of the network. A high-specification solar/battery/inverter package can provide all the services of a grid-scale generator (Stevenson et al., 2018). It follows that the specification of power electronics will make a big difference to the role that DER can play in a future electricity system. Yet most households who choose inverters for their photovoltaic installations do not consider the benefits of a higher specification. The EA is considering this issue, and whether EDBs could require certain inverter settings, as part of its work programme on integration of hosting capacity (pers. comm. 17 April, 2018).

12.6 Regulation for a low-emissions electricity system

An efficient very low-emissions electricity system will require a much greater proportion of generation from intermittent renewable sources and the integration of DR and DER into the system. Some form of on-call generation will be required for peak loads and to cover the risk of dry years. This section looks at regulatory, governance and pricing issues that will likely arise in such a system.

Managing a greater proportion of generation from intermittent renewables

Unless well designed and managed, an increasing proportion of intermittent renewable energy can pose significant challenges for transmission system operation (Box 12.6).

Box 12.6 Grid stability in South Australia

Increasing the proportion of intermittent renewable generation in a system can cause network instability, due to a reduction in what is known as inertia. In systems with thermal and hydro generation inertia is usually provided by large synchronously spinning turbines. These provide inertia by buffering the system against sudden fluctuations in frequency caused, for instance, by the failure of a generator or transmission line.

For example, high winds caused loss of transmission lines in South Australia, resulting in a state-wide blackout in September 2016. South Australia's system lacks inertia, because it generates 70% of its electricity from intermittent renewables (mostly wind and solar) and has closed two coal-fired plants. The lack of inertia was a large contributor to the blackout (Harmsen, 2017).¹³⁴ A well-configured system, even with intermittent renewables, should be able to cope with emergencies caused by component losses.

In response to the blackout, the Australian Energy Market Commission now requires each state's transmission network to provide and maintain a defined level of inertia at all times. In the longer term, it is investigating whether to establish a market for inertia as an ancillary service (Australian Energy Market Commission, 2018). The South Australian Government has installed a large grid-scale battery paired with a wind farm. The battery can provide system inertia as well as firming the supply of wind energy (McConnell, 2017). With the right technology to connect with the grid, wind turbines can also provide inertia directly (Harmsen, 2017).

¹³⁴ Failure of an interstate connector that helped stabilise South Australia's grid was also a contributor (Harmsen, 2017).

Stevenson et al. (2018) identify challenges in a system with a high proportion of intermittent renewable energy, including:

- reduced inertia in the system so that relatively small shocks could cause large frequency deviations and large shocks could become unmanageable;
- a need for instantaneous under- and over- frequency reserves to deal with the risk of failure in HVDC transfers (particularly in the transfer of large amounts of electricity between islands);
- increased voltage management problems because of transmission of renewable energy over long distances to large sources of demand (such as in Auckland); and
- a need for more fast, standby reserve to deal with the volatility of wind generation and the risk of a generator or line trip.

Stevenson et al. (2018) recommend that the EA address these challenges by investigating a market for inertia and more sophisticated markets for frequency management, voltage management and standby reserve.¹³⁵ They recommend that these markets should be open to DER as well as to the major generators. DER, for instance, could provide inertia through incorporating ultra-fast response characteristics in batteries and inverters, or the direct connection of industrial motors. It could provide voltage stability through inverters.

Integrating distributed energy resources and demand response to benefit consumers and lower emissions

As argued by a number of submitters, more active management of distribution networks than at present is needed to realise the potential contribution of DER and DR (Orion, sub. 6; Vector, sub. 63; Auckland Council, sub. 97). This, in turn, will require a substantial shift in current regulatory and institutional arrangements.

In the future, distribution systems and the market arrangements will need to:

- provide rewards to DER and DR that reflect their supply of energy and ancillary services in particular locations and at particular times;
- provide a platform to give equal access to diverse participants (including consumers) to competitively buy and sell services;
- manage the safe and secure sharing of information between participants to facilitate service design and targeting to meet consumer needs;
- maintain the quality of energy supply and a balance between supply and demand, while using intermittent DER at greater volumes than at present; and
- integrate DER and DR services with the requirements of the transmission grid.

The current system has primarily developed to distribute electricity from large generators through the national grid and distribution networks to customers safely and reliably. The physical lines network is configured radially to perform this function, transmitting electricity through successively smaller substations until it reaches consumers. A future distribution system will need to overlay this radial physical network with a platform for multidirectional local and national trading relationships. Telecommunications provides a rough parallel, where Chorus supplies and owns the physical lines and infrastructure that are then used by many competing service providers.

Pricing should reflect the contribution of DER and DR at particular times and places

The value of DER and DR to other consumers varies by the location and time of input. This reflects a combination of network congestion effects and transmission losses. The wholesale electricity market already prices energy according to the transmission node and time at which it is supplied (section 12.3). Distribution network pricing has the potential to vary in a similar way by time and location. This need not be through

¹³⁵ The Electricity Council of Texas is currently considering a market for “inertia” and has implemented an operating reserve demand curve to strengthen scarcity pricing (Stevenson et al., 2018).

published prices (as in the wholesale market); it could be through smart grid systems automating responses to demand conditions.

To fully realise its potential scale, DER should enjoy the same incentives as grid-scale generators to provide energy services and (with high-quality inverters and/or batteries) ancillary services such as frequency and voltage stability (Stevenson et al., 2018; John Crook, sub. 31). Currently DER, unlike grid-scale generators, are only paid the average cost of energy and cannot access markets for ancillary services (such as frequency and voltage control), even if they meet the requirements.

Other problems with current distribution pricing models exist. Transpower noted that “[m]ost end users today have pricing structures that over-stimulate self-production, under-stimulate efforts to moderate peak usage, and overly deter electrification” (sub. 81, p. 7). For instance, a number of participants submitted that the low-fixed charge regulations, while well-intentioned, have the effect of dissuading the adoption of new energy technologies, particularly EVs (Box 12.7; Contact Energy, sub. 29; Vector, sub. 55).

Box 12.7 **The low-fixed charge regulations and new energy technologies**

The Electricity Retailers’ Association of New Zealand (ERANZ) and the Electricity Networks’ Association (ENA) commissioned Concept Consulting to assess (among other matters) the potential effect of the Low Fixed Charge (LFC) tariff option regulations on the adoption of new technologies (sub. 8). The regulations were introduced in 2004 with both social and energy efficiency objectives.

Concept Consulting looked particularly at the adoption of behind-the-meter solar power and electric vehicles (EVs). The regulations set an LFC for distribution and retail costs (30 cents each day in total) which retailers must offer. Customers on the LFC must, as a result, pay higher variable costs for their energy use. The level of the LFC and the variable charges are set so that North Island customers who consume 8 000 KWh a year would have the same yearly bill under the LFC as under the standard tariff. (The threshold is set at 9 000 KWh for South Island customers.) Customers who use less electricity than the threshold each year will be better off on the LFC than on the standard tariff.

Concept Consulting show that to recover revenue lost from low-user customers, retail companies must charge customers on the standard tariff more, with a higher variable charge than would otherwise be the case. Because some low-income households are big and use more electricity, the LFC means that they effectively subsidise other households (some of whom may be comparatively well-off).

The higher variable charges means that the costs of charging an EV are higher than the true costs of supply, reducing incentives to purchase EVs. Conversely, behind-the-metre solar panels allow households to avoid the higher variable charges while making it more likely that they will benefit from adopting the LFC. High-income households who own their own house are more likely than others households to install solar panels, therefore further distorting the intended targeting of the LFC to low-income households.

Solar power, even with batteries, does not suit New Zealand’s need to meet winter demand peaks. As a result, Concept Consulting argues that increasing the use of solar power does not offer any particular benefits in reducing overall emissions. Instead, as the NZ Wind Energy Association (sub. 40) and Mercury (sub. 49) point out, increased solar power generation slows the growth in more efficient grid-scale wind generation (and leads to more thermal generation in the longer term than would otherwise have been the case).

The Electricity Authority (EA) considered submissions on the LFC regulations as part of its work on enabling mass participation (Electricity Authority, 2017). It concluded that “the competition, reliability and efficiency effects of the LFC Regulations are not as material as has been assumed” (p. 9). The EA noted instead that

distributors' and retailers' preference for consumption-based charges is as much a barrier to efficient pricing as the LFC Regulations, and distributors could improve pricing efficiency by introducing variable capacity-based or peak-based charging or time-of-use charges. (p. 9)

Integration of DER may also undermine the current business models of EDBs. According to the IEA:

...evidence is emerging [globally] of a potential "death spiral" associated with traditional volumetric-based pricing models which may result in under-recovery of regulatory revenues where substantial volumes of distributed generation are present...

Several [New Zealand] distributors have registered growing concern about the revenue and costs risks posed by distributed generation, with one distributor responding by increasing connection charges for all new residential rooftop solar systems and batteries installed within its service area ... (IEA, 2017a, p. 140)

The IEA considers that the balance between fixed and incremental charges may need to be adjusted (to give more weight to the fixed element) and that, conversely, "efficient, cost-reflective network pricing will need to more accurately reflect time-of-use" (IEA, 2017a, p. 157).

Also, if rapid penetration of EVs requires increased distribution line capacity in some locations, a pricing model will need to allocate the costs of upgrades equitably among customers. Higher-income households will likely adopt EVs first, so charging may be concentrated in particular suburbs (Vector, 2018).

Facilitating competition in services

Competition among service providers across the distribution system will stimulate innovation, increase efficiency and lower costs to consumers. The IEA argues that regulation should give assurance to market participants that system development and operating decisions "are objective, non-discriminatory and comply with relevant rules and standards" (IEA, 2017a, p. 151).

The IEA identified two alternative models for EDBs that were emerging globally in response to rapid technological change. In one model, distributors provide value-adding services (such as owning or selling rooftop solar-panels or operating EV charging stations) to provide additional revenue streams to supplement their regulated cashflows. In the other model, the distributors act as neutral facilitators for other businesses (retailers and aggregators) to provide services. In this model, distributors provide information, operate the system, and establish, maintain and manage the network infrastructure.

The IEA considers that the latter "platform-for-services" model is more suitable to meet the challenges facing the sector because it will increase competition and innovation, reduce transaction costs and more effectively integrate a diverse range of suppliers and new technologies. In addition, it will maintain a more effective separation of contestable and natural monopoly functions.

The IEA notes that policy changes in 2010 allow some New Zealand EDBs to be involved in retailing in specified circumstances. It argues that these changes could hinder the distribution structure efficiently moving into a platform-for-services model (IEA, 2017a). The Commerce Commission, in considering input pricing methodologies for EDBs, also thought that boundaries between different segments of the electricity market may be blurred and require changes to regulation or legislation (Commerce Commission, 2016, pp. 2-3).

In any case, under current arrangements, the distribution system is still largely orientated towards minimising distribution investments and supplying a bundle of network services within a constrained set of possibilities. Current regulation fits this approach, but is unlikely to successfully accommodate the contribution of large amounts of small-scale, distributed renewable energy in the future (Stevenson et al., 2018). A more efficient and dynamically innovative system would provide access and competitive neutrality for all DER and DR providers (Pioneer Energy, sub. 44; Vector, sub. 63).

Technical and data-sharing standards

A fit-for-purpose distribution system moving to more dynamic cost-reflective distribution pricing is likely to need mandated electrical standards for consumer connections. The standards should reflect the possibility that a consumer may be able to provide some generation and other services for themselves while meeting the standards. The whole service need not be provided from the bulk supply power system.

Standards for data sharing among market participants need to be updated to facilitate the efficient provision of responsive services (Orion, sub. 6; Vector, sub. 63). Transparent, good quality and timely data will, for instance, enable participants to identify where the transmission and distribution network may need reinforcement, where they could offer more competitive alternative services, or where consumers are having supply or power quality problems. This data would allow providers of DER or their agents to market their services directly to consumers or groups of consumers who would benefit. Data-sharing standards should provide for appropriate levels of data security, meet privacy standards and give consumers control of personal data.

The electricity system regulators are working to facilitate mass participation

The electricity system regulators – the Commerce Commission and the EA – have been working on reducing barriers to, and incentivising, a wide range of participants in an innovative electricity market. The work includes a focus on DR and DER. For instance, in 2016, the Commerce Commission made changes to EDB input-pricing methodologies to better incentivise technological innovation in short-lived investments (Commerce Commission, 2016).

The EA is sponsoring or leading five projects to improve distribution regulation. The projects cover:

- how to shift to more efficient distribution pricing to encourage efficient investments by consumers and line companies and the development of DR;
- how to support multiple trading relationships to reduce barriers to consumers using services provided by more than one party at the same time;
- developing more fluid data exchange between retailers and EDBs to support more participation and choice for consumers;
- developing a default distribution agreement between EDBs and retailers to support competition, efficiency and innovation in retail and related markets; and
- amending the definition of participants in the Participation Code 2010 to include consumers becoming active buyers and sellers of electricity and related services (Electricity Authority, 2017).

In addition, the recently formed Innovation and Participation Advisory Group is undertaking a project for the EA on equal access of participants to electricity networks (Electricity Authority, 2017).

A number of submitters supported a move to more flexible and cost-reflective pricing, particularly to reduce demand peaks (John Crook, sub. 31; Meridian, sub. 55; NERI, sub. 53; Vector, sub. 63; Transpower, sub. 81).

F12.4

Integrating distributed energy resources (DER) and demand response (DR) into the electricity system will require significant adjustment to the current distribution pricing and regulatory regime. The Electricity Authority is leading or sponsoring a substantial programme of work to address the need for pricing and regulatory adjustment. The programme covers changes to pricing to better incentivise investment in DER and DR capability; and changes to regulation to provide for:

- consumers to be involved in multiple trading relationships;
- more fluid data exchange between retailers and EDBs;

- a distribution agreement to support competition, efficiency and innovation in retail and related markets;
- consumers to become active buyers and sellers of electricity and related services; and
- equal access of participants to electricity networks.

R12.3

The Electricity Authority should continue its programme of work to update pricing and regulation to facilitate the integration of distributed energy resources (DER) and demand response (DR) into the electricity system. The programme should cover changes to pricing to better incentivise investment in DER and DR capability; and changes to regulation to provide for:

- consumers to be involved in multiple trading relationships;
- more fluid data exchange between retailers and EDBs;
- a distribution agreement to support competition, efficiency and innovation in retail and related markets;
- consumers to become active buyers and sellers of electricity and related services; and
- equal access of participants to electricity networks.

Strengthening capability in distribution services

The EA work programme covers a broad front of potential change in electricity distribution arrangements. It should result in a substantial shift in regulation, roles and relationships to match rapid, yet complex and uncertain, changes in technology. This shift is likely so profound that it raises the question of whether there is sufficient current capability in electricity distribution to meet the challenge.

EDBs, because of asset ownership and historical arrangements, are currently in the strongest position to manage and/or provide a platform for DER services. In its review of New Zealand's energy policies, the IEA (2017) looked particularly at electricity distribution arrangements. After noting the challenges of rapid technological change facing the sector, the IEA comments that

...the relatively small size of some distributors may limit their capacity to efficiently and cost-effectively invest in the monitoring, management and control systems required to maintain reliability as distribution systems become more complex and subject to more dynamic real-time power flows. (p. 160)

The IEA argues that EDBs are likely to need new business management systems "to support the increased level of engagement with distribution system users" that integrating DER and DR into the wider system involves.

Real-time co-ordination and communication capabilities may need to be enhanced, especially with the transmission system operator and possibly with other distributors, reflecting the more dynamic and increasingly multidirectional nature of power flows within and between distribution systems and the transmission system. As a result, more effective and coordinated real-time system planning and management is likely to be required to ensure that reliable and secure electricity services are maintained at the distribution level over time. (IEA, 2017, p. 149)

The IEA also noted concerns (raised by the Auditor-General) about the governance and decision-making capability of some EDBs.¹³⁶ The IEA noted that consolidation of the sector into a smaller number of larger businesses would likely meet considerable opposition, and suggested other options (in addition to

¹³⁶ Transpower (sub. 81) also raised questions around the capacity and capability of the EDBs to undertake the required distribution system investments.

amalgamation) to harness economies of scale. EDBs could enter into regional shared-services and management agreements, or form joint ventures to manage and operate distribution assets.

The combination of current shortfalls in the capability of EDBs, the increasing sophistication required to operate new distribution service models, ambiguities in the EDB role, and the barriers to incrementally developing the existing model, suggests a fresh look at EDB capabilities, and developments to improve them, is needed.

Even so, and consistent with how the EA is addressing the need for change, the IEA (2017) points out that there are

considerable risks associated with adapting the legal and governance framework [for electricity distribution], given the substantial uncertainty around the nature and timing of this transformation [in the roles and activities undertaken in electricity distribution]. Hence an incremental and proportional approach may be the most appropriate way to proceed. As roles and functions change, or new ones emerge, it will be important to ensure that they are appropriately allocated among distribution sector participants. (p. 144)

Clarifying roles in distribution services

Stevenson et al. (2018) propose a reform of distribution arrangements, based on the current transmission-level arrangements (section 12.3). This would require the creation of the role of a distribution system operator (DSO), distinct from the ownership of distribution networks, to oversee the trading of unbundled energy and ancillary services over a common distribution platform.

A DSO would:

- ensure all power system resources (including DER) have competitive access to a well-configured common distribution infrastructure, at a reasonable cost for monopoly assets (as sought by EA's equal access project);
- coordinate DER (including smart, flexible demand) to meet participants' preferences for security, quality and reliability; and
- provide rewards and allocate costs commensurate with each load's and generating source's marginal costs and benefits.

A DSO role has the potential both to better realise the benefit of smart technology and to enable competition between traditional (predominantly supply-side) solutions and DER (storage, distributed generation and/or flexible demand).

The UK National Infrastructure Commission (2016) looked at the DSO role.

First, a DSO with a clear idea of what the local network needs at each moment in time will be able to purchase or procure these services to manage its system, creating revenue streams and market signals to suppliers... This change will also incentivise the development of new and innovative business models, and save money for consumers by reducing or deferring the need for costly physical enhancements to the grid...

Second, better visibility of the network, combined with more monitoring, control and smart technologies means that network operators will be able to adapt to more complex and unpredictable electricity flows. This means that more distributed and intermittent generation will be able to connect to the networks at a lower overall cost to the system...

Third, it will enable better coordination between the transmission and distribution networks. A set of DSOs could have a role in ensuring the effective management of the interface with the transmission network and a coordinated system-wide approach. They could work with the transmission system operator to ensure that the benefits of new technologies such as storage and demand flexibility are maximised across the system as a whole, helping to coordinate what deploys when to ensure no detriment to local services. DSOs could operate local balancing markets, linked to the national balancing markets run by the SO [system operator]. (pp. 68–69)

A DSO role could be added to the current network-ownership role of the EDBs. This would parallel the arrangements by which the role of Transpower as system operator and its role as the owner of the transmission network are kept separate within the same organisation. This is one possible outcome of the current work programme of the EA. Key prerequisites are the successful outcome of this work programme and the development of sufficient capability across the distribution sector to carry the role.

R12.4

The Electricity Authority should, in conjunction with its work programme to update pricing and regulation of the electricity distribution sector, undertake a review of and develop measures to raise the capabilities of the electricity distribution businesses to:

- ensure all power system resources (including distributed energy resources – DER) have competitive access to a well-configured common distribution infrastructure, at a reasonable cost for monopoly assets;
- coordinate DER (including smart, flexible demand) to meet participants' preferences for security, quality and reliability; and
- provide rewards and allocate costs commensurate with the marginal costs and benefits of each load and generating source.

Should the Electricity Authority take emissions reductions into account in its activities and decisions?

The EA has a statutory objective of promoting “competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers” (Electricity Industry Act 2010, s 15). Some submitters argued that reducing GHG emissions should form part of the EA’s statutory objectives (NZ Wind Energy Association, sub. 40; IEGA, sub. 58; Trustpower, sub. 59; Vector, sub. 63). Yet, unless carefully formulated, an additional objective may not help reduce emissions efficiently across the economy.

Effective emissions pricing should incentivise emissions reductions in the electricity sector where this is the most efficient way across the economy to do so. If a statutory objective for electricity causes emissions reductions that are more costly than in other parts of the economy, this would be inefficient. It would raise the cost of electricity unnecessarily, and also make it more costly to use electricity to lower emissions in other parts of the economy, such as in transport and process heat (section 12.1).

Further, the Commission recommends that the emissions price be guided by a fixed carbon budget or emissions trading cap (see Chapters 4 and Chapter 7). With a fixed budget or cap, any additional reductions in emissions in the electricity sector would be offset by lower reductions elsewhere in the economy.

Yet it is possible that regulatory barriers in the electricity sector increase the cost of reducing emissions, without producing commensurate benefits. If so, a statutory objective for the EA to address such barriers could have benefits in finding the most efficient way of reducing emissions across the economy. Relevant barriers could, for instance, be those that hinder the full integration of DER and DR into the electricity market.

F12.5

With an effective emissions-pricing system, a statutory objective for the Electricity Authority (EA) to have regard to reducing greenhouse gas emissions in electricity is unlikely to incentivise efficient emissions reductions across the economy as a whole. There may be some case to amend the EA’s objectives to include minimising any regulatory barriers to efficient emissions reductions in the electricity sector.

12.7 Conclusion

New Zealand already has 85% of its electricity generated from mostly low-emissions renewable sources. In the longer term, new technology should enable even more electricity to be generated at reasonable cost from low-emissions sources even as electrification of transport and industrial heat push up demand. Yet providing on-call generation to meet peaks in demand, and most importantly to provide energy in dry years, will remain a challenge. Under current technology, assigning this on-call role to non-renewable sources such as geothermal generation will cause a substantial rise in electricity prices. The Government should be cautious about setting stringent targets for electricity sector emissions before technology becomes available to further reduce emissions at reasonable cost.

Globally and in New Zealand, electricity systems are increasingly incorporating DER and DR to provide more efficient and more responsive electricity services to consumers. These developments hold great promise for further lowering emissions and reducing the need for on-call generation to meet demand peaks and to provide energy in dry years. Yet they can also disrupt the efficiency and stability of the existing grid. Regulation and governance for electricity distribution need to be refreshed to enable these emerging developments to fully achieve their potential benefits. The Electricity Authority is leading work to update distribution regulation.

The Government also needs to review governance and operational capability in the distribution sector so that it can deliver the potential emissions reduction and efficiency benefits from innovation. Yet adjustments to regulatory, institutional and infrastructure arrangements for the electricity system carries risks (Meridian Energy, sub. 55). Getting regulation and prices right matters if New Zealand is to avoid costly and unintended consequences from changes to the electricity system.

13 Heat and industrial processes

Key points

- There are two main sources of industrial emissions: those created by burning fossil fuels to generate process heat, and those created from “industrial processes” (the transformation of one substance into another, such as iron sands into iron). Together, they account for around 15% of New Zealand’s gross greenhouse gas (GHG) emissions.
- Most opportunities to reduce emissions from heat processes are for medium- and lower-temperature heat needs (eg, drying milk powder and wood pulp, heating glass houses), and lie in process efficiencies and conversion to lower-emissions fuel sources. Some lower-emissions fuel alternatives are not currently universally available (eg, geothermal, gas) or cost-competitive.
- Rising emissions prices will be central to driving emissions-reducing investments in industrial heat plant. However, given the long lives and high costs of boilers and other heat plant, decarbonisation of industrial heat processes is likely to occur gradually, as these capital assets reach the end of their useful lives.
- Biomass has been referred to as a possible lower-emission alternative to coal and other high-emissions heat fuel sources. But significant technological and logistical improvements, as well as a much higher emissions price, will be needed before biomass becomes a cost-competitive alternative fuel for industrial process heat.
- The Energy Efficiency and Conservation Authority should have its mandate changed to focus on lowering GHG emissions, and should refocus its efforts on working with smaller firms, where there is a stronger case for government assistance.
- Milk processing is one of the biggest sources of process-heat emissions. The Commission is interested in hearing more from stakeholders about whether there would be a net benefit in giving Fonterra discretion to refuse milk supply if such refusal would lead to a significant increase in Fonterra’s GHG emissions.
- Barring technological breakthroughs, opportunities to significantly reduce industrial process emissions from iron, steel and aluminium production are limited.
- Carbon capture and storage (CCS) is a rapidly-evolving and potentially significant mitigation technology, which could be well-suited to large-scale, single-source emitters such as iron, steel and aluminium production. When and whether CCS will be viable in New Zealand remains unclear. Existing legislation is not adequate to manage the risks of CCS. The Ministry for the Environment should carry out policy work on new legislation to appropriately regulate CCS activities.

This chapter discusses options and opportunities to reduce emissions in process heat and industrial processes (such as the production of aluminium, iron, steel and cement). It also considers the potential of carbon capture and storage (CCS) and the suitability of current legislative frameworks for governing CCS activities.

13.1 Industrial sources of emissions

Emissions from industrial sources make up roughly 15% of New Zealand’s gross emissions, and these have been growing significantly in recent years:

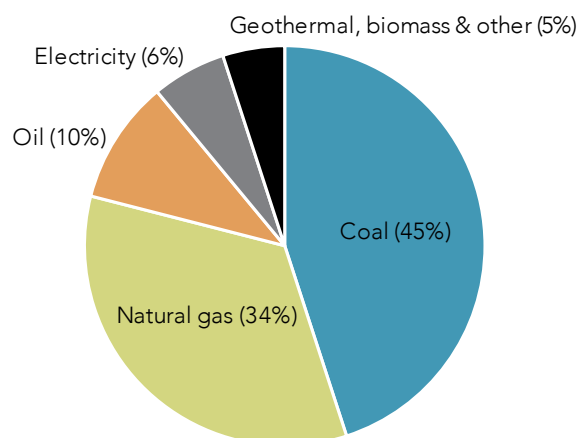
- 8.5% of New Zealand’s GHG emissions result from using fossil fuels in manufacturing, particularly to produce process heat;¹³⁷ and
- industrial processes and product use (IPPU) produce 6.6% of New Zealand’s gross emissions, resulting largely from the process of producing iron, steel, aluminium and cement.

Between 1990 and 2015, the industrial processes and product use sector was one of the fastest-growing source of GHG emissions in New Zealand, increasing by 47.3% (MfE, 2017g). Emissions from industrial process heat are the second largest source of energy-related emissions, having overtaken electricity generation in 2013. Much of this growth has been due to the expansion of New Zealand’s dairy industry (Concept Consulting, 2017a, pp. 61, 64).

13.2 Process heat

Process heat is generated for a number of purposes, including converting raw products such as liquid milk into powder and wood pulp into paper, sanitising medical equipment, and chemical production. The overwhelming majority of this heat is generated using fossil fuels (Figure 13.1)

Figure 13.1 Energy sources of process heat generation in New Zealand



Source: RSNZ (2016)

Most process heat emissions are produced by “a relatively small number of super-large heat plant fuelled by coal and gas...over 90% of the emissions come from less than 5% of the heat plant” (Concept Consulting, 2017b, p. 19). The two largest sources of process heat GHG emissions are the food processing and chemicals production sectors, which respectively created 44% and 25% of all process heat emissions in 2015 (Concept Consulting, 2017a).

13.3 Opportunities to reduce emissions from process heat

The Royal Society estimates that GHG emissions from industrial process heat could be reduced by approximately 35% by 2035 (RSNZ, 2016), and the International Energy Agency has argued that heat use in New Zealand industry “offers excellent opportunities for further decarbonisation” (2017a, p. 207). However, the viability of abatement opportunities depends on the nature and location of the production process, the scale of heat required, and the level of emissions price.

Little scope with high-temperature process heat

High-temperature (ie, over 300 degrees Celsius) heat users have no viable short-term economic abatement opportunities. The major users of such heat in New Zealand are methanol producers and manufacturers. Methanol heat is fuelled by natural gas, while manufacturers use a mix of gas, electricity, diesel, coal and wood. Converting to alternative, lower-carbon fuel sources (eg, biomass) would carry significant capital and operating expenses than the status quo. Also, both the chemicals and manufacturing sectors are exposed to

¹³⁷ This excludes any fossil fuels used to generate electricity used in manufacturing.

international competitions from firms that do not face emissions prices. Concept Consulting (2017a, p. 66) therefore concluded that fuel switching for these industries was not “a feasible option”. Ongoing efficiency improvements may reap smaller gain, however.

F13.1

High-temperature heat users have no viable short-term economic abatement opportunities.

More opportunities to abate with low heat and medium heat

The dairy industry is the single largest producer of intermediate heat emissions, resulting from its use of coal and gas boilers to dry milk. Coal is also used for some lower-temperature heat uses, such as glasshouses for horticulture. Abatement opportunities lie in process efficiencies, and in replacing coal and gas with other fuels or reducing their use (especially coal). The potential of other fuel sources (natural gas, geothermal heat, and electricity) as alternatives varies, depending on a number of factors.

Reducing emissions through process efficiencies

Regardless of location or energy source, manufacturers could improve energy efficiency through employing technologies such as:

- integrated control systems, using sensors to adapt process conditions;
- sub-metering (monitoring energy used by specific equipment or parts of a plant); or
- better flue-gas monitoring for boilers and dryers (ICF International, 2015).

However, Concept Consulting (2017b), in a report prepared for the Parliamentary Commissioner for the Environment, concluded that while there are some “cost effective abatement opportunities through ‘boiler tuning’ (i.e. efficiency increases)...these are relatively small” (p. 19). A number of submitters made similar comments.

There is always potential for incremental improvements, particularly with the advancement of control systems. However, in many cases, step change improvements in efficiencies have already taken place. (Graymont, sub. 33, p. 6)

For Ballance the low hanging fruit was captured a long time ago, with efforts now chasing single percentile improvements eg, as computing power in control systems, catalysts and equipment improves. (Ballance Agri Nutrients Limited, sub. 34, p. 8)

...technology and energy conservation developments in the industry have stagnated since the late 2000s, as EECA’s support ran its course; no further energy efficiency gains were available without replacing entire greenhouses. (Horticulture NZ, sub. 41, p. 4)

F13.2

Operational efficiencies offer scope to reduce process heat-related emissions, although large potential gains are not likely.

Fuel switching

Natural gas

Although natural gas is a fossil fuel, it has a lower emissions profile than coal. According to IPCC guidelines, natural gas releases about half the amount of CO₂ to provide a unit of energy as coal. Replacing coal with gas as a fuel for industrial heat would therefore contribute to emissions reductions. In its submission, First Gas estimated the reduction in CO₂ emissions that would result from replacing coal with natural gas in North Island industrial process heat plants. The predicted result was a 41% reduction in CO₂ emissions (Table 13.1).

Table 13.1 Estimated GHG emissions reduction from shifting North Island heat processes from coal to gas

Option	Coal use per annum		CO ₂ emissions – tonnes		
	Gigajoule (GJ)	Tonnes	Status quo – coal	Equivalent gas	CO ₂ reduction
Plant A	150 000	6 818	13 725	8 103	5 622
Plant B	1 500 000	68 182	137 250	81 029	56 221
Plant C	300 000	13 636	27 450	16 206	11 244
Plant D	250 000	11 364	22 875	13 505	9 370
Plant E	990 000	45 000	90 585	53 479	37 106
Total	3 190 000	145 000	291 885	172 321	119 564

Source: First Gas, sub. 47, p. 6.

Notes:

1. First Gas anonymised the firms to respect commercial confidentiality.

However, the ability to convert coal-based heat production to gas is currently an option only in the North Island, as no reticulated supply is available in the South Island.¹³⁸ Even in the North Island, the ability to switch depends on proximity to the existing distribution network. Conversion to gas-based energy production is reasonably capital-intensive and may leave a firm with stranded assets or less able to change to even lower- or no-emissions fuels over the medium term.

Geothermal energy

Geothermal energy has a lower emissions profile than natural gas, although this can vary depending on the source. First Gas stated that the “amount of carbon emissions from New Zealand geothermal plants varies widely and can range from as low as 9kg/GJ to as high as 166 kg/GJ” (sub. 47, p. 3). Geothermal energy is also a proven energy source for intermediate heat production; for example, Miraka’s plant in Mokai uses geothermal steam to dry milk and Asaleo Care, in partnership with the Ngāti Tuwharetoa Trust, began using geothermal steam to produce tissue paper at Kawerau in 2010, resulting in a 46% reduction in GHG emissions (GNS Science, 2017). Mercury Energy noted that the

displacement of gas/coal generation by geothermal is the single-biggest reduction to date in NZ’s emissions profile with over 2 million tonnes CO₂-e per year permanently reduced (sub. 49, p. 3).

As with natural gas, the ability to switch to geothermal energy depends on proximity to the heat sources, most of which are located in the central North Island and Northland. Geothermal energy also typically involves relatively high capital expenses and economies of scale (East Harbour Energy, 2014), meaning that it is likely to be more suitable for larger-scale operations.

Electricity

Although electricity is the lowest-carbon source of energy in New Zealand, it can be a poor substitute for coal, which provides the same unit of heat for a third of the price. However, power prices can vary significantly by season. Concept Consulting (2017b, p. 76) noted that such seasonal variations may create opportunities for industries whose heat requirements “are anti-correlated with electricity prices (eg, dairy processing, and specifically milk drying which is very emission intensive)”. This was especially relevant to the South Island, where “electricity prices are lower on average (particularly in spring when most milk production occurs” and where coal is used for dairy processing heat (Concept Consulting, 2017b, p. 76).

Horticulture NZ observed that, for some greenhouses in the South Island, solar heating may be an alternative to coal (sub. 41, p. 7). Potential barriers to replacing coal or gas with electricity include the delays

¹³⁸ However, New Zealand Oil and Gas noted that exploring gas reserves off the South Island is under consideration (sub. 56).

and costs involved in building the necessary capacity in, and connections to, the transmission network (Fonterra, sub. 88, p. 7; Contact Energy, sub. 29, p. 6). However, technological advances may ease this constraint and provide new options in the South Island (Box 13.1).

Box 13.1 Concentrated solar power

Concentrated solar power (CSP) is a technology that uses lenses and mirrors instead of photovoltaic panels to generate energy. In some versions, the mirrors collect the sun's rays and reflect them onto a receiver pipe filled with oil. The oil can be heated to temperatures over 300°C, creating:

- heat that can be used for industrial or residential purposes, and
- energy that can be used to generate electricity.

CSP allows even relatively sun-starved areas to use solar energy, and is being used in a number of parts of Denmark to generate heat. In other variants of CSP, the solar energy is reflected onto tanks of molten salt. The heat generated during the day is used at night to drive steam-powered turbines.

A number of CSP projects are in place in Australia, including one in South Australia which uses seawater to fuel the Sundrop horticultural farm. The seawater is heated by the solar lenses, generating heat for the 200 000 square metre glasshouses in winter, powering a steam turbine to produce electricity, and providing freshwater (once desalinated) for irrigation. The Sundrop project has been estimated to avoid 16 000 tonnes worth of CO₂ every year.

Source: Ross (2018); Euronews (2018); Hiscock (2014); Aalsborg CSP (2015).

F13.3

There are more opportunities for switching to lower-emissions fuel sources for low and intermediate process heat needs for firms in the North Island, reflecting better access to gas and geothermal energy.

In the South Island, switching to electricity may be feasible for firms whose heat needs are negatively correlated with electricity prices.

Biomass

Biomass refers to organic material that can be converted into energy, generally by combustion. In New Zealand, forestry has been identified as a possible source of biomass (known as "woody biomass"), with a number of trials and ventures under way using it and other plant-based materials as fuels:

- Wood Energy South, an initiative of Venture Southland and the Energy Efficiency and Conservation Authority (EECA), aims to establish new commercial and industrial heating systems fuelled by wood and woody biomass (Wood Energy South, 2017).
- New Zealand Steel entered into an agreement in 2013 with CarbonScape (a Marlborough-based cleantech firm) to trial "green coke" created from forestry waste as an "additive in its steel making operation at Glenbrook to reduce carbon emissions" (New Zealand Steel & CarbonScape, 2013).
- Pulp, paper and packaging producer Oji Fibre Solutions (NZ) Ltd commented in its submission that it uses "over 21 PJ [petajoules] of energy from wood-based biomass (Kraft black liquor and wood residues)" (sub. 71, p. 1).
- Fonterra has been testing the suitability of miscanthus (a crop) "for use in their existing boiler systems to replace some of the coal that is currently burned" (GPI International, sub. 20, p. 2).

According to Oji Fibre Solutions, there is "enough recoverable woody biomass available throughout New Zealand that 60% of current coal use in heat plant could be replaced with biomass fuel" (sub. 71, p. 7).

The Bioenergy Association said that it “has been assessed that the bioenergy sector could contribute greenhouse gas (GHG) emission reductions of 490kt of CO₂-e a year by 2030 and 1150kt of CO₂-e a year by 2040” (sub. 37, p. 1). The Royal Society of New Zealand sees bioenergy as potentially making the single largest contribution to emissions reductions in the heat sector between now and 2040 (RSNZ, 2016, p. 176).

However, quality concerns, transportation costs, boiler suitability, price and the source of the plant material mean that biomass is unlikely to be a viable and economic lower-emission fuel source for large industrial heat plant in the short term. Graymont observed that “[w]oody biomass has a low energy density and so efficiency and transportation (eg, increased truck movements) can be a barrier to implementation. Pre-processing of biomass into a high(er) energy density fuel is one option to be considered but availability and cost are currently prohibitive” (sub. 33, p. 6). Horticulture New Zealand made similar points, noting that wood chip “requires 7–10 times the fuel volume to generate the equivalent BTU [British Thermal Unit] heat rate as coal, this means 7–10 truckloads to provide the equivalent output of one truckload of coal” (sub. 41, p. 8).

Vivid Economics (2017a, p. 14) concurred, commenting that

[b]iomass could be used for applications with a high energy demand such as milk drying, although some upgrading of the biomass feedstock may be required in order to deliver heat to meet temperature and quality requirements. The management of transport costs and challenges in ensuring security of biomass supply have also been barriers to date.

The environmental respectability of biomass has been the subject of considerable academic debate. Four findings of researchers are noted below.

- The combustion of biomass generates high amounts of pollution, including carbon monoxide, nitrogen oxide and total organic carbon (Wielgosiński et al., 2017).
- Depending on the source of organic material used to create biomass, carbon emissions from burning biomass can “stay higher for decades than if fossil fuels had been used” (Brack, 2017, p. 5).
- Biomass boilers can be less efficient than fossil fuel boilers, and the variable quality of wood can further erode efficiency (Partnership for Policy Integrity, 2011).
- A full analysis on the climate impact of biomass needs to take into account changes in the forest carbon stock, emissions from combustion, and supply-chain emissions from harvesting, collection, processing and transport. There is still uncertainty over some of these factors (Brack, 2017).

First Gas similarly observed that the source of material for biomass will affect its relative GHG intensity and possible emissions reductions.

The net emissions from burning biomass are more complex to assess. If the biomass comes from waste that would otherwise be left to rot (and thereby release its carbon), there may be little net carbon emissions from burning biomass. However, if vegetation (for example, a tree) is felled specifically to use as fuel and not replanted, or the vegetation takes many years to re-grow, using biomass for fuel may have a larger impact on global warming than using natural gas. (sub. 47, p. 3)

In its review of New Zealand’s energy policies, the International Energy Agency (IEA) concluded that

[c]urrent coal prices and the low energy content of biomass compared to coal have been obstacles for the switching of large industrial users in the South Island to biomass. At the same time, biomass has also considerable greenhouse gas (GHG) emissions and cannot be seen as low-carbon in a lifecycle analysis. (IEA, 2017a, p. 200)

F13.4

Significant technological and logistical improvements will be needed before biomass becomes a cost-competitive and emissions-neutral alternative to fossil fuels for large industrial heat plant.

13.4 Policies to reduce emissions from process heat

Current policies

The previous government had a target to reduce industrial emissions by at least 1% each year between 2017 and 2022, with a particular focus on process heat (MBIE, 2017b). The EECA works directly with large energy users, and through energy management experts with medium-sized businesses, to promote more efficient and lower-emissions energy options. EECA provides advice to other businesses through industry associations and web-based information and tools (EECA, 2017c).

Emissions-intensive and trade-exposed industries are freely allocated the majority of their New Zealand Unit (NZU) requirements under the NZ Emissions Trading Scheme (ETS) to support their international competitiveness and prevent the leakage of production and emissions offshore. These allocations are based on the emissions arising both from energy use (including electricity) and from industrial processes (discussed below). ETS allocations are discussed in Chapter 4.

The impact of increasing emissions prices

Arguably the most powerful policy for promoting fuel switching and other emissions reductions in industrial energy is a significantly higher emissions price. Concept Consulting (2017a, 2017b) explored the impact of moving from the then-current emissions prices (NZ\$8 per tonne of carbon dioxide) to a NZ\$75/tCO₂ price for three different hypothetical intermediate process heat plants, which varied in terms of their size / energy use. The analysis also compared the impact of rising prices on whether the plant had an existing workable boiler or needed to install a new one, and considered impacts on both operating and capital costs.

The Concept Consulting analysis indicated two assumptions.

- Under both emissions price scenarios, gas is a cheaper source of energy than coal where new boilers are needed. In the lower price scenario, this largely reflects the higher capital costs associated with installing a new coal-fired boiler. In the \$75 scenario, the preference for gas reflects the substantially higher emissions price.
- The shift up to a \$75 per tonne emissions price makes gas cheaper than coal in every scenario where the presence of an existing workable boiler is assumed, although the scale of the advantage depends on the size of heat plant.

The report also found that “[i]nitial analysis indicates that electric solutions for some plant could give rise to a sub \$100/tCO₂ abatement cost” (2017a, p. 76). Concept Consulting concluded that “a cost of carbon of about \$60 to \$70/tCO₂” would be needed to make a switch to “the lowest-cost biomass resources” economic, although they noted that the costs of biomass are “very situation-specific” and could be much higher in some cases (2017b, p. 20). In both cases, technological advancements could lead to significant cost reductions.

Emissions prices of \$60 to \$100 per tonne are well within the range of mitigation scenarios modelled for this report (see Chapter 3), and significantly higher prices are possible depending on the scenario. Expectations of future price increases would affect current and upcoming investment decisions and tend to move firms towards lower-emissions heat sources.

F13.5

Rising emissions prices will be central to driving emissions-reducing investments in industrial heat processes.

Possible other policies

The role of EECA in promoting industrial emissions reductions

EECA currently provides a range of guidance and advice to firms on energy efficiency and emissions reductions strategies. EECA does not distinguish between the size of firm or its capability to self-fund any emissions reductions activities. These business support activities make sense in an environment in which little

incentive to mitigate emissions is provided through the ETS price. As discussed in Chapter 4, emissions prices created through the ETS have been too low to have a substantial impact on business decisions.

However, if the Commission's wider recommendations to establish emissions budgets and reform the NZ ETS are accepted, the emissions price will rise. Also, the case for broad-based assistance to firms to seek efficiency improvements seems weaker, especially for those businesses that have large-scale process heat facilities.

Some form of continued assistance and advice to smaller firms may still be appropriate in the future, to overcome information barriers to climate change adaptation or mitigation. The Parliamentary Commissioner for the Environment has argued that EECA's current mandate of energy efficiency and renewable energy is outdated, and should be changed to lowering GHG emissions.

In recent years, it has become clear that the finiteness of fossil fuels is not the problem; rather the problem is the carbon dioxide emitted when fossil fuels are burned. The real scarcity is the limited ability of the atmosphere to absorb greenhouse gases without substantially changing the climate. EECA's mandate should now be changed to working to reduce carbon dioxide emissions. Often renewable energy is low carbon, but this is not always the case. (sub. 54, p. 9)

The Commission concurs that a change in EECA's mandate would be useful and timely.

R13.1

The statutory functions of the Energy Efficiency and Conservation Authority (EECA) should be changed to make lowering GHG emissions its primary mandate.

The barriers to adopting emissions-reducing technologies are far less likely to apply with larger firms. EECA should therefore re-orient its business emissions reductions activities towards smaller firms in the future. To the extent the EECA continues to work with larger firms, it should do so on a cost-recovery basis.

R13.2

EECA should refocus its support for business to adopt emission-reducing techniques towards smaller firms. To the extent that EECA continues to work with larger firms, this should be conducted on a cost-recovery basis.

Boiler standards

Replacing existing fossil fuel boilers with lower or zero-carbon alternatives was identified as an important mitigation strategy by a number of submitters. One way of encouraging this shift would be to regulate the type or performance of boilers that can be installed in future. The Morgan Foundation noted that the Danish Government had prohibited new fossil-powered boilers for low-temperature heat, and that New Zealand could take similar steps.

Regulations such as emissions standards on new boilers, a requirement for new or refitted coal boilers to be capable of co-firing with biomass, or a ban on some types of boilers in certain applications. (sub. 127, p. 12)

The Commission does not see a compelling future for coal-based process heating, given its emissions intensity. Over time, the existing coal-based boilers should be replaced with more sustainable alternatives. However, a regulatory intervention to ban or limit the installation of new coal boilers may be problematic.

- A number of businesses that use fossil fuel boilers are trade-exposed and in competition with firms not currently subject to equivalent rules. As such, they have little opportunity to recover the additional costs that result from more expensive boiler systems (see, for example, Horticulture NZ, sub. 41, pp. 5–6).
- Boilers, like other capital investments, are long-lived assets and may not be replaced for many years or decades. Owners of current fossil-fuel boilers are also likely to consider future emissions costs when making replacement decisions. Regulatory restrictions may not add much value, if higher future emissions prices are credibly signalled.

- Most of New Zealand’s industrial energy emissions come from intermediate heat processes and larger plant, where boiler requirements are likely to be more firm-specific. It could be difficult to accommodate these firm-specific needs within regulation.

The Commission considers that the other reforms proposed in this report should provide sufficiently strong reasons for firms to shift away from emissions-intensive heat sources. Examples of specific related reforms are emissions budgets with associated rises in emissions prices, the progressive withdrawal of free allocations, and climate-related financial disclosures.

Dairy industry regulation

Industry-specific regulatory requirements may be acting as barriers to a shift away from carbon-intensive heat production. In its recently-released Sustainability Report, Fonterra (2017) noted that the Dairy Industry Restructuring Act (DIRA) (which facilitated the creation of Fonterra, while regulating its market conduct) requires the company

to collect all milk under certain conditions. This limits our influence over where, when and how milk volume growth occurs and requires us to expand our processing capacity to meet all potential demand. While we do not intend to install any new coal boilers from now, this means increased demand in certain locations may require this in the short term where there are no alternatives available. (p. 50)

DIRA obliges Fonterra to accept applications to become new shareholders, and to accept milk supplied by shareholders (these obligations are known as ‘open entry and exit’). These obligations (and other parts of the Act) are designed to limit the ability of Fonterra to exercise market power. They are also subject to some conditions and exceptions. For example, Fonterra is only required to accept shareholder applications during specified time periods and can put in place temporary restrictions on accepting milk supply where capacity constraints exist. Fonterra can also reject shareholder applications where the costs of transporting milk would be exceptionally high, or where the anticipated supply of milkfat solids from an applicant is very low. However, none of the current statutory exceptions to, or conditions on, Fonterra’s obligation to accept milk supply explicitly factor in the impact of acceptance on the company’s GHG emissions.

The operation of DIRA is subject to review by the Commerce Commission. In its most recent report on the state of competition in the milk market, the Commerce Commission recommended that the Minister for Primary Industries explore the option of removing open entry for new dairy conversions. This recommendation was taken up, with the former government ultimately agreeing to give Fonterra discretion to reject such applications. The government agreed on the grounds that open entry in this case could have “perverse outcomes in encouraging inefficient land use changes to dairying” (MPI, 2016b, p. 20).¹³⁹ A Bill amending the DIRA to this effect was introduced to Parliament in March 2017, although the Bill has since been set aside. Instead, the new Agriculture Minister has indicated that a more comprehensive review of DIRA will be undertaken (O’Conner, 2017).

Allowing Fonterra to refuse supply in circumstances where such refusal would lead to inefficient (and thus higher-emissions) land use and/or a significant increase in its GHG emissions may be of benefit. To avoid creating undesirable incentives, the exercise of this discretion could be limited by adding statutory conditions.

Q13.1

Would giving Fonterra discretion to refuse milk supply where this would lead to inefficient land use and/or a significant increase in the company’s GHG emissions provide any benefit? What, if any, conditions would need to be attached to the exercise of such discretion?

¹³⁹ Inefficient land use is linked to higher emissions intensity (Chapter 9).

13.6 Industrial processes

Industrial process emissions occur when one substance is transformed into another in an industrial setting. In New Zealand, GHG emissions are reported from eight industrial processes:

- calcination of limestone in cement production;
- calcination of limestone in burnt and slaked lime production;
- production of ammonia, which is further processed into urea;
- production of methanol;
- production of hydrogen in oil refining and for making hydrogen peroxide;
- production of steel, from iron sand and from scrap steel;
- oxidation of anodes in aluminium smelting; and
- use of soda ash and limestone in glass making (MfE, 2017g, p. 101).

The main GHGs directly emitted by industry are CO₂ (two thirds of emissions), followed by hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

The metal industry (mostly iron, steel and aluminium production) contributes the largest proportion of industrial emissions (about 3% of New Zealand's total), although its total emissions and share of IPPU emissions fell between 1990 and 2015 (Table 13.2).

Table 13.2 Greenhouse gas emissions from New Zealand's IPPU sector, 2015

Source	2015 emissions (kt CO ₂ -e)	Change 1990- 2015 (%)	2015 share of sector emissions (%)
Mineral industry	876.3	56.0	16.6
Chemical industry	389.0	91.6	7.4
Metal industry	2366.3	-11.4	44.8
Non-energy products from fuel and solvent use	46.5	57.1	0.9
Product uses as substitutes for ozone-depleting substances	1523.5	-	28.9
Other product manufacture and use	78.0	-34.9	1.5
Total	5279.7	47.3	-

Source: MfE (2017g)

The next biggest source of industrial emissions comes from HFCs used to replace ozone-depleting substances in refrigeration and air conditioning. A mitigation pathway for HFCs is described in Chapter 8. The calcination of limestone at high temperatures in the manufacture of cement and lime produces just over 1% of all New Zealand's GHG emissions.

Opportunities to reduce emissions from industrial processes

The emissions from industrial processes and products are intrinsic to the physical processes involved in production and in product use. Existing plants (such as steel mills and aluminium smelters) use technologies founded on these physical processes. In the long run, new low-carbon technologies to produce these materials, or shifting end use to other (perhaps new) low-carbon products, may be possible. A high enough carbon price will induce a search for low-emissions product substitutes, such as replacing steel with wood in

construction, cement substitutes or low-emissions cement variants. It may also make the introduction of mitigation technologies viable. However, as discussed in Chapter 4, higher carbon prices raise viability and fairness issues for trade-exposed firms whose competitors are not subject to equivalent pricing. The closure of domestic firms, and the shift of production to less emissions-efficient producers offshore, would be a loss for New Zealand and globally.

Aluminium

Most of the direct GHG emissions from aluminium production in New Zealand result from the smelting process, during which aluminium oxide (alumina) is dissolved in cryolite and electrolysed within a cell. The process separates oxygen from the alumina by combining it with carbon to create CO₂. PFCs can also be produced from ‘anode effects’, when insufficient alumina is dissolved and inefficient production occurs. However, PFCs make up a very small share (0.07%) of New Zealand’s gross emissions.

Barring any breakthroughs in production technologies, the potential for significant reductions in GHG emissions from aluminium production in New Zealand seems limited. Aluminium production processes are about 130 years old and no obvious replacement technologies are yet available. New Zealand’s sole aluminium producer (New Zealand Aluminium Smelter Ltd) already has a low-emissions production profile relative to overseas producers, due largely to its use of renewable hydroelectricity.

NZAS [New Zealand Aluminium Smelter Ltd] aluminium smelter at Tiwai Point has one of the lightest carbon footprints per tonne in the world. With less than 4 tonnes of CO₂ per tonne of aluminium compared to a global industry average of over 11.5 tonnes of CO₂ per tonne (cradle to gate assessment). (Metals New Zealand, sub. 120, p. 2)

Pacific Aluminium, which owns the majority share of NZAS, noted that it has taken a number of steps to reduce its carbon footprint.

NZAS has already reduced its on-site emissions by 55% from ~4.5 tCO₂-e/t Aluminium to ~2 tCO₂-e/t since 1990 and this was achieved prior to the introduction of a price on carbon. (sub. 21, pp. 1, 3)

The most promising emissions reductions opportunities in the short term are likely to come from process improvements, although the impacts may be small. Such improvements typically improve energy efficiency and reduce waste, and the industry should therefore have sufficient incentives to pursue them. Alamdari (2017) outlines some recent research into process improvements, which includes trials of new, more environmentally-friendly materials for sealing the electrolysis cell and techniques for better identifying quality faults in anodes (which are made of carbon and consumed in the smelting process). The Columbia Climate Center (2012, p. 2) points to opportunities to “almost entirely eliminate anode effects and thus PFC emissions” through the use of prebaked anodes and retrofits to computer control and point-feeding systems. At an international level, the aluminium industry has voluntarily pledged to reduce PFCs per tonne of aluminium by at least 50% by 2020 as compared to 2006 (IAI, 2010).¹⁴⁰ NZAS is a signatory to this pledge due to its ownership structure.

A further source of emissions reductions is greater recycling. Aluminium can be “infinitely recycled” and the recycling process “requires 5% of the energy used in primary production, and emits 5% of the GHGs” (Columbia Climate Center, 2012). According to Metals New Zealand, emissions

from the processing of recycled aluminium in New Zealand are exceptionally low by world standards, with New Zealand’s sole recaster of aluminium having a low carbon footprint of 1.21kg of CO₂ per kg of aluminium (based on a cradle to gate assessment). (sub. 120, p. 5)

Public policy can influence recycling rates, although the potential scale of increases in New Zealand is unclear. Most¹⁴¹ of the aluminium produced in New Zealand is exported and is cast to customer requirements. A 2007 cost–benefit report prepared for the Ministry for the Environment found that 51% of household aluminium waste in New Zealand was recovered, and that 85% was “technically recoverable” (Covec, 2007, p. iii). However, the report also concluded that recycling “all aluminium containers provides

¹⁴⁰ At present, global PFC emissions per tonne of aluminium production have reduced by approximately 30% since 2006, but global emissions intensity has remained stable since 2009 due to significant aluminium production in China (World Aluminium, 2017).

¹⁴¹ Of the aluminium produced at the New Zealand Aluminium Smelter in 2016, 90% was exported (NZAS, 2017).

net benefits even without the inclusion of external benefits". This raises the questions of why recycling rates are not higher. Data is not available on recycling rates for non-household aluminium waste.

Iron and steel

Most GHG emissions from the iron and steel sub-sector result from the production of iron, which uses coal as a reducing agent. CO₂ is created by heating and drying concentrated iron sand and coal, and by the conversion of the oxide in iron sand into iron. Some carbon dioxide is also emitted from the use of limestone in iron and steel production.

Opportunities to directly reduce GHG emissions from iron and steel production are currently limited. Carbon "is an intrinsic requirement of the steelmaking process for which there is currently no substitute" (New Zealand Steel, sub. 64, p. 14). Some submitters pointed to the potential to use lower-carbon alternatives to coal to produce heat for the steel-making process (sub. 37; sub. 68; sub. 127). However, this does not deal with the carbon produced by the coal reduction process.

Recycling is another possible means of reducing GHG emissions. Steel is potentially infinitely recyclable, and the GHG footprint of recycled steel can be almost two-thirds lower than for new metal (IEA Greenhouse Gas R&D Programme, 2000). This does, however, rely on a sufficient supply of high-quality scrap and there are limits to the proportion of recycled material that can be used.¹⁴² New Zealand Steel noted that approximately "70 000 tonnes of scrap steel is recycled each year in the steel making process" (sub. 64, p. 4).

Beyond changes to production inputs, the pursuit of greater process and energy efficiency and the capture and use of carbon dioxide are the remaining options. Sixty percent of the Glenbrook steel plant's energy needs are met from the re-use of waste gases and heat, and carbon dioxide at the same plant has been converted into fuels using domestically-developed technology. Further efficiency gains are possible, although international commentary on the iron and steel sector indicates that the bulk of efficiencies in the developed world have already been achieved (Columbia Climate Center, 2012). Incentives to pursue efficiencies and adopt technological improvements in iron, steel and aluminium production will be strengthened by rising emissions prices and the gradual withdrawal of free allocations.

F13.6

Barring technological breakthroughs, opportunities to significantly reduce emissions from iron, steel and aluminium production remain limited.

Lime and cement

Over 90% of emissions in the 'minerals industry' subsector in 2015 came from lime and cement production. To produce lime (a core input to cement), limestone (calcium carbonate) is baked at high temperatures (ie, higher than 1000° C), releasing CO₂. Fossil fuels such as coal and gas are often used to achieve the high temperatures required to calcinate lime.

Shifting away from coal to lower-carbon fuel sources is one way to reduce emissions in lime and cement production, although geographic and other factors limit the range of alternative fuel options in some cases. Some companies in New Zealand have experimented with alternative fuel sources for cement production, backed by public funds. In June 2017, the former government announced a grant of \$18.6 million to replace coal with waste tyres as the primary heat source for cement production. One grant recipient, Golden Bay Cement, will burn 3.1 million waste tyres a year, reducing its GHG emissions by 13 000 tonnes each year.

The potential for breakthrough technological advances and associated carbon reductions may be higher for cement than other industrial processes. For example,

- scientists at the University of California Los Angeles reported in 2015 that they had successfully trialled a process to recombine the carbon dioxide released during lime calcination with calcium hydroxide to recreate limestone (S. Mason, 2015); and

¹⁴² The presence of "undesirable residue metals" in scrap can make it unsuitable for high-quality steel products (IEA Greenhouse Gas R&D Programme, 2000, p. iii).

- a British firm announced in 2008 that it had invented a magnesium-based cement that requires less heating than lime-based options and which “absorbs large amounts of CO₂ as it hardens, making it carbon negative” (Jha, 2008).

The viability and applicability of such new technologies in New Zealand will depend on their cost-competitiveness and scalability, and the ability of existing production facilities to accommodate them. In the shorter term, however, opportunities may emerge to reduce carbon emissions from cement by changing its composition and use. Beyond Zero Emissions (BZE) (2017) in Australia identifies five strategies for “moving to a zero carbon cement industry in 10 years” (Table 13.3).

Table 13.3 Beyond Zero Emissions carbon reduction strategies for cement

Strategy	Description	Estimated impact timeframe
Supplying 50% of cement demand with geopolymer cement	The reactions involved in making geopolymer cements do not generate GHGs. Geopolymer cements are made from fly ash (a by-product of coal-fired power stations) and ground-granulated blast-furnace slag (a by-product of steelmaking). It is also possible to make such cements from clay.	Within 10 years
Supplying 50% of cement demand with high-blend cements	Increasing the proportion of replacement materials in cement (eg, fly ash, slag, clay and ground limestone) to 70%. High-blend cements can be largely manufactured on existing equipment.	Within 10 years
Mineral carbonation	Waste CO ₂ is captured and chemically sealed within rock. The process can produce substances with commercial value, such as magnesium carbonate and silica.	Within 10 years
Using less cement	Designing structures to use concrete more efficiently, using high-strength cement and replacing concrete with timber.	Within 10 years
Carbon-negative cements	Developing magnesium-based cements that absorb CO ₂ .	30 years

Source: Beyond Zero Emissions (2017).

BZE identifies a range of policy and regulatory actions required to put these strategies into action, including:

- changes to cement standards to enable more use of alternative and lower-carbon inputs;
- imposing a carbon price on cement;
- incentives for companies to recover waste materials that are components of lower-carbon cement;
- incentives to reduce the proportion of processed lime and increase the use of waste materials in construction cement; and
- public infrastructure procurement strategies to encourage more use of lower-carbon cements.

Some of the strategies outlined by BZE may be less suitable or relevant to New Zealand. For example, the focus on incentives to recover and retain waste materials partly reflects the heavily coal-based nature of power generation in Australia and the fact that fly ash (a key component of alternative cements) is a by-product of coal-fired generators. As discussed earlier, coal makes up a relatively small share of electricity production in New Zealand. And, unlike New Zealand, Australia currently has no emissions trading system or other mechanisms to apply carbon prices. The changes to regulation, procurement and incentives proposed

by BZE can therefore be seen as a 'second best' approach, filling the gap left by the absence of an emissions price.

The Commission is interested in understanding whether applying some of the other BZE strategies in New Zealand would offer a net benefit here.

Q13.2

Does New Zealand need to amend its cement standards to permit greater use of lower-carbon components?

Q13.3

Do any New Zealand-specific factors exist that would make the use of lower-carbon cements and concretes unsuitable (eg, seismic or other geographic conditions)?

Q13.4

Would a higher effective emissions price be sufficient to encourage greater use of lower-carbon cements? Would doing so require more active government policy (such as procurement standards and targets)?

13.7 Carbon capture and storage

For large, single-point sources of significant carbon emissions such as steel, aluminium and cement manufacture, carbon capture and storage (CCS) may be a suitable means of reducing or eliminating net emissions in the future (RSNZ, 2016). The future adoption of CCS in New Zealand will depend on a number of factors, including the location and type of industry, and regulatory and policy change.

Many key organisations predict that CCS technologies will play a significant role in meeting international emission targets. For instance, modelling from the International Energy Agency (2015) predicts that CCS will deliver 13% of the emissions reductions needed by 2050 to limit the global increase in temperature to 2°C.

CCS involves capturing, compressing, transporting and permanently storing carbon dioxide emitted from large point sources such as gas and coal-fired power stations and industrial plants. This process can be broken down into three stages.

- First, capture technologies **isolate and separate** the carbon dioxide. Depending on the nature of the emitting activity, this can occur before, during or after combustion, and use various methods. For instance, a coal-fired power station could separate the carbon dioxide after the coal has been burned. Separation is possible by bubbling the flue gases through an absorber column containing liquid solvents. Those solvents remove the carbon dioxide.
- Second, the carbon dioxide is **purified and compressed** into a supercritical state – at a pressure and temperature above its critical point – so it behaves like a liquid. This process allows the carbon dioxide to then be transported to a suitable location underground for storage. In most cases, the carbon dioxide is transported through a pipeline.
- Third, the carbon dioxide is **injected** into geological formations deep underground where it is **permanently stored**. Storage locations must be at least 800 metres under the earth's surface to keep the carbon dioxide in a supercritical state.¹⁴³ Examples of potentially suitable formations include deep saline aquifers, and depleted oil and gas fields.

Use of CCS is slowly growing worldwide

The use of CCS technologies globally is slowly growing. By December 2017, 37 large-scale CCS projects worldwide were either in operation, under construction or being developed (Global CCS Institute, 2017). Twelve of these projects are located in North America. Australia's first CCS project, the Gorgon Carbon Dioxide Injection Project, is expected to be in operation later this year. Located off the coast of Western

¹⁴³ Suitable geological formations for storing carbon dioxide can be as deep as 3 500 m below the earth's surface.

Australia, the project aims to separate carbon dioxide from natural gas streams, and store it in a deep reservoir unit more than 2000 metres underground. New Zealand currently has no CCS projects operating or under development.

...and could be a viable option in New Zealand in future

Recent studies consider CCS to be a potentially viable option for several large emitters in New Zealand, and a number of potential sites for carbon storage have been identified in areas such as Taranaki, Canterbury, and Whanganui. Economic considerations – in particular the level of emissions prices – will be key in deciding whether to invest in CCS. The estimated level of emissions price needed for CCS projects to break even varies considerably, depending on the industry, the type of facility (ie, new or retrofitted) and ETS policy settings.

Transfield Worley (2011) developed two case studies to assess the relative costs of installing CCS technologies. The first looked at retrofitting an existing natural gas, combined-cycle power station; the second considered adding a carbon dioxide compression system to a hypothetical new lignite processing plant. The retrofit required a much higher emissions price to break even (Table 13.4), although Transfield Worley noted that retrofitting may be economic at current emission prices “for existing process plants with carbon dioxide separation processing” (2011, p. 11). The higher emissions prices envisaged by Transfield Worley (Table 13.4) are also well within the range of those identified in the Commission’s modelling scenarios (Chapter 3).

Table 13.4 Potential CCS break-even emissions prices

Discount rate	Retrofit carbon price to break even (by tonne of CO ₂ equivalent)	New plant carbon price to break even
5% (social discount rate)	\$NZ 83 per t CO ₂ e	\$NZ 20 per t CO ₂ e
10% (then-Treasury discount rate)	\$NZ 103 per t CO ₂ e	\$NZ 32 per t CO ₂ e
15% (industry/commercial discount rate)	\$NZ 128 per t CO ₂ e	\$NZ 45 per t CO ₂ e

Source: Transfield Worley (2011)

Notes:

- Discount rates are a tool used for putting the costs and benefits of a potential investment or policy proposal that occur at different points in time onto a comparable footing. Higher discount rates put more weight on short-term benefits and costs. The current Treasury default discount rate is 6%, not 10%.

New Zealand Oil & Gas in their submission agreed that CCS could be viable at current prices, especially if this took place at oil or gas fields and if the CCS activity took place as part of oil or gas production.

Our preliminary estimates indicate that carbon could be sequestered in certain realistic New Zealand cases for a net cost of \$18/tonne. A field with the right production qualities potentially could be economic at today’s NZU [New Zealand Unit] values if emissions credits were available for CO₂ sequestration to a producing oil and gas field. With no oil and gas production, we estimate that carbon sequestration could be economically viable at \$68.90/tonne. (sub. 56, p. 9)

The lower \$18 per tonne viability price when CCS took place alongside oil and gas production reflected the “enhanced recovery” that would result from the captured gas being “re-injected to boost performance of the well” (sub. 56, p. 10). Under the \$68.90 per tonne price, captured gas would be injected into an end-of-life field and there would not be any improvements to gas and oil production to offset the additional expense.

The Transfield Worley (2011) study identified a number of suitable locations for CCS, including Marsden Point Oil Refinery, Huntly Power Station and Kapuni Gas Treatment Plant. Plants such as Marsden Point already separate CO₂ as part of their existing operation. So CCS is likely to be more cost-effective for these locations. Barton, Jordan and Severinsen (2013) note that some New Zealand industries have experience working with similar sorts of technology.

Due to the large costs and economies of scale associated with undertaking CCS, both studies suggest that CCS is viable for coal-fired power stations with carbon dioxide emissions above 0.8–1 million metric tonnes a year, and above 0.4–0.5 million metric tonnes a year for other operations.

The role of the NZ ETS in CCS

CCS is currently treated as a “removal activity” under the NZ ETS, and ETS participants conducting CCS could therefore claim credits for CO₂ removed from the atmosphere. However, credits can only be claimed for emissions from activities that must surrender units under the NZ ETS. This means that CCS activities not directly linked to NZ ETS participants or that sought to remove general carbon from the atmosphere would not qualify for NZ ETS credits. This disadvantages CCS against other carbon removal activities such as forestry. The Commission concurs with Barton, Jordan and Severinsen (2013) that the NZ ETS should be amended, so that CCS is “a removal activity whether or not the CO₂ is from an activity that is required to surrender units” (p. xi). Such amendments would also need to be accompanied by other policy changes to ensure that CCS operators were required to surrender any credits where captured carbon leaked, including after a CCS site had closed (Barton et al., 2013).

Existing legislation does not adequately govern CCS activities

Existing legislation is not set up to deal with the complexities of CCS, and acts as a barrier to the uptake of these technologies. Barton et al. (2013)¹⁴⁴ assessed the current legislative frameworks applicable to CCS and conclude:

A close analysis of the RMA [Resource Management Act 1991], the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act), and the Crown Minerals Act 1991 produces the conclusion that none of those Acts is capable, either in its detail or its general architecture, of delivering the legal framework that is required for CCS. (p. vii)

Key problems identified with existing legislation include:

- the limited ability of the RMA to provide “close ongoing regulatory supervision that CCS requires over very long time frames” (p. vi);
- inadequate procedures for allocating permits, especially the ‘first in, first served’ rule when there are competing resource consent applications;
- the lack of mechanisms in the RMA for dealing with “long-term liability for CCS operations after closure” (p. vii);
- potentially unbalanced assessment criteria — resource consent authorities are limited in their ability to consider the positive impacts of CCS activities on climate change when considering applications, but can consider negative impacts;
- inconsistent rules between regions, with some local rules effectively prohibiting some CCS activities; and
- slow rule-making processes and variable “institutional capacity of councils to regulate technically complex activities” (p. 36).

Because of the significant weaknesses of the existing legislative frameworks, Barton et al. concluded that the best response was not to amend existing laws but to establish a new “CCS Act”. That Act would be specifically designed to facilitate and regulate geological sequestration of carbon dioxide.

Having a suitable regulatory framework for CCS activities will be important, given the technology’s potential significance for climate change management. The Commission concurs with the analysis of Barton, Jordan and Severinsen that an entirely new Act is the best response and that any new legislation should focus on the “regulation of CCS, not for CCS”. In essence, the law should provide for appropriate cost–benefit assessments of new activities, rather than promote CCS.

¹⁴⁴ Transfield Worley (2011) and RSNZ (2016) have also emphasised the need for legislative reform if CCS is to become viable.

R13.3

New legislation should be prepared to regulate carbon capture and storage activities (CCS).

R13.4

Once new CCS legislation is in place, the New Zealand Emissions Trading Scheme should be amended to make CCS a recognised removal activity, no matter the source of emissions being captured and stored.

13.8 Conclusion

Industrial sources make up a significant and rising share of New Zealand's total GHG emissions. Low and intermediate process heat uses have scope to decarbonise, but the viability of abatement opportunities depends on the nature and location of the production process and the scale of heat required. Higher emissions prices will be needed to encourage changes to production process and investment. Even then, the process of decarbonisation may take some time, given the fact that any capital plant (such as a boiler) has a long life. Barring significant technological advances, opportunities to reduce emissions from industrial processes (such as iron, steel and aluminium production) remain limited, at least in the short term.

Large, single-point sources of significant emissions such as steel, aluminium and cement could be suitable candidates for carbon capture and storage (CCS) processes. As CCS technologies are still developing, the scale and price at which they will become viable remains very uncertain. Even so, it will be important that New Zealand's regulatory system is appropriately set up to accommodate these changes and manage risks. New legislation should be introduced to appropriately regulate CCS.

14 Waste

Key points

- Waste represents 5% of New Zealand's greenhouse gas (GHG) emissions. New Zealand also has the highest waste emissions per person, and is the most waste-emissions-intensive economy of all members in the Organisation for Economic Co-operation and Development. However, emissions data from waste is highly uncertain, particularly as regards emissions from unmanaged waste disposal (including on-farm disposals known as farm dumps).
- Most emissions (91%) are methane (CH₄) from solid waste disposed to landfill, with the rest from wastewater treatment and discharge (mostly CH₄, but some nitrous oxide, N₂O). Nearly two-thirds of total waste emissions are from unmanaged waste disposal.
- Organic waste is the dominant driver of CH₄ emissions, and comprises nearly 40% of total waste to municipal landfills. Emissions reductions from solid waste therefore rely on reducing organic waste volumes to landfill in the first place, and better management of CH₄ once organic waste reaches landfill.
- Better CH₄ management does not require the development of new technology. While technological improvements can make mitigation more efficient, emissions can be effectively avoided by existing technologies, such as landfill gas recovery or anaerobic digestion systems.
- New Zealand takes a predominantly market-based approach to waste, via the emissions price under the NZ ETS (incentivising emissions reductions) and the waste disposal levy (incentivising reduced waste to landfill). However, neither currently operates at a level adequate to incentivise emissions reductions. Nor are they adequate in their coverage across waste disposal sites.
- To transition to a low-emissions waste sector, there is an urgent need to improve waste data. Much data is out of date, inconsistent or incomplete. As a result, there is limited ability to clearly identify or quantify opportunities to reduce emissions. Any projects to improve waste data should include specific information on waste emissions.
- Given what current data illustrates about sources of waste emissions, the priority action must be to reduce emissions from unmanaged solid waste sites. This will require extending the waste disposal levy to all unmanaged, yet known and consented, facilities for disposing of solid waste, and changing consenting processes, bylaw processes or both to cover remaining disposal sites.
- A more effective emissions price under the New Zealand Emissions Trading Scheme (NZ ETS) will help to reduce emissions from managed sites. The Commission is also interested in submitters' views on whether to extend the NZ ETS to include wastewater treatment plants.

Waste is the smallest of New Zealand's greenhouse gas (GHG) emissions sources, producing 5% of gross emissions in 2015. But, according to current data, and in carbon dioxide equivalent (CO₂e) terms, this is only slightly less than emissions from electricity. Waste also represents a major mitigation opportunity. At present, New Zealand has the highest waste emissions per person in the Organisation for Economic Co-operation and Development (OECD), suggesting significant scope to further reduce emissions. It is also likely that considerable emissions reductions can occur at modest emission prices.

This chapter will:

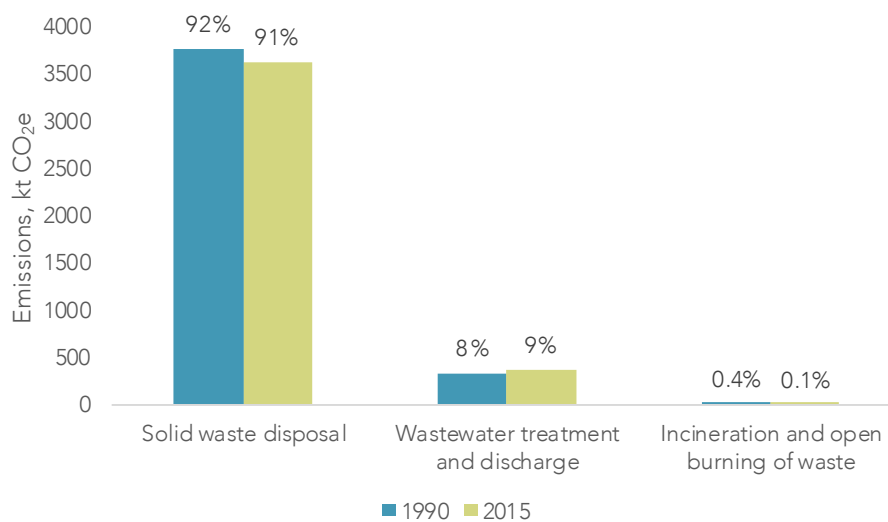
- explain the main sources of, and associated policy framework for, waste emissions in New Zealand;
- show how New Zealand's policy framework compares to leading international comparators;

- describe Māori perspectives on waste management;
- identify opportunities to reduce emissions from New Zealand's main sources of waste emissions, focusing in particular on matching policy responses (such as an emissions price under the New Zealand Emissions Trading Scheme (NZ ETS), or the waste disposal levy) to key emission sources; and
- consider the future of waste emissions, including the potential for embedding a circular economy approach to the New Zealand economy.

14.1 Waste emissions in New Zealand

Methane (CH₄) comprises the majority of waste emissions (97%), followed by nitrous oxide (N₂O) at 3% (solely from wastewater treatment) and carbon dioxide (CO₂) at 0.03% (solely from incineration) (MfE, 2017g). The vast majority of emissions are from solid waste disposal (ie, waste to landfill), followed by wastewater (Figure 14.1). CH₄ emissions occur when organic material decomposes without the presence of oxygen (ie, anaerobically). The process by which this occurs is called methanogenesis, which is the formation of CH₄ by microbes known as methanogens.

Figure 14.1 New Zealand's GHG emissions from waste by source category



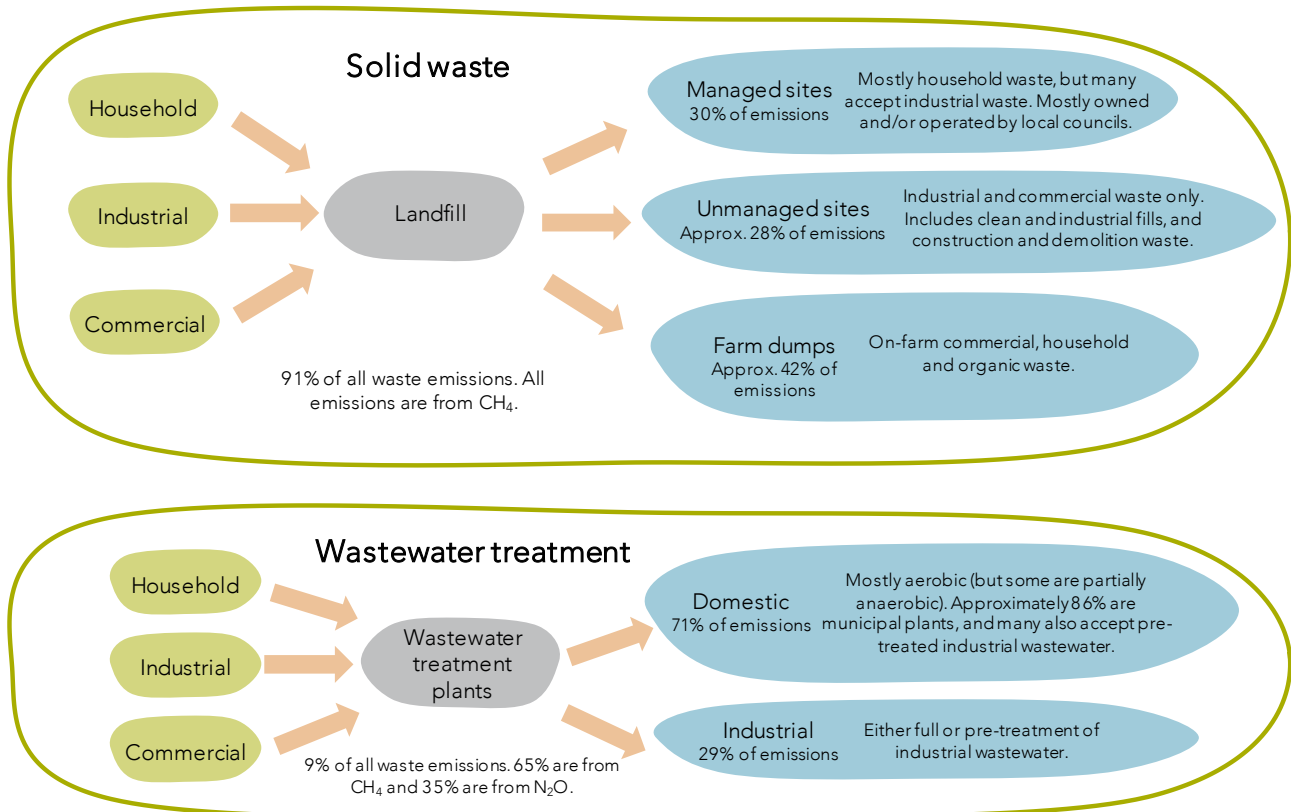
Source: MfE (2017j).

Between 1990 and 2015, total waste emissions decreased slightly from 4 118 kilotonnes (kt) of carbon dioxide equivalent (CO₂e) to 4 001 kt CO₂e. Emissions reductions from better landfill management practices such as improved CH₄ recovery have been offset by increased emissions from income and population growth. The correlation between economic growth and the amount of waste generated is well-known, despite attempts internationally to “decouple” this relationship (Bogner et al., 2008; Sjöström & Östblom, 2010).

The relationship between total waste volumes and waste emissions is also strong. Much effort both in New Zealand and internationally to reduce emissions from waste has focused on overall waste minimisation efforts. However, even though actions to reduce waste volumes (specifically organic waste volumes) may also reduce emissions, actions to reduce waste emissions (such as CH₄ recovery) may not necessarily reduce waste volumes.

Waste types and facilities

Figure 14.2 shows the sources and processing of the two main waste types in New Zealand: solid waste, and wastewater treatment. All emissions from solid waste and 65% of emissions from wastewater treatment are CH₄ emissions. Wastewater treatment also results in N₂O emissions during biological nitrogen removal, and incineration results in CO₂ emissions (not shown in Figure 14.2 due to its small scale).

Figure 14.2 Main waste types in New Zealand

Source: MfE (2017g, 2017j); Morgan Foundation (sub. 127); Water New Zealand, pers. comm. 20 February 2018.

Notes:

1. A managed solid waste disposal site has controlled placement of waste, and includes at least one of the following: cover material, mechanical compacting, or levelling of waste. Sites that fail to meet this definition are considered to be unmanaged (UNFCCC, 2015a). All currently operational municipal landfill sites in New Zealand are managed sites.
2. Not shown are minor emissions (1.2% of all solid waste emissions) from uncategorised municipal landfill sites operating before 2010.
3. Clean fills are sites disposing of largely inert waste (eg, concrete or sand) that does not decompose and therefore cause emissions.

Solid waste

As Figure 14.2 shows, all solid waste in New Zealand is processed at landfills. However, the total number of landfills is unknown. A 2014 survey identified 1 048 landfills (of which 264 were open to waste disposal, 460 were closed (ie, no longer accepting waste), and 324 were of unknown status) (MWH, 2017). Another survey identified 426 known, consented waste disposal facilities (a subset of the wider landfill category) as of mid-2016 (MfE, 2017o). Of these, 45 are managed sites and are subject to the waste disposal levy (MfE, 2017o). Within this group, 34 also participate in the NZ ETS (MfE, 2010b) (section 14.2). The remaining 381 known, consented waste disposal facilities fall under the category of unmanaged sites as shown in Figure 14.2. The limited number of facilities subject to either of these two instruments has implications for the volume of emissions reductions that can be expected to occur under present arrangements.

Since 1971, municipal waste sites have decreased in number significantly (by over 90% according to data from the national GHG inventory), with many smaller sites being closed in favour of larger, regional facilities with better management practices (MfE, 2017g). Key drivers include requirements to meet resource consent conditions, and the development of the New Zealand Waste Strategy (section 14.2).

A substantial number of small, unmanaged waste sites also exist over and above the 426 consented waste disposal facilities, including on-farm waste disposal known as farm fills or farm dumps. In the 2014 GHG emissions inventory, these farm dumps were estimated to comprise 42% of total emissions from solid waste (Morgan Foundation, sub. 127). However, this figure must be treated with extreme caution. The inventory states that significant uncertainty of plus or minus 140% exists for emissions data from unmanaged waste sites (MfE, 2017g). This very large uncertainty range is mostly because limited information is available on farm dumps and their management practices. One reason for this lack of data is because construction of a

farm dump is often identified as a permitted activity by regional councils and so does not need to be notified to the council.

Wastewater

Wastewater emissions rose 11% between 1990 and 2015 due to an increased volume of wastewater handled during this period. The majority of emissions are CH₄, but N₂O emissions occur both directly at wastewater treatment plants (WWTPs) and indirectly after effluent disposal into waterways or the ocean.¹⁴⁵

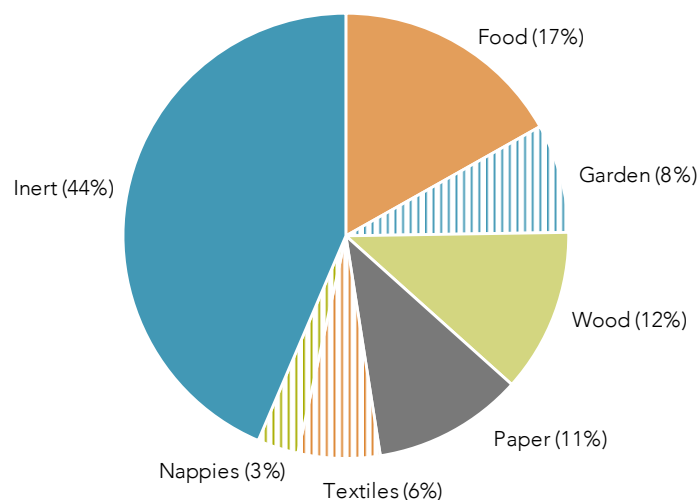
In total, 252 municipal WWTPs exist, treating nearly 450 million cubic metres of wastewater a year (Water New Zealand, 2018). WWTPs are not subject to the NZ ETS or any other emissions reduction instrument. Most WWTPs treat domestic wastewater; but across sites where data is available, on average 8.5% of wastewater treated is trade waste. Of the 252 sites, 19% only conduct primary treatment (also known as physical treatment, where wastewater is held in a basin so that heavy solids sink and other material rises to the surface). The remaining 81% conduct either secondary or tertiary treatment. Secondary treatment is where microbes consume biodegradable organic materials and tertiary treatment enables wastewater to be discharged to sea or other waterways. Most wastewater treatment processes are aerobic (ie, use oxygen to break down waste), but a significant number of WWTPs use partially anaerobic processing such as oxidation ponds or septic tanks.

The meat, and pulp and paper industries comprise the two main sources of industrial wastewater in New Zealand (MfE, 2017g). Most industrial wastewater treatment is aerobic, with most CH₄ arising from anaerobic treatment flared (MfE, 2017g).¹⁴⁶ However, these industrial wastewaters are nitrogen-rich, which is the reason for the relatively high level of industrial N₂O emissions from wastewater in New Zealand.

Waste composition

A key mechanism to reduce landfill CH₄ emissions is to reduce organic waste volumes because this is the dominant source material for methanogenesis to occur. Food, wood and garden waste are considered to be organic waste (Hoorweg & Bhada-Tata, 2015). Paper is only classified as organic waste if it is contaminated by food residue. Some textiles can be considered as organic waste (eg, cotton or woollen fabrics), but many other textiles are made from synthetic sources (eg, nylon or polyester). As such, in general, textiles are not classified as organic waste. Figure 14.1 shows the waste composition to municipal landfills in New Zealand between 2013 and 2015. It shows that a substantial proportion of waste to landfill comprises organic material (37% of total waste, excluding paper and textiles).

Figure 14.3 Estimated composition of waste to municipal landfills, 2013–2015



Source: MfE (2017g).

¹⁴⁵ WWTPs also produce CO₂ emissions when wastewater decomposes under aerobic conditions (eg, in the soil). However, these form part of the natural carbon cycle and so represent no net change to the system (Coster, n.d.).

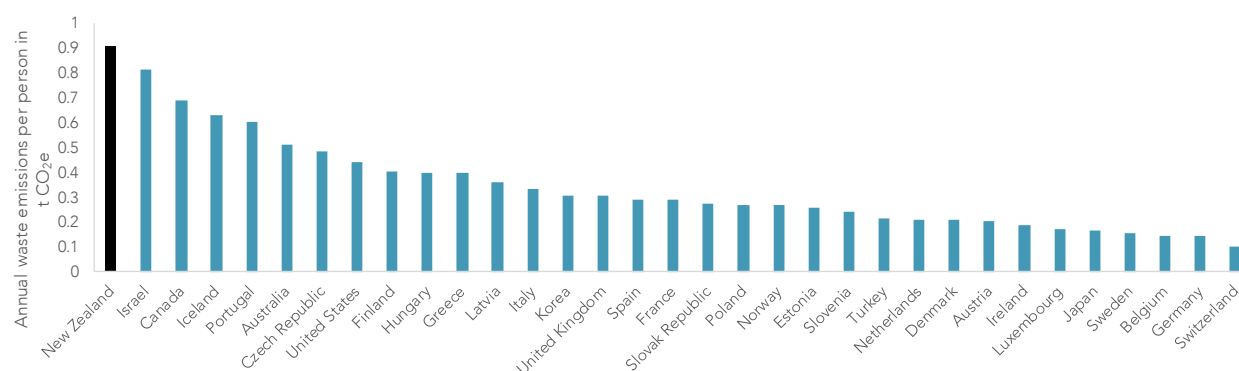
¹⁴⁶ Flaring CH₄ produces CO₂ emissions. However, as with the CO₂ produced by decomposing wastewater, this is considered to be part of the natural carbon cycle and so is not counted as an emission. It is however a potential fuel source.

Waste composition to municipal landfills has stayed largely static since the 1950s, with slight decreases in the proportion of garden, paper and inert waste, and increases in wood, textiles and nappies. While overall waste composition is known, information available on the proportion of waste disposed to managed municipal sites from industrial sources is limited (MfE, 2017g). Further, no recent or comprehensive data is available on waste generated by economic activity (ie, by sector), either in total volume, or in terms of emissions produced. A sample of six landfill sites occurring over 2007 and 2008 showed widely varying waste volumes by sector (eg, industrial waste ranged from 10% to 80% of total waste volume, and landscaping and earthworks waste ranged from less than 5% to approximately 40%) (MfE, 2008).

New Zealand compares unfavourably on waste emissions internationally

While highly uncertain, the substantial emissions attributed to unmanaged waste sites may explain why New Zealand's waste emissions per person are the highest in the OECD (Figure 14.4).

Figure 14.4 Waste emissions per person, OECD countries, 2014



Source: OECD (2018a); UN DESA (2018).

Emissions reductions do not require the development of new technology

Emissions mitigation in the waste sector does not require the development of new technology. As experts in the field clearly state, "GHG emissions from waste can be effectively mitigated by current technologies" (Bogner et al., 2008, p. 27). Installing a landfill gas recovery or extraction system is "the single most important measure to reduce emissions" (Bogner et al., 2008, p. 19). These systems recover CH₄ via a system of extraction wells and industrial processes, with the recovered gas available as a renewable energy source (eg, to replace fossil fuels in industrial processes such as boilers or steel production) (US EPA, 2018a). CH₄ recovery rates range considerably from approximately 20% to 90% (Waste Not Consulting, 2009). These systems can be profitable, particularly if they offset emission charges borne by waste facility operators.

All 24 of New Zealand's large municipal landfill sites have some form of landfill gas extraction system. These sites account for approximately 90% of waste disposed to municipal landfills (MfE, 2017g). In New Zealand, recovery efficiencies for all landfill sites that recover CH₄ range from 42% to 90%, with an overall average of 68%. For municipal landfills, approximately 40% of generated CH₄ is recovered (MfE, 2017g).

Other emissions reductions technologies include anaerobic digestion, which is where bacteria break down organic waste (including food waste, manures or crops) inside an anaerobic digester to produce biogas (which can then be converted into electricity). The remaining solid waste (known as digestate) can also be used as a fertiliser replacement (Anthony, 2015). This is not to say that technological improvements could not reduce emissions more effectively or efficiently (ie, at lower cost). For example, improving landfill gas recovery systems, particularly in terms of achieving greater volumes of recovered gas, could make these systems more profitable at smaller landfill sites.

F14.1

Mitigation in the waste sector does not require the development of new technology. Waste emissions can be effectively mitigated by current technologies such as landfill gas recovery systems or anaerobic digestion.

14.2 The policy framework for waste and emissions in New Zealand

The New Zealand Waste Strategy

The policy framework for waste and emissions in New Zealand is comprised of several legislative elements sitting underneath the overarching context of the New Zealand Waste Strategy (MfE, 2010a). In general, waste policy takes a market-based approach in New Zealand, particularly compared to many other countries that take a more regulatory approach (eg, by banning particular types of waste from landfill, section 14.4).

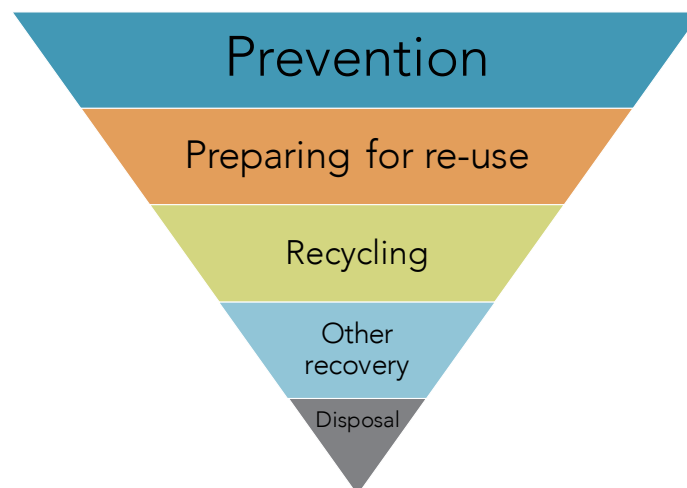
Particularly relevant pieces of legislation to emissions reductions are the:

- Waste Minimisation Act 2008 (WMA) which focuses on reducing overall waste volumes;
- Resource Management Act 1991 (RMA) and Local Government Act 2002 (LGA) which regulate waste disposal and management via consenting and bylaw processes; and the
- Climate Change Response Act 2002 (CCRA) which, via the Climate Change Response (Emissions Trading) Amendment Act (2008), requires disposal facility operators to participate in the NZ ETS.

The New Zealand Waste Strategy, published in 2010, has two key goals: 1) to reduce the harmful effects of waste; and 2) to improve the efficiency of resource use. As such it aims to cover the entire waste hierarchy (Figure 14.5). These high-level goals replace the vision of a “zero waste” New Zealand which was supported by numerous specific and quantitative targets in the first New Zealand Waste Strategy published in 2002.

Several of the specific waste targets contained within the 2002 Strategy were directly related to mitigating GHG emissions. An example was the target for the diversion of garden wastes from landfill to beneficial use will have exceeded 95% by the end of 2010. However, both a lack of data and implementation capacity, and insufficient or uncertain means to actually achieve many of the targets, meant that the specificity of the 2002 version was replaced with the more flexible and high-level 2010 approach (MfE, 2004).

Figure 14.5 The waste hierarchy



The 2010 version contains less precise direction relating to mitigating waste emissions. For example, it no longer specifies quantity targets for specific types of waste reduction, and does not focus on reducing organic waste as a priority. The Strategy does however retain two main avenues for linking waste and emissions: via the waste management and minimisation plan (WMMP) process, and by territorial authorities spending the waste disposal levy. Both WMMPs and the levy are required under the WMA.

The Waste Minimisation Act 2008

The purpose of the WMA is to encourage waste minimisation and a decrease in waste disposal so as to protect the environment from harm, and to provide environmental, social, economic, and cultural benefits. The WMA clearly focuses on the prevention aspect of the waste hierarchy. Five particularly relevant parts relating to reducing emissions by avoided waste creation are noted below.

- **Product stewardship** encourages responsible management of the environmental impact of products. Under the WMA, the Minister for the Environment can declare a product to be a priority product. Once so declared, a product stewardship scheme must be developed and accredited. Such schemes involve any party involved in the life of a product accepting responsibility for reducing the product's environmental impacts. While several voluntary schemes exist, no mandated product stewardship schemes have been established to date (MfE, 2017c).
- The **waste disposal levy** raises revenue for waste minimisation activities, and increases the cost of waste disposal to recognise that disposal imposes costs on the environment, society and the economy.
- The **responsibilities of territorial authorities** are to prepare and review WMMPs, and, if it provides a service that collects waste (either directly, or via a contractor), to do so promptly, efficiently, and at regular intervals. This section also deals with the ability of territorial authorities to make bylaws relating to waste, such as prohibiting or regulating the deposit of waste.
- **Reporting and audits** enable the Governor-General, on the recommendation of the Minister for the Environment, to make regulations for reporting and audits relating to waste management and minimisation.
- The **Waste Advisory Board** provides advice to the Minister for the Environment on topics including product stewardship schemes, the effectiveness of the waste disposal levy, and regulations as regards records. No information is publicly available about the work of the board (eg, board minutes).

Waste minimisation and management plans

As noted above, waste emissions may be addressed via the requirement for territorial authorities to consider the Strategy when creating WMMPs. The Strategy identifies GHG emissions as an example of a harmful property of waste. Therefore, when aiming to reduce the harmful effects of waste, territorial authorities can prioritise mitigating GHG emissions as a driver for local investment and policy decisions.

Some examples of this exist. For example, Auckland, Christchurch City and East Waikato Councils discuss climate change in their WMMPs, while in Wellington Region's WMMP (2017), Hutt City Council identifies a number of goals in the explicit context of reducing emissions. Those goals include reporting on its own emissions, supporting household composting to reduce emissions, and reducing waste to landfill relative to GDP; and also to reduce emissions. However, in general, this avenue to address emissions is circuitous, and offers limited concrete direction to territorial authorities for reducing waste emissions in their jurisdiction.

Territorial authorities must also use their WMMPs to guide their spending of the waste disposal levy.¹⁴⁷

The waste disposal levy

A type of landfill tax, the waste disposal levy is set at \$10 a tonne (excluding GST) on waste disposed of at a disposal facility. Landfill operators pay the levy. Yet operators may choose to pass this cost on to the person or company disposing of the waste. Under Section 7 of the WMA, a disposal facility is defined as

a facility, including a landfill, — (i) at which waste is disposed of; and (ii) at which the waste disposed of includes household waste [waste from a household that is not entirely from construction, renovation, or demolition of the house]; and (iii) that operates, at least in part, as a business to dispose of waste.

A conservative levy rate was chosen so as to avoid unintended consequences (such as increased illegal dumping) and to reduce the impact on businesses and households (MfE, 2017a). The funds collected by the levy are divided equally across two sources:

- to territorial authorities for waste minimisation activities set out in their WMMPs; and
- to the Waste Minimisation Fund, to support waste minimisation projects.

¹⁴⁷ As set out in Section 31 of the WMA, territorial authorities' share of the levy is calculated according to a formula based on population.

Over the 2015 to 2016 year, the total levy collected was \$33.5 million (MfE, 2017o). At present, 45 waste disposal facility operators are subject to the levy. As required under the WMA, the levy is regularly reviewed, with reviews occurring in 2014 and 2017 (and another scheduled for 2020).

The Resource Management Act 1991 and the Local Government Act 2002

The RMA provides two main avenues for reducing emissions from waste. First, via section 418 (1A), it regulates waste disposed at managed facilities, such as by proscribing the discharge of contaminants into the air or land from the storage, transfer, treatment or disposal of waste. Second, it provides for local governments to determine whether waste disposal sites require consents or permits, ranging from larger facilities through to waste disposed as unmanaged waste sites such as farm dumps (Knowles & Wilson, n.d.).

Part 8 of the LGA is also pertinent as it enables local authorities to make bylaws relating to onsite wastewater disposal systems, waste management, trade wastes and solid wastes. Bylaws can be made to protect the public from nuisance and to protect, promote and maintain public health and safety.

The Climate Change Response Act 2002

The CCRA, amended by the Climate Change Response (Emissions Trading) Amendment Act 2008, requires disposal facility operators to report their CH₄ emissions and, in response, to surrender New Zealand Units (NZUs) under the NZ ETS. Disposal facilities are defined the same as for the WMA, with the additional exclusion that the definition “does not include a facility, or any part of a facility, at which waste is combusted for the purpose of generating electricity or industrial heat” (Section 6 of the CCRA (Emissions Trading) Amendment Act 2008). Wastewater treatment facilities are not subject to the NZ ETS, and other exemptions relating to size, location and age of solid waste disposal facilities also apply.

Box 14.1 outlines the different goals of the waste levy and the emissions price under the NZ ETS, the two main market-based mechanisms to minimise waste in New Zealand.

Box 14.1 The difference between the NZ ETS emissions price and the waste disposal levy

The two key pricing mechanisms to reduce waste are the emissions price via the NZ ETS and the rate of the waste disposal levy. Each has a different aim. The NZ ETS price aims to reduce waste emissions at least cost across the economy (and is agnostic about how that happens). In contrast, the waste disposal levy aims specifically to reduce the volume of waste disposed of at landfill (including for purposes other than emission reductions, such as amenity or cultural values or to reduce soil contamination).

While the levy will have some effect on emissions (because it aims to reduce total waste volumes, of which organic waste is a substantial component) (D. Wilson et al., 2017), these different aims mean that it is not possible to solely rely on the levy to reduce emissions. This is for two main reasons. First, the levy does not specifically target a reduction in organic waste volumes, which is the main driver of CH₄ emissions from waste. A differentiated waste disposal levy rate for organic waste could achieve a more effective emissions reduction result (section 14.5), but this is not the case at present.

Second, and perhaps most importantly, only an effective emissions price can encourage the adoption of better CH₄ reduction or capture technologies at landfill sites, as any emissions effect arising from the levy ends at the point of waste disposal. This is particularly relevant as emissions still occur from closed landfills, and given the relationship between increased waste volumes and economic growth and population. So, for example, while local government (as primary landfill operators) may attempt to induce behaviour change related to waste minimisation, some degree of post-disposal emissions management is vital.

At present, 34 disposal facility operators are registered participants under the NZ ETS (EPA, 2018). Of these, 24 are district or city councils. Councils can also operate landfills as part of public-private partnerships, such as between Whangarei District Council and Northland Waste Limited.

Waste is one of the sectors affected by the phased removal of the one-for-two transitional measure. As of 2018, the surrender obligation is at 83%, and will rise to 100% in 2019 (MfE, 2016f). There is no case for free allocations because waste is not an emissions-intensive, trade-exposed sector. However, an effective emissions price may not necessarily be very high. Studies suggest that, even at a cost of US\$10 a tonne of CO₂e, 86% of landfill CH₄ emissions in the OECD could be mitigated for the year 2030 (Monni et al., 2006).

Landfills may either use a default emissions factor for their emissions, or, if they believe their emissions factor should be lower, they may apply to the Environmental Protection Authority for a unique emissions factor (UEF) which reflects the actual emissions from their facility. This means that if disposal facilities have a landfill gas recovery system which allows them to either flare or use the captured CH₄ for fuel, they can claim a UEF of up to 90% (D. Wilson et al., 2017). This can substantially lower surrender obligations under the NZ ETS.

The public liability under the NZ ETS, particularly as prices rise, is considered by some councils as “a really strong economic driver to fix the way we [councils] do our waste, because it’s going to cost us significant amounts of money if we don’t resolve the issue” (Wellington City Councillor Iona Pannett in Cann, 2017). As well as efforts to reduce waste disposed of at landfills, councils are considering various mechanisms to cover liabilities, including higher gate fees at landfills, higher council rates, and restrictions on organic waste able to be disposed of at landfills (Cann, 2017).

14.3 Māori perspectives on waste management

How waste is managed is an important consideration when understanding the Māori relationship with the environment. Improper waste management is considered to be a threat to sustaining the mauri (life force) of iwi, as it can contaminate ecosystems and associated mahinga mataitai (customary food gathering) (Te Ātiawa o Te Waka-a-Māui, 2014). The tikanga (cultural) issues associated with the disposal and management of waste that are of particular importance to Māori are the use of water as a receiving environment for waste, and maintaining a separation between waste and food (Mahaanui Kurataiao Ltd, 2013; Morgan, 2004). Indeed, when developing wastewater treatment facilities,

the universal driver for many of the technological solutions and associated resource consent conditions is the abhorrence to Maori of direct discharge of human waste (domestic wastewater) to natural water almost regardless of the degree of treatment. (Bradley, n.d., p. 1)

Māori cultural considerations are also important when considering mitigation technologies. For example, while anaerobic digestion of wastewater can create, as a by-product, biosolids which can be used as a fertiliser replacement, this violates the separation between food and human waste. Therefore, “while tāngata whenua may support the disposal of biosolids onto forestry plantations, the use of biosolids on food crops would be culturally unacceptable” (Mahaanui Kurataiao Ltd, 2013, p. 113).

As well as proper waste management, reducing waste volumes is considered to be a priority action in many iwi management plans (Mahaanui Kurataiao Ltd, 2013; Te Ātiawa o Te Waka-a-Māui, 2014). While the emissions consequences of waste minimisation are not the immediate focus in management plans (as compared to the emphasis on immediate degradation to soils or waterways), it is recognised in general that “reducing the volume of solid waste and wastewater produced in the takiwā (district) will reduce pressure on existing infrastructure, and on the environment and cultural values” (Mahaanui Kurataiao Ltd, 2013, p. 113).

14.4 International approaches to waste emissions reductions

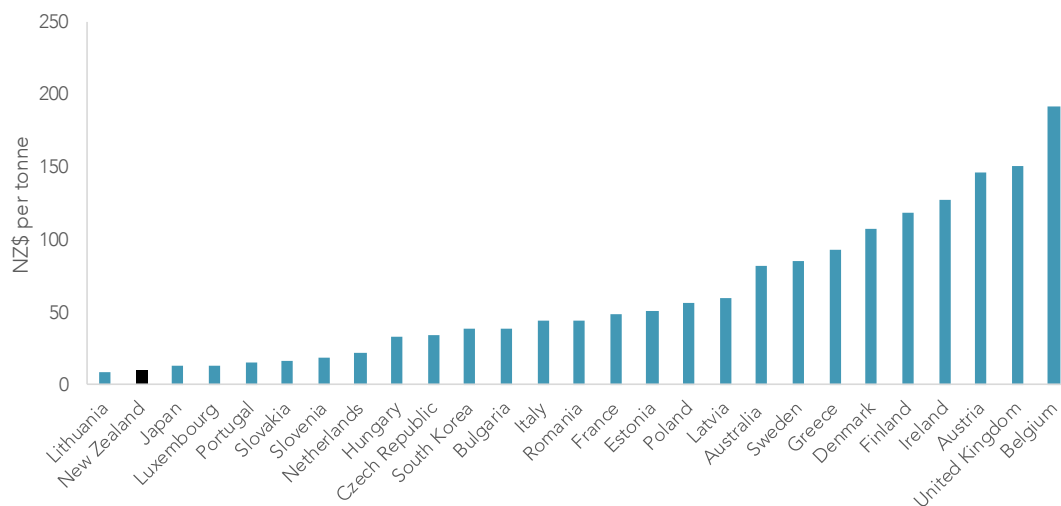
In comparison to other developed countries, New Zealand is unusual in not reducing its waste emissions over recent decades. For example, between 1990 and 2016, UK waste emissions decreased by 70% (BEIS, 2018), and in Germany, waste emissions reduced by 72% over the same period (Umwelt Bundesamt, 2017). Waste emissions also fell by 46% in Australia between 1990 and 2015 (Government of Australia, 2017b).

Much of this reduction can be attributed to policy intervention. In the European Union (EU), waste emissions are not included in the European Union Emissions Trading System (EU ETS), but are instead managed through the Waste Framework Directive. This framework establishes a waste-management hierarchy where prevention is the preferred option, followed by re-use, recycling and other forms of recovery, with disposal such as landfill being the last resort.

Underneath the overarching framework, Directive 1999/31/EC on the landfill of waste (the Landfill Directive) specifically targets solid waste disposal (European Commission, 2010). It required EU member states to reduce the amount of biodegradable waste they sent to landfill to 35% of 1995 levels by 2016. It also requires CH₄ capture at landfill sites and, if possible, use of the recovered gas to produce energy (Council of the European Union, 1999).

In the United Kingdom, the main drivers of emissions reductions are improvements in landfill standards, changes to the type of waste to landfill, and an increase in the amount of landfill gas used for energy (BEIS, 2018). The United Kingdom also has a much higher landfill tax rate. The rate has increased from £7 a tonne when the tax was first introduced in 1996, to a current level of £88.95 (\$151) a tonne (HMRC, 2017). Indeed, most countries have a substantially higher landfill tax rate compared to New Zealand (Figure 14.6).

Figure 14.6 Landfill tax rates for municipal solid waste in New Zealand and comparator countries



Source: CEWEP (2017); The Korea Bizwire (2017).

In addition to landfill taxes, many countries also have landfill bans. Of relevance to emissions reductions, these include banning waste to landfill that could either be recycled or incinerated to produce energy (eg, Denmark), or banning biodegradable or organic waste to landfill (eg, Finland, Luxembourg, Netherlands, Norway, and Poland) (CEWEP, 2017).

While waste emissions are not included in the EU ETS, they are included in California's cap-and-trade programme (under the Global Warming Solutions Act 2006). In Québec and Ontario's cap-and-trade systems, waste emissions are also included as a result of participants being able to purchase offset credits to cover up to 8% of their emissions. An offset credit represents

a quantity of GHG emissions that was never emitted or that was permanently and irreversibly removed from the atmosphere by a project voluntarily implemented by an individual, organization or business, above and beyond usual practices" (Government of Québec, 2018a, p. 9).

Both systems contain specific protocols for the creation of offset credits through the treatment or destruction of CH₄ at landfill sites. This is in comparison to the NZ ETS which requires disposal facility operators to surrender units for any emitted CH₄ (and therefore are incentivised to reduce emissions to avoid the financial liability, rather than to receive credit for avoided emissions). In Québec, as of March 2018, offset credits have been issued for six landfills, which are estimated to generate a total reduction of 76 kt CO_{2e} a year (Government of Québec, 2018b).

Other policy instruments are noted below.

- In the UK's Waste and Emissions Trading Act 2003, yearly allowances are set for local authorities. These allowances limit how much biodegradable municipal waste a local authority can landfill in any particular year. Authorities can buy and sell allowances from other authorities if they expect to landfill more, or less than their allocations. Also in the United Kingdom, feed-in-tariffs for low-emissions electricity generation have incentivised CH₄ capture.

- In Australia, a landfill tax is complemented by the Australian Government Emissions Reduction Fund, enabling businesses, local councils, state governments and land managers to earn Australian carbon credit units through activities that reduce emissions. These units can be sold to the Government through a carbon abatement contract, or to other businesses seeking to offset their emissions (Government of Australia, 2017a). Activities specific to waste include burning landfill gas, processing organic waste through alternative technologies, or diverting organic material for composting or energy generation.
- In California, the Air Resource Board Landfill Measure imposes landfill gas collection and control system rules to reduce CH₄ emissions. Larger landfills are also subject to federal New Source Performance Standards and Emission Guidelines (implemented by local air districts) to reduce CH₄ emissions.

When compared with the above examples, New Zealand has a substantial policy deficit regarding emissions and waste. In particular, specific, quantitative waste reduction targets were removed without an effective pricing regime to drive emissions reductions (either under the waste disposal levy or the NZ ETS emissions price). This has seen New Zealand make minimal progress in reducing emissions, especially in contrast to other developed countries.

14.5 Opportunities to reduce emissions from waste

Framework principles for making decisions about minimising waste emissions

When identifying opportunities to reduce waste emissions, it is useful to highlight several key decision-making considerations. These principles can help to clarify the reasons why particular policy instruments (such as an emissions price under the NZ ETS) may be more or less suitable to certain contexts than others:

- What harm is being avoided, or behaviour being incentivised, through the policy instrument?
- How can unnecessary overlap between instruments be avoided (eg, to reduce the risk of departing from the effectiveness of a single emissions price)?
- How are co-harms and co-benefits dealt with, and are supplementary mechanisms required?
- What transaction costs are associated with the instrument, and are they proportionate?

Numerous policy strategies are available to reduce waste emissions. Considering the above principles, this section outlines the six most important opportunities to reduce emissions from waste in New Zealand. The first addresses the substantial uncertainty regarding waste-related emissions data in New Zealand. The following three opportunities relate directly to specific types of waste disposal facilities, while the final two are more cross-cutting opportunities across multiple types of waste. These opportunities also recognise that New Zealand is unlikely to radically move away from landfill as a waste disposal method in the near future. As a result, prioritising mechanisms to reduce landfill emissions is important.

Better waste data

New Zealand has poor waste data. Much of the data collected on the waste sector is out of date, inconsistent or incomplete, indicating that the reporting and audit provisions of the WMA are under-used. The majority of New Zealand's environmental indicator reports, Solid Waste Analysis Protocol data, and landfill surveys are over five years old (with many over 10 years old). Data coverage is also poor, as

the only reliable data about waste that the Ministry [for the Environment] has access to, comes from the 45 levied waste disposal facilities. These facilities receive an estimated 30% of New Zealand's total waste disposed to the land. The Ministry does not have access to data from the remaining estimated 70% of waste disposed at 381 known, consented landfills or at uncontrolled environments like farm dumps. (MfE, 2017o, p. 54)

In its 2017 Environmental Performance Review of New Zealand, the OECD also concluded that "New Zealand lacks comprehensive, timely and internationally comparable data on waste generation, treatment and disposal" (OECD, 2017e, p. 23).

This lack of data is concerning from an emissions perspective, particularly due to the limited information available relating to emissions management practices in the unmanaged landfill sector (non-municipal landfills and farm dumps). This is evidenced by the very large uncertainty range of plus or minus 140% for emissions data relating to these sites in the national GHG inventory (MfE, 2017g). Lack of data also has implications for the ability of local and national government to identify opportunities for further reducing emissions (and means that it is not possible to quantify in this report the likely emissions reductions from these opportunities). Better data is critical to direct mitigation action.

In response to these gaps in data, MfE is currently developing a project to collect better waste data (MfE, pers. comm. 27 February 2018). Key topics will include:

- waste infrastructure available nationwide (eg, transfer stations, resource recovery parks, landfills, rural recycling facilities, and materials recycling facilities);
- services available nationwide (eg, council kerbside services, commercial recycling);
- major processing facilities (eg, plastics processing, cardboard manufacturing, concrete waste re-use, and wood waste processing); and
- recycling collection volumes (glass, metals, paper, cardboard, plastics).

Ensuring that data also meets the requirements of the Environmental Reporting Act 2015 (the purpose of which is to create a national-level environmental reporting system) has been identified as relevant.

One technology-based possibility to achieve better waste data collection is by using innovative survey techniques. There is a long history of using technology (such as remote sensing, GIS and optical satellite images) to detect and monitor land-use change. These technologies can also be used to identify unknown waste disposal sites (Glanville & Chang, 2015; Silvestri & Omri, 2008).

F14.2

Good quality data on waste in New Zealand is lacking. This has major implications for understanding emissions management practices related to waste in New Zealand, and identifying subsequent opportunities to further reduce emissions. In response to these issues, the Ministry for the Environment is developing a project to collect better waste data in New Zealand.

R14.1

The Ministry for the Environment should ensure that, in its project to collect better waste data in New Zealand, emissions-related data is included so as to reduce the very large uncertainty regarding waste emissions, and to identify opportunities to reduce emissions in the future.

Reducing emissions from unmanaged solid waste sites

Reducing emissions from unmanaged solid waste sites is critical because, according to current (albeit highly uncertain) data, these sites represent an estimated 64% of all waste emissions, or 2 561 kt CO₂e. To reduce emissions, organic waste disposed of at these sites must either be reduced in volume, or it must be diverted to managed disposal facilities where the CH₄ can be more effectively managed.

It is important to reiterate that the category of unmanaged solid waste sites covers two very different types of disposal facilities:

- 381 known, consented waste disposal facilities that are not subject to either the NZ ETS or the waste disposal levy (representing about 28% of emissions from solid waste); and
- an unknown number of small, unmanaged waste sites, mostly farm dumps (representing an estimated 42% of emissions from solid waste).

Reducing emissions from known, consented facilities

At present, there is no driver to reduce emissions from known, consented but unmanaged facilities. In other words, a problem of coverage exists in terms of suitable policy instruments. To reduce emissions, the most likely effective measure will be to extend some form of volume (waste disposal levy) or emissions (NZ ETS) price to these sites (D. Wilson et al., 2017). Either measure could achieve emissions reductions because site operators could pass on their price liability to site users, which would result in reduced volumes of waste to landfill. This would be particularly effective if operators applied higher charges for organic waste (see Box 14.2 for a discussion on the appropriate rate for the waste disposal levy in particular).

Box 14.2 What rate should the waste disposal levy be?

The waste disposal levy rate of \$10 a tonne is considered by many to be too low. Several submitters argued that it should be increased significantly (eg, up to \$150 a tonne) to drive further emissions reductions (Christchurch City Council, sub. 13; Hitachi Zosen Inova Australia Pty Ltd, sub. 68; Sustainable Business Network Circular Economy Accelerator, sub. 75; Deidre Kent, sub. 87; Auckland City Council, sub. 97; and The Morgan Foundation, sub. 127).

The 2017 review of the levy found that given the quantity of waste to landfill is increasing, it was not meeting its objective. It concluded that “gradually increasing the levy will drive the message that waste disposal is unviable and will provide the necessary signals to industry to prepare for this change well in advance” (MfE, 2017o, p. 73). The 2017 review also suggested investigating a differential levy rating system (where a differential rate adjusted for harm caused by each waste stream). This is particularly relevant for the issue of organic waste and its emissions consequences.

Another review specifically focusing on the potential impacts of adjustments to the current levy rate and structure was commissioned by a consortium of organisations, including seven local government bodies (D. Wilson et al., 2017). That review found that applying a gradually increasing levy rate to the level of \$140 a tonne by 2024 would increase recycling rates from 35% (current baseline) to 60%. This represents a nearly 40% reduction in overall waste volume to landfill. It also showed a substantial increase in gross value added (outweighing additional overall costs to the economy).

Due to limited data availability, the Wilson et al. review did not quantify expected rates of emission reductions, but expected these to occur as a co-benefit of higher diversion away from landfill. Even so, it is clear that a higher waste disposal levy, and particularly one that encourages reductions in organic waste disposed of at landfill, will be more effective at reducing emissions than its current rate.

Either the levy or an emissions price would also encourage better waste stream management on the part of site operators. This, in its broadest definition, comprises separate collection, management and processing of different types of wastes. An example is paper which, if contaminated, cannot be recycled and instead decomposes in landfill causing CH₄ emissions. At non-municipal sites, this would focus on separate management and processing of waste at the disposal facility (rather than separate collection, which is more relevant to managed municipal sites as discussed below). Better waste stream management was a notable theme of submissions (Tony Banks, sub. 3; Canterbury District Health Board, sub. 16; Bioenergy Association, sub. 37; Hitachi Zosen Inova Australia Pty Ltd, sub. 68; OI NZ, sub. 85; and Auckland Council, sub. 97).

As noted above, many other jurisdictions have instituted bans on biodegradable or organic waste to landfill. However, such an approach may not be needed in New Zealand in light of an effective emissions price. Passing the emissions price onto users could serve to discourage such waste to landfill as effectively as a ban. This would be especially so if disposal facility operators charged an adequately differentiated price for organic and non-organic waste in light of their contribution to CH₄ emissions. However, this should not preclude bans being considered by the Government if the emissions price does not achieve desired results.

Extending the NZ ETS to known, consented facilities could also reduce emissions by providing an incentive for site operators to invest in landfill gas recovery systems. However, given that many of these sites are small,

it may not be economically viable to install these systems, and they may either choose to pay the emissions price or close. Closing would also achieve emissions reductions by diverting waste to sites with better management practices, even given the potential emissions increase from requiring more transport services to dispose of waste at locations more removed from the waste source (Lundie & Peters, 2005).

However, the administrative complexity and transaction costs of extending the NZ ETS mean that broadening the coverage of the simpler volume-based levy, rather than the NZ ETS, is likely to be the most appropriate option. At present, many of these sites have no ability to manage or even monitor emissions: the only way to mitigate emissions in response to an emissions price is to reduce waste volumes. Therefore, an effective levy, particularly one that charged a higher rate for organic materials, would be successful at reducing emissions by incentivising overall waste volume minimisation.

In response to the 2017 review of the levy, MfE is planning to extend the levy to cover all known, consented waste disposal sites (an additional 381 sites) (MfE, pers. comm. 27 February 2018). This will also achieve the valuable co-benefit of achieving a better understanding of the waste disposed of at these facilities, such that more accurate emissions estimates are possible. It will also mean that the higher revenue gathered by the levy will result in a larger quantity of funds going directly to territorial authorities, or via the Waste Minimisation Fund, for waste minimisation activities, leading to further emissions reductions. A proportion of this higher levy rate could be usefully directed to education or behavioural campaigns to discourage illegal waste dumping. MfE is considering the levy rate as part of its work to extend its coverage.

F14.3

There are a large number of solid waste sites that, while known and consented, are technically considered to be “unmanaged”. Reducing emissions from these sites is vital because current data estimates that they comprise nearly two-thirds of all waste emissions. The most effective solution to achieving emissions reductions at these sites is to apply an effective waste disposal levy. The Ministry for the Environment is planning to extend the levy to all 381 known, consented facilities not currently subject to the levy.

R14.2

The Government should amend the Waste Minimisation Act 2008 so that the waste disposal levy is applied to all known, consented waste disposal facilities.

R14.3

As part of its work to extend the waste disposal levy, the Ministry for the Environment should investigate, for all 426 sites subject to the levy, both increasing the levy rate via a graduated process, and introducing a differentiated levy rate where organic waste is charged at a higher rate than non-organic waste.

Reducing emissions from farm dumps and other, unknown, waste disposal sites

Achieving emissions reductions from farm dumps, and other, unknown, waste disposal sites is especially challenging, predominantly due to significant gaps in data and uncertainty about their management practices, number and emissions. The key goal is to ensure these sites are better managed so that emissions are mitigated, or to divert waste from these sites to disposal facilities where CH₄ emissions are either avoided (eg, through better waste stream management) or mitigated (eg, through landfill gas recovery).

It is extremely unlikely that either of these outcomes would be achieved via the NZ ETS or the waste disposal levy. This is because such sites are not commercial operations, and are therefore unsuitable for either of these mechanisms. Instead, a regulatory avenue, either via the bylaw process under section 56 of the WMA and Part 8 of the LGA, or changes to the resource consenting process via the RMA, is considered to be the most effective option. This could mean, for example, local government bodies no longer allowing farm dumps as permitted activities, and instead requiring such sites to obtain a resource consent (eg, they would become a controlled, discretionary or non-complying activity under the RMA).

Pursuing this strategy would likely require better support for local government bodies to develop more effective consenting requirements through an overarching regulatory framework for wastes such as agricultural waste. A potential mechanism would be a national environmental standard, issued under section 43 of the RMA. Indeed, the OECD (2017e, p. 73) noted that “New Zealand has no national regulation for disposal of agricultural waste, despite the large size of the sector”. Councils could also enact rules in their local planning processes to require waste disposal methods that had lower emissions consequences, which would incentivise better uptake of technologies such as anaerobic digestion.

Restrictions via bylaws or the resource consent process may encourage waste diversion to managed sites, or reduced waste production. Yet it may also encourage illegal waste dumping, or have negative transport emissions consequences (when waste is diverted to other sites). These implications will need to be carefully managed at the level of each local government. The case could also be made that a proportion of the additional funds gathered from a more extensive waste disposal levy should be specifically directed towards providing incentives for uptake of technologies such as on-farm anaerobic digesters, or directed at behavioural interventions with affected parties.

F14.4

Emissions reductions at farm dumps and other, unknown, waste disposal sites, could be encouraged by the creation of bylaws as allowed under the Waste Minimisation Act 2008 (and Part 8 of the Local Government Act 2002), or resource consenting processes under the Resource Management Act 1991.

R14.4

Local government should be better supported, as needed, to develop effective bylaws or consenting requirements for farm dumps and other, unknown, waste disposal sites, through an overarching regulatory framework for wastes such as agricultural waste. The Ministry for the Environment should investigate whether a national environmental standard relating to waste is an appropriate mechanism to deliver this framework.

Reducing emissions at managed solid waste sites

As with unmanaged sites, two main actions will have the most impact at reducing emissions from managed solid waste sites: reducing organic waste volumes to landfill in the first place, and better management of CH₄ once organic waste reaches landfill. The key driver for reducing emissions at these sites is most likely to be a higher price via the NZ ETS. While a higher waste disposal levy would work to reduce overall waste volumes to landfill (and therefore emissions), a higher emissions price would more specifically target emissions reductions (see Box 14.3 for a discussion of overlap between these instruments).

Box 14.3 **Should managed landfills be covered by the waste disposal levy and by the NZ ETS?**

At present, most managed solid waste sites are covered by both the waste disposal levy and the NZ ETS. Higher prices under both instruments are anticipated to reduce emissions, so it is important to consider whether sites could be excluded from the levy if covered by the NZ ETS.

If the sole aim is to reduce emissions, then an exclusion may be justified. However, given that the levy targets other waste minimisation goals, the two instruments may be suitable to continue to be deployed in tandem. However, it is inefficient for waste emissions to be subject to two policy instruments as it departs from the effectiveness of a single emissions price. While the levy rate is low (at its current rate of \$10 a tonne), and the NZ ETS emissions price is also relatively low (under \$25), this may not be a significant issue. However, if substantially higher levy or emissions prices occur, it will be important to investigate whether some form of levy offset may be necessary for those sites also subject to the NZ ETS (at a level that does not subvert the targeted waste minimisation goals of the levy).

In response to a higher price, councils (as the majority holder of the emissions liability for these sites) can make individual decisions about which activities may be the most effective in their local area. For example, the NZ ETS price could incentivise councils to enact measures to specifically reduce organic waste to landfill. These could include information or behaviour campaigns about waste reduction (such as “Love Food Hate Waste”), or higher landfill gate fees or rubbish charges (Covec, 2012; Love Food Hate Waste New Zealand, 2018). Evidence shows that higher NZ ETS prices are already being passed through as higher landfill gate fees. At Dunedin City Council’s landfills, the cost to dispose of a carload of rubbish will increase by 25% from \$36 to \$45 on 1 July 2018 in direct response to higher emissions prices under the NZ ETS (ODT, 2017).

A higher emissions price could also make waste stream management, either at a household or transfer station level, more cost-effective. This could entail moving away from comingled kerbside rubbish collection to separate collection and composting of food waste.¹⁴⁸ Councils could also charge by quantity or by volume¹⁴⁹ for non-organic waste disposal, and subsidise (and collect more often) a separate organic waste collection (as is currently the case with recyclable materials, such as glass, plastics or paper).

Finally, an effective emissions price could also encourage better landfill gas recovery systems. Most managed sites have recovery systems, but a higher emissions price could incentivise further uptake or for less-efficient systems to be upgraded to achieve greater recovery efficiencies (D. Wilson et al., 2017).

F14.5

The most effective actions to reduce emissions at managed municipal solid waste sites are a reduction in organic waste volumes to landfill and better management of CH₄ at landfill. An effective emissions price will help to achieve both, while giving facility operators (particularly local authorities) the flexibility to determine which strategy is likely to be the most cost-effective at reducing emissions in their own jurisdiction.

R14.5

As part of any analysis regarding the rate of the waste disposal levy, the Government should consider whether a partial levy offset is required to avoid unnecessary overlap with the emissions price under the New Zealand Emissions Trading Scheme.

Better wastewater treatment

Reducing emissions at WWTPs represents a relatively small emissions reduction opportunity (representing 0.45% of New Zealand’s total emissions). However, technical options to reduce emissions by better control of the operational conditions of WWTPs exist. For example, operators can:

- operate WWTPs at “high solid retention times to maintain low ammonia and nitrite concentrations”, to reduce N₂O emissions; and
- cover “thickening sludge tanks and sludge disposal tanks...to avoid gas leakages” and achieve subsequent capture of CH₄ emissions (Campos et al., 2016, p. 3).

At present, because WWTPs are not covered by the NZ ETS or any other emissions reductions policy, no mechanism directly encourages uptake of such technical options (MfE, pers. comm., 16 March 2018). In other words, as with known, consented facilities, coverage is a problem relating to policy effectiveness. However, some incentives do apply to WWTP operators that encourage emissions reductions as a co-benefit. For example, capturing CH₄ for biogas is a cost-saving mechanism (as it can substitute for fossil fuels), and is currently occurring in New Zealand. At the sole dairy processing facility in New Zealand that uses anaerobic

¹⁴⁸ In the Auckland Regional Public Health Service submission (sub. 105), the important point was noted that any schemes encouraging separate collection of domestic food waste must consider the nuisance creation potential and public health aspects (eg, from *Legionella* infections) of such schemes.

¹⁴⁹ While charging by quantity or volume occurs in some places in New Zealand (such as Auckland and Wellington), others such as Hamilton include a rubbish disposal charge as part of residential rates. Yet not separating the charge reduces the incentive to minimise waste by volume. In its environmental performance review of New Zealand, the OECD (2017) recommended encouraging local authorities to introduce this type of charge. If such a charge is more widely introduced, it will however be important to mitigate any unintended consequences (such as increased illegal waste dumping) and effects on lower-income households (Chapter 9) (Te Rūnanga o Ngāi Tahu, pers. comm., 26 March 2018).

wastewater treatment, the subsequent emissions are recovered and the captured biogas is mostly used for process heat in boilers (with the remainder flared) (MfE, 2017g).

Even so, it is highly uncertain whether relying on these co-benefits is adequate to encourage desired emissions reductions. While WWTP operators have limited ability to reduce waste inflows, as with the emissions price incentivising landfill gas recovery systems, extending the coverage of the NZ ETS could further incentivise better emissions management at WWTPs. If this occurs, it is vital that no deterioration in effluent quality results, particularly in the wastewater disposed of to waterways (including in respect to Māori cultural considerations).

The Commission is interested in understanding more about the potential arguments for and against extending the NZ ETS to cover WWTPs in New Zealand, including any minimum size or operational conditions that may be relevant.

Q14.1

Should the New Zealand Emissions Trading Scheme be extended to cover wastewater treatment plants?

Waste-to-energy

Rather than landfilling or otherwise disposing of waste, it is instead possible to reconsider waste as a source material. As the Wise Response Society notes, “a major barrier is that we have come to view certain materials as waste rather than material resource” (sub. 102, p. 34). One key avenue is waste-to-energy (WtE). This comprises transforming organic waste (eg, via incineration of municipal waste or wood wastes, or anaerobic digestion of farm wastes) into a renewable energy source (such as biogas).¹⁵⁰ Many submitters identified the potential for, and current examples of, WtE.

There is significant underutilised potential for energy generation from both solid and liquid waste disposal. (Canterbury District Health Board, sub. 16, p. 11)

Waste to energy remains the low cost hanging fruit... Adoption of waste-to-energy programmes around use of solid and liquid municipal waste and food processing waste could result in emission reductions of 90 kt CO₂e per annum by 2030 and 150 kt CO₂e per annum by 2040. Many of the waste-to-energy opportunities are financially attractive today with around 4-6 year financial payback periods. (Bioenergy Association, sub. 37, pp. 2-8)

Liquid and solid organic waste along with proven conversion technologies can provide biofuel resources which can replace fossil fuels. (Hitachi Zosen Inova Australia Pty Ltd, sub. 68, p. 3)

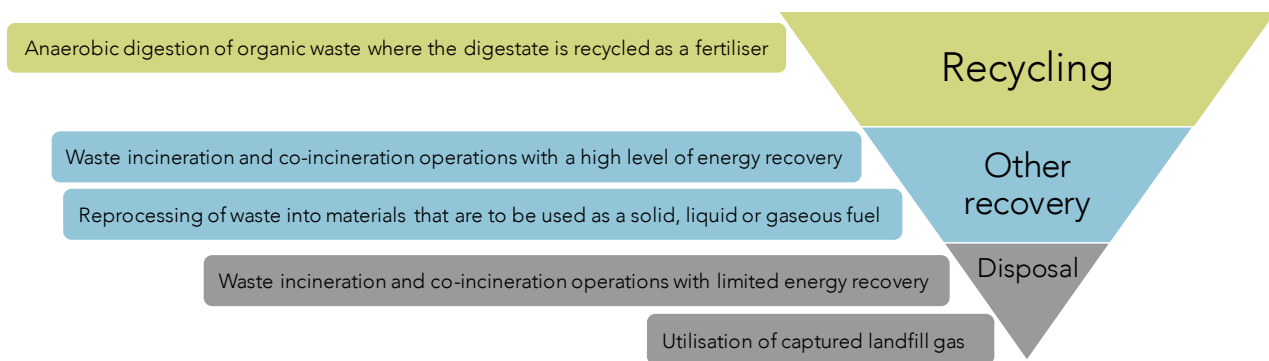
WtE fits into the waste hierarchy at various scales (see Figure 14.7 on the next page). In New Zealand, Nana et al. (2011) estimated that waste in New Zealand could produce up to 630 000 megawatt hours (MWh) of renewable electricity each year. This included using effluent from the meat and dairy sectors, with the subsequent 1 petajoule¹⁵¹ of methane biofuel sufficient to replace 2% of the current national power production from natural gas.

The economics of incinerating waste to produce energy are unclear...

WtE from the incineration of waste is a common method for waste processing, and to achieve emissions reductions, in other countries, particularly in Europe. However, at present, no WtE plants incinerate waste in New Zealand (excluding the use of wood wastes as a fuel source for industrial boilers, Chapter 13). Key factors working against such WtE plants include public acceptance and consenting processes under the RMA, particularly in terms of managing particulate emissions to air (EFI, 2008). A proposed \$250 million household WtE plant in Westport to encourage employment and reduce GHG emissions (Buller District Council, 2016) was due to receive financial support for a feasibility study from the Provincial Growth Fund. However, funding is presently on hold.

¹⁵⁰ See also Chapter 11 for liquid transport biofuels, Chapter 12 for biogas for electricity supply, and Chapter 13 for biomass for industrial processes.

¹⁵¹ A petajoule is a unit of energy. One petajoule equals one quadrillion (10¹⁵) joules, or approximately 163 400 barrels of oil.

Figure 14.7 Waste-to-energy within the waste hierarchy

Source: Adapted from European Commission (2017).

In general, WtE is costlier in the short term as compared to landfilling waste. However, in the longer term, and depending on system characteristics (such as the distance between the WtE plant and the waste source), the potential emissions reductions benefits and co-benefits can make WtE plants an attractive economic proposition (Assamoi & Lawryshyn, 2012). This is particularly likely if a higher emissions price or waste disposal levy is applied. In an analysis of the waste disposal levy, a rate of \$100 a tonne was identified as necessary to incentivise WtE. However, if a separate levy on incineration (introduced to discourage incineration due to air pollution concerns) of \$40 a tonne is also included, scenario modelling showed that WtE via incineration would no longer be viable (D. Wilson et al., 2017).

The level of NZ ETS price necessary to make WtE using the incineration of waste, especially household waste, cost-effective in New Zealand is unclear. The Commission considers that the emissions price should however remain a key driver of whether or not WtE plants are cost-effective. Further, while some submitters (such as Pioneer Energy, sub. 44) suggested that NZUs should be allocated to WtE projects in recognition of avoided GHGs, this type of offsetting credit is not recommended. Instead, the key incentive mechanism should remain the reduced financial cost for liable parties.

Focusing on the NZ ETS price will also help to ensure cost-effectiveness remains a key driver, so that emissions are reduced at the lowest cost across the entire economy. As the National Energy Research Institute (sub. 53, p. 6) notes in relation to waste as an energy source,

[w]aste in various forms is the low hanging fruit for increasing the availability of biofuels, however it requires large accumulations at specific locations to offer any scale. Often at that point the feedstock becomes more valuable for other uses. To the extent it will be useful it will be in thermal loads and gaseous and liquid fuels, most likely on a district basis because of the costs of transportation. For the foreseeable future we are not facing constraints on the availability of low cost renewable electricity so it is unlikely that waste will be a significant contributor outside some specific niches.

...but anaerobic digestion can offer a cost-effective opportunity to re-use organic waste

Many examples of anaerobic digestion exist in New Zealand, with the bioenergy produced able to either be used onsite (eg, to create a fully self-sufficient WWTP), or on-sold to an external user (eg, power companies purchasing excess energy). For example, Palmerston North City Council successfully operates large-scale anaerobic digesters at its WWTP (including sourcing additional external biomass including food waste) (Palmerston North City Council, 2017).

At present, 53% of the current effective New Zealand population is connected to 15 WWTPs with anaerobic digesters that help to provide onsite energy. With additional drivers, such as an increased emissions price under the NZ ETS, it is estimated that 78% of New Zealand's population could be covered. This would help to divert solid waste away from landfill sites without effective gas recovery systems to anaerobic digesters co-located at WWTPs (Calibre Consulting, 2017). Recent research also shows that processing residual industrial waste from WWTPs in anaerobic digestion plants could reduce emissions by up to 151 kt CO₂e a year by 2050. This represents 150% of projected GHG emissions from industrial wastewater, suggesting that industrial wastewater treatment has the ability to become emissions neutral by 2030, and emissions negative by 2050 (Boušková, 2018).

At present, anaerobic digestion of farm waste (eg, dairy effluent) is less cost-effective. Research suggests that in New Zealand a herd of approximately 1 000 cows is required to consider installation of an anaerobic digestion system, and even then, “the net benefit is modest and is sensitive to assumptions about capital and operating costs and the value of energy” (Milet et al., 2015, p. 75). However, once agriculture is included in the NZ ETS, WtE may be a more financially viable proposition for farmers to offset on-farm energy costs.

Policy guidance regarding waste-to-energy in New Zealand

Some submitters identified a lack of policy guidance regarding WtE in New Zealand. This includes that the New Zealand Waste Strategy does not adequately consider how to better use the amount of inevitable waste, as well as a lack of direction for specific sectors and technological applications (Bioenergy Association, sub. 37; Hitachi Zosen Inova Australia Pty Ltd, sub. 68). Other jurisdictions provide specific guidance regarding WtE (such as the New South Wales Energy from Waste Policy Statement). At present, it appears doubtful, given existing anaerobic digestion projects in New Zealand, and the uncertainty regarding the financial viability of WtE using incineration, whether such a policy statement is needed.

F14.6

Waste-to-energy provides an opportunity to reduce emissions by diverting waste from landfill and substituting for fossil fuels. Anaerobic digestion (eg, at wastewater treatment plants) is a current cost-effective approach to reduce emissions, but the potential to incinerate waste (especially household waste) is less clear.

Reducing waste at source

Reducing the volume of total organic waste created (eg, through less household or commercial food spoilage) will contribute to lowering waste emissions. As noted above, a higher waste levy or NZ ETS price will incentivise councils to encourage reduced organic waste production via behavioural or other campaigns.

Some submitters also commented on the need to avoid single-use plastic products and packaging (such as plastic bags) (Kirsten, sub. 11; Rick Blazeley, sub. 12; Ross Clark, sub. 24; Wiremu Thomson, sub. 78). Other countries have banned such items (such as France’s ban on plastic bags and non-biodegradable disposable utensils, with the latter in effect from 2020). This type of waste does have emissions implications in terms of its source material, as plastic packaging is made from polyethylene which is made from crude oil or natural gas. However, these emissions are not attributed to New Zealand (as no polyethylene is made in New Zealand), and plastics do not decompose to produce GHG emissions. Even so, through overall waste minimisation initiatives (eg, via the Waste Minimisation Fund), New Zealand could contribute to reduced global emissions by lowering the demand for such products.

14.6 The future of waste

The above section has focused on priority areas where waste emissions reductions need to occur if New Zealand is to achieve its low-emissions goals. However, this more urgent focus (particularly on reducing landfill emissions) should not preclude a more transformative perspective on how waste could contribute to emissions reductions, or even be conceived of, in the future.

One well-known concept is that of the circular economy. This is an economy where “the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised” (European Commission, 2015, p. 2). The three key principles of the circular economy are to design out waste and pollution, keep products and materials in use, and regenerate natural systems (Ellen MacArthur Foundation, 2018). Incorporating circular economy principles means ensuring disposal is a measure of last resort on the waste hierarchy, with a primary focus on waste prevention, such as by designing products so that they stay in circulation for longer. Where waste is inevitable, a circular economy does encourage better waste use, such as via WtE (European Commission, 2017).

The circular economy is also an issue of relevance beyond the confines of waste. An increasing emphasis in New Zealand and internationally is to engage with businesses about how incorporating such principles can be directly economically beneficial, such as by acting as a platform for innovation (Sustainable Business Network Circular Economy Accelerator, sub. 75). A more circular economy can also directly reduce overall

emissions. In Scotland, applying circular economy principles is estimated to reduce emissions by 11 Mt CO_{2e} a year by 2050 compared to business as usual practices (Pratt & Lenaghan, 2015).

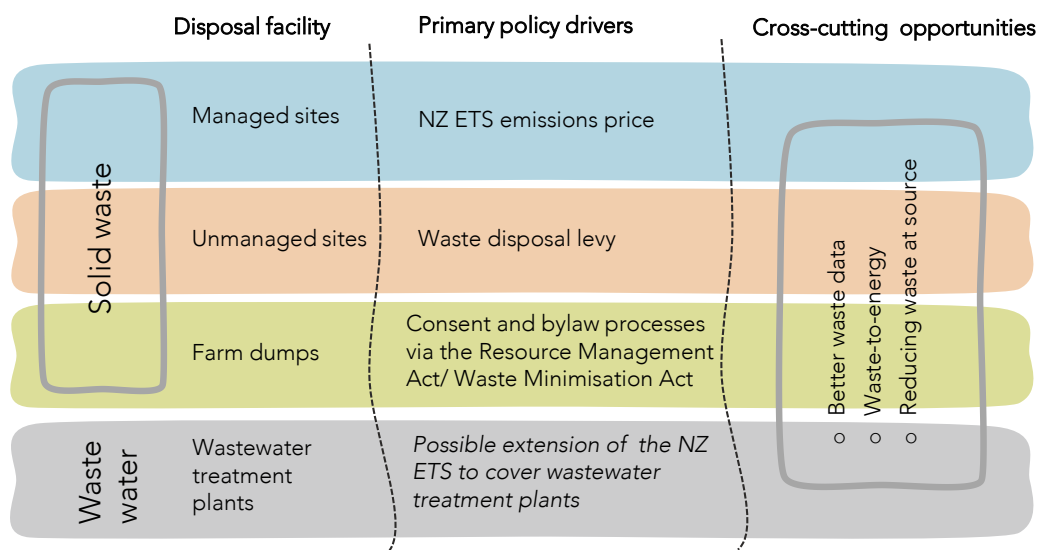
Ensuring the circular economy can be implemented in practice requires a comprehensive examination of policy frameworks so that regulatory barriers can be removed. An analysis of European policy in relation to the circular economy identified numerous regulatory barriers hindering effective uptake of its principles. These included legislative gaps, incomplete implementation or enforcement of legislation, and conflicting legislation (such as hygiene issues in relation to food waste) (Technopolis Group, 2016).

At present, some avenues exist within the New Zealand policy framework to encourage circular economy principles (eg, via the product stewardship route under the WMA, and via the current funding round for the Waste Minimisation Fund which is focusing on circular economy projects). Encouraging better waste stream management or WtE can also assist activities further down the waste hierarchy. However, it is unclear whether any significant legislative conflicts as regards the circular economy require policy attention in New Zealand. A lack of knowledge of circular economy business models has also been identified as a barrier to their development, specifically in terms of access to finance (Neumann & Achimescu, 2018). Establishing a stable climate policy regime will help to overcome this market failure (Chapter 6).

14.7 Conclusion

Reducing waste emissions represents a substantial opportunity for New Zealand, even given the significant uncertainty of plus or minus 140% in relation to emissions data from unmanaged waste sites (MfE, 2017g). Figure 14.8 summarises the opportunities for reducing waste emissions in New Zealand. It shows that primary policy drivers are available that relate directly to particular types of disposal facilities, but so too are cross-cutting opportunities, including better waste data and reducing organic waste at source.

Figure 14.8 Opportunities for reducing waste emissions



Based on its analysis, the Commission does not consider it necessary to recommend specific waste emission reduction targets, or even specific volume reduction targets of particular types of waste (ie, reverting to the approach of the 2002 Waste Strategy). This is because, in comparison to other jurisdictions that have adopted a more regulatory approach with integrated targets (such as the European Union), waste is able to be covered by an effective range of other approaches in New Zealand (namely the emissions price and the waste disposal levy). Instead of a target, price will continue to be the key mechanism to drive emissions reductions. If the coverage of the levy and the NZ ETS is extended as recommended above, then the only remaining gap is farm dumps. Yet, if more reliable data shows that unmanaged waste sites do represent a substantial emissions source, farm dumps are likely to require a separate regulatory approach because they are not suitable to either the levy or the NZ ETS.

15 The built environment

Key points

- Emissions are generated throughout the life-cycle of buildings and infrastructure. This includes emissions embodied in the production of building materials and building processes; and emissions generated through the operation, maintenance and disposal of buildings and infrastructure.
- Establishing an effective price on emissions is the most efficient mitigation strategy for most of the emissions generated from the built environment.
- The emissions embodied in buildings can vary significantly depending on the materials used and the construction technique. Recent advances in building materials, such as laminated timber beams, have created opportunities to reduce the use of emissions-intensive materials, such as concrete and steel, without compromising building strength.
- Establishing limits on the emissions embodied in buildings through changes to the New Zealand Building Code (Building Code) would be impractical. However, it is important that the Building Code does not present barriers to building technologies and materials with lower embodied emissions. Forthcoming reviews of the Building Code should assess the extent to which the Code enables the adoption of low-emissions construction.
- Commercial and residential buildings account for more than half of New Zealand's electricity consumption. Because New Zealand already has a low-emissions electricity system and abundant untapped sources of renewable electricity, improving the energy efficiency of buildings does not hold the same importance in an emissions mitigation strategy as it does in other countries.
- However, electricity generation still accounts for around 5% of New Zealand's emissions due largely to the use of coal and gas-fired stations to meet peak demand, much of which is generated by domestic electricity use on winter mornings and evenings. A range of policy measures are already in place to improve the energy efficiency of buildings. A more effective emissions price would further incentivise the uptake of technologies that improve building efficiency and reduce electricity use during periods of high demand.
- Increasing the density of urban areas, combined with good public transport and accessibility, can reduce vehicular travel and emissions. But intensification of this nature has proven difficult to accomplish and runs counter to the living preferences of many New Zealanders. Urban planning policies are likely to take many years to achieve significant increases in density. By then, reductions in vehicle emissions may have already been achieved through advances in low-emissions transport.
- When deciding whether to invest in infrastructure, decision-makers should be aware of the life-cycle emissions associated with infrastructure assets. Effective asset management can help to reduce demand for new investment.
- Where government investment in additional infrastructure is required, an effective emissions price along with stable and credible climate policy will incentivise decision makers to factor in current and likely future emissions prices in their assessment of different options.

15.1 Introduction

This chapter examines the potential for reducing emissions within the built environment, specifically buildings, urban areas, and infrastructure. For buildings and infrastructure, the focus is primarily on emissions embodied in the production of building materials and building processes; and emissions generated through the operation, maintenance and disposal of buildings and infrastructure. For urban areas, the chapter also

considers emissions not directly related to the construction or operation of buildings, but affected by the nature of the built environment. For example, the way some cities have developed has made residents less reliant on private vehicle travel, producing lower transport emissions.

Most parts of the built environment have a long lifetime. This has two important implications from the perspective of emissions mitigation strategies:

- the initial design and construction of built environments can lock-in certain behaviours and emissions for a long time; and
- changes in the built environment are usually very gradual, and are therefore unlikely to make a material contribution to emission reduction targets in the short term.

Co-benefits are another important consideration when examining emissions reduction strategies relating to the built environment. Many inquiry participants who proposed mitigation strategies relating to the built environment noted that they had important co-benefits – for example health and emissions co-benefits from improved thermal performance of residential buildings (Auckland Regional Public Health Service, sub. 105). While co-benefits should form an important part of any cost-benefit analysis (CBA), this chapter does not try to assess the extent of all co-benefits, and instead focuses on the main options to reduce emissions.

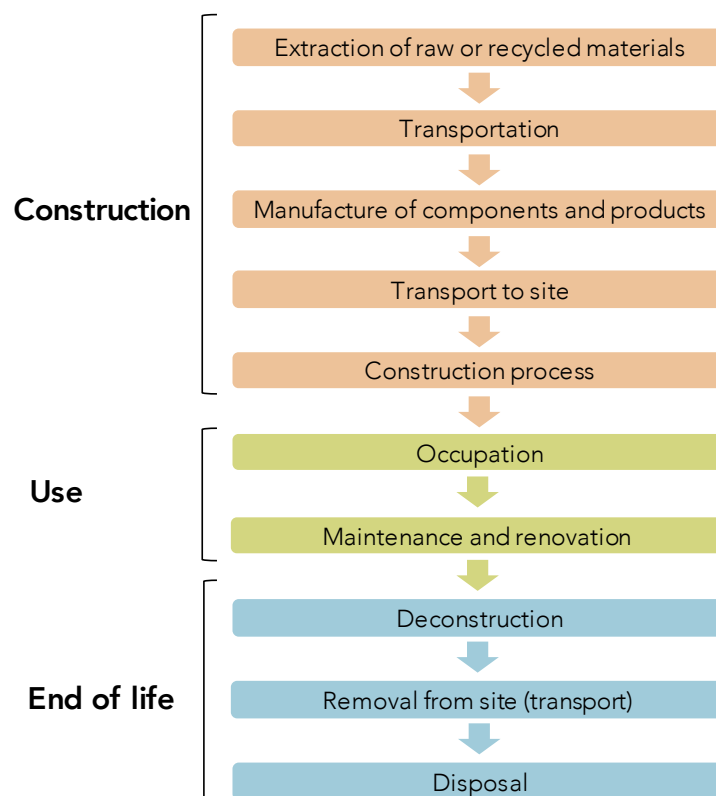
15.2 Emissions through the life-cycle of a building

Emissions are generated throughout the life-cycle of a building.

Greenhouse gas emissions from buildings are generated throughout the buildings full life cycle from the production of building materials, to the operational energy consumption of a building (heating, cooling, hot water heating, lighting, appliances and electrical equipment), building maintenance and end-of-life disposal. (Scion, sub. 67, p. 6)

Figure 15.1 shows some important emissions sources, split across three stages of a building's life. The following sections examine the extent of emissions in each of these stages, and the scope for mitigation.

Figure 15.1 Emissions sources in the life-cycle of a building



Source: Adapted from Monahan and Powell (2011).

Emissions embodied in construction

Although the majority of New Zealand's building stock that will exist in 2050 is already in place, using building materials with lower embodied emission, and using lower-emissions building practices to further reduce emissions is possible.

When a building is constructed – before it starts operating and generating operating emissions – it is already responsible for tons of GHG emissions. And even though the majority of embodied emissions happen once – when the building is constructed – and operating emissions happen over time and are cumulative, the majority of GHG emissions for the first 15–20 years of a building's life will be the embodied emissions from materials and construction. (Strain, 2017 cited in Strategic Lift Inc. sub. 60, p. 2)

Giesekam et al. (2014, p. 425) note that over half of the embodied carbon in construction is associated with the production of materials, and a range of embodied carbon mitigation strategies exist.

These include strategies that seek to minimize extraneous material usage through 'lightweighting', structural optimization or site waste reduction; strategies that focus upon maximizing the useful life of materials by extending the life of existing structures and designing new structures to be adaptable and easy to deconstruct (allowing reuse of materials and components); or substitution of materials and construction products for alternatives with lower carbon supply chains. A variety of alternative materials are available, including materials derived from naturally occurring substances; materials that incorporate waste or recycled content; materials that have been repurposed or sourced for reuse from other sites; and construction products that have been optimized through novel production techniques.

Numerous studies have examined the potential of different design and construction strategies to reduce embodied emissions. The International Energy Agency (IEA) reviewed 80 studies that assessed mitigation strategies, including substitution of materials, reduction of resource use, and design changes to reduce the total volume of construction. Overall, the analysis found that the substitution to bio-based materials will reduce emissions, due to the low-energy production methods. Studies examining substitution to recycled materials produced mixed results. Studies evaluating strategies to reduce the use of materials – for example through the use of lightweight construction and re-use of old building structures – generally found that these approaches were effective in reducing emissions (IEA, 2016b).

In an example of a study that examines substitution of different materials, Monahan and Powell (2011) calculated the embodied carbon emissions for an 83m² detached three-bedroom home in the United Kingdom based on three different construction techniques. Their results show a significant variation in emissions (Table 15.1).

Table 15.1 Embodied emissions for three construction techniques

Building method	Embodied emissions
<i>Timber framing and cladding</i> – using a timber framing system that was factory constructed offsite with wooden weatherboards installed onsite	405 kg CO ₂ /m ²
<i>Timber framing with brick cladding</i>	535 kg CO ₂ /m ²
<i>Conventional masonry cavity wall</i> – block internal wall and an outer brick cladding	612 kg CO ₂ /m ²

Source: Monahan and Powell (2011).

The total floor area of standalone dwellings built in New Zealand was 4.35 million square metres in 2017. Based on the embodied emissions figures calculated by Monahan and Powell (2011), a total (hypothetical) carbon dioxide emissions reduction of around 900 kilotonnes could be achieved if every building was constructed using the lowest-emission approach compared with the highest-emission approach (this reduction is equal to 7% of New Zealand's road transport emissions in 2015). Clearly, emissions reductions of this nature are not feasible as much of New Zealand's residential building already uses timber cladding and framing. However, it shows that embodied emissions vary significantly depending on the materials and building methods used.

Several inquiry participants raised the issue of embodied emissions. Waikato Regional Council (sub. 48) and Scion (sub. 67) advocated for a transition from relatively high-emissions materials such as concrete and steel to wood.

High-technology wooden construction for structural elements instead of steel not only reduces emissions from material manufacture but provides a carbon sink for the life of the building. (Waikato Regional Council, sub. 48, p. 6)

Wood has lower embodied energy compared with alternative structural construction materials, and in addition to this provides carbon sequestration and storage benefits. (Scion, sub. 67, p. 7)

Recent advances in technology have widened the range of opportunities for the use of wood in construction. For example, researchers at the University of Canterbury have developed *Pres-Lam*, a prestressed laminated timber building system that is designed to be a sustainable alternative to heavier, non-renewable, concrete and steel framing (University of Canterbury, 2017). This technology was used in the construction of a three-story arts building at the Nelson Marlborough Institute of Technology. The construction project was supported by the Ministry of Agriculture and Forestry (now the Ministry for Primary Industries) who at the time, provided funding support toward buildings that promoted the use of timber in low-rise construction (Philip, 2011). Similar technology will be used in a planned office block in Wellington's CBD, which at 52 metres tall, will be the world's tallest wooden office building (Winter, 2017).

Some inquiry participants suggested changes to the Building Code provide scope to transition to materials with lower embodied emissions.

... [A]mendments to the resource and building consent frameworks [are] needed to enable and incentivise low emitting building materials and methods. (Greater Christchurch Partnership, sub. 57, p. 7)

In particular, some submitters suggested amending the Building Code to encourage greater use of wood.

The Building Code should be reviewed to ensure the correct balance between climate change issues and other requirements. In particular, consideration of the benefits of wood and wood-related products in any review of the building code is encouraged, both in construction and for insulation... Timber and other carbon-neutral building products should be preferred over carbon-intensive products. (Oji Fibre Solutions, sub. 71, p. 8)

Consideration of the benefits of wood and wood-related products in any review of the Building Code is ... encouraged... It is a low-embodied energy building material and a store of GHG for the life of the building. (New Zealand Institute of Forestry, sub. 73, p. 7)

While evidence strongly suggests that mitigation opportunities exist through different building techniques, particularly the use of low-emissions materials, it is not apparent that making changes to the Building Code is the best way to incentivise such opportunities. In theory, the Building Code could include specific limits on allowable embodied emissions, but this would be undesirable for a number of reasons.

- It is difficult to accurately capture the full range of emissions embodied in buildings. Giesekam et al. (2014) note that many life-cycle assessments of building products suffer from limited system boundaries that fail to encompass the full direct and indirect impacts of products and building processes. Furthermore, it may be very difficult to establish in advance embodied emissions over a building's life-span. For example, a building's initial embodied emissions might be low, yet, due to the choice of materials, the building might require frequent and emissions-intensive maintenance throughout its life.
- For some building types, low-emissions materials may not be cost effective. Or, for some buildings types the scope to reduce emissions-intensive materials may be limited. For example, although the use of wood in high-rise buildings is increasing rapidly, globally, there are the only a handful buildings made from wood that are over 50m tall. Accordingly, different embodied emissions caps might need to be established for different types of buildings.
- An upper limit on emissions would remove the incentive to lower embodied emissions below the specified cap.

A more straightforward approach would be to raise the emission's price in New Zealand's Emissions Trading Scheme (ETS) (Chapter 4). This will induce a search for low-emissions product substitutes, such as replacing

steel with wood in construction, cement substitutes or low-emissions cement variants. Similarly, a higher emissions price would incentivise architects and engineers to design buildings that require fewer resources or incentivise them to re-use components of existing buildings.

F15.1

Increasing the price of emissions in the New Zealand Emissions Trading Scheme is the most effective way to incentivise a transition toward the construction of buildings with lower embodied emissions.

While no strong case exists for a cap on embodied emissions in the Building Code, building regulations must be sufficiently flexible to enable the adoption of low-emission building materials and processes (without compromising on other regulatory objectives, such as fire safety). The Building Code sets out the minimum structural and safety standards for building work (such as protection from fire, durability and moisture control), but not how the building should meet them. Building practitioners can comply with the Code by using prescriptive guidelines (“Acceptable Solutions”) prepared by the Ministry of Business, Innovation and Employment (MBIE). Alternatively, building practitioners can propose other ways (“Alternative Solutions”) to meet the requirements of the Code. Where an Alternative Solution is used, the burden is on the practitioner to demonstrate how their solution complies with the Code (NZPC, 2014).

The Productivity Commission has previously found that this approach to regulation (known as a deemed-to-comply model) can help to enable innovation.

Deemed-to-comply models can help shift regulatory regimes from prescriptive/input-based approaches to more enabling approaches where desired: the existing input-based guidance becomes the detailed rules, but firms are allowed to seek other options. Deemed-to-comply models can also allow regulatory systems to adapt to changes in technology or shocks. Rather than having to change the underlying statute and regulatory framework, the detailed rules can be updated to reflect new developments. (NZPC, 2014, p. 196)

The government has recently stated that they intend to review the Building Code (Swannix, 2017). In addition, the *New Zealand Energy Efficiency and Conservation Strategy 2017–2022*, prepared by MBIE, included a commitment for MBIE and the Energy Efficiency and Conservation Authority (EECA) to support improvement in the energy performance of commercial and residential buildings “through reviews of the energy efficiency provisions in the building code and increasing minimum energy performance over time, where cost-effective on a lifecycle cost basis” (2017c, p. 17).

The main driver underlying both these commitments to review the Building Code appears to be a desire to lift the operational performance of buildings. However, given the potential for significant reductions in embodied emissions, it would be beneficial if future reviews of the Building Code included an exploration of whether the Code (in practice) presents any undue barriers to adopting materials and building techniques with low embodied emissions.

R15.1

Future reviews of the New Zealand Building Code should examine whether the Code is sufficiently flexible to enable practitioners to adopt building materials and techniques with low embodied emissions.

Emissions generated from using buildings

The commercial and residential sectors account for 2% of New Zealand’s emissions (MfE, 2017g). Table 15.2 sets out a breakdown of these emissions, and shows that most emissions are CO₂ produced through the combustion of fossil fuels. The New Zealand emissions inventory does not distinguish what these fossil fuels are actually used for, although space heating is a likely significant component.

Table 15.2 Emissions from domestic and commercial/institutional buildings

Emissions source in each building type	Fuel consumption (TJ)	CO ₂	CH ₄	N ₂ O	Total emissions CO ₂ equivalent
Commercial/institutional	16134.1	993.6	0.11	0.01	998.5
Liquid fuels	6267.9	423.6	0.06	0.01	426.6
Solid fuels	996.8	92.0	0.01	0	92.7
Gaseous fuels	8869.4	478.0	0.04	0	479.2
Residential	10306.6	592.0	0.15	0	596.5
Liquid fuels	3132.1	190.2	0.01	0	190.8
Solid fuels	391.6	36.2	0.11	0	39.2
Gaseous fuels	6782.9	365.5	0.03	0	366.5

Source: MfE (2017g).

Effective emissions pricing could mitigate the continued use of coal and natural gas to heat a building for as long as owners continue to use them. This was noted by Robert McLachlan (sub. 9, p. 13) who stated that a higher price on carbon “will stop people building buildings heated by coal and gas pretty quickly”.

Electricity use in New Zealand buildings

Although the majority of New Zealand’s electricity is generated from renewable sources, electricity generation is still responsible for around 5% of New Zealand’s emissions. Based on a production accounting model, these emissions are all attributable to the electricity generation industry (because the emission enters the atmosphere at the point that the electricity is generated). If emissions are calculated based on the point at which electricity is consumed, over half of emissions associated with electricity generation can be attributed to residential and commercial use. In 2016, 31% of electricity was consumed by residential customers, and 25% was consumed by commercial users (MBIE, 2017a).

Several inquiry participants noted that advances in building technology and design have created opportunities to reduce energy use in buildings.

Design innovations such as use of passive solar, green roofs, high factor insulation all contribute to using less energy and therefore less emissions. (Waikato Regional Council, sub. 48, p. 6)

Technological advancements and implementation of sustainable practises including stormwater first flush diversion and storage, passive solar heat generation and retention and utilisation of ground sourced heating (with appropriate mitigation measures to ensure no water contamination) provide opportunities to reduce overall energy consumption. (Canterbury District Health Board, sub. 16, p. 11)

Most emissions from electricity generation occur as a result of the use of thermal generation to meet periods of peak demand on winter mornings and evenings (Chapter 12). Accordingly, from the perspective of reducing emissions, measures to reduce electricity during peak times are of central importance.

Much of the peak generation of electricity in New Zealand is met with fossil fuel (thermal) plant and therefore efforts to increase the share of renewables on the New Zealand grid need to include measures to flatten energy demand and make buildings more responsive to the more intermittent availability of renewables. (NZGBC, sub. 82, p. 1)

Raising energy efficiency standards in the Building Code

As with emissions embodied in construction, several inquiry participants argued that energy efficiency standards in the Building Code should be strengthened as a way to reduce electricity use and associated

emissions (eg, Guardians of New Zealand Super, sub. 32; Shravan Miryala, sub. 17; The Morgan Foundation, sub. 127). The NZGBC (sub. 82, pp. 1–2) noted that “New Zealand has one of the weakest Building Code’s in the developed world” and that “while EU members have been rapidly tightening their building codes in the race towards ‘nearly zero carbon’ standards New Zealand has largely stood still with only very minor improvements to insulation standards in the building code since 1978”.

As noted above, both the Government and EECA/MBIE have already committed to reviewing New Zealand’s Building Code. These reviews present an opportunity to fully assess whether there are net benefits in raising energy efficiency standards. From the perspective of reducing emissions, these reviews should establish how higher standards will affect demand for electricity, and how this affects emissions from the generation of electricity. These benefits will need to be assessed against any costs, including higher building costs. Additionally, improvements in the efficiency of operations also need to consider emissions embodied in materials. For example, EECA (2018c) notes that the correct use of thermal mass, such as masonry walls and concrete slab floors, can help to moderate internal temperatures, making houses more comfortable and energy efficient. But while thermal mass can help to reduce electricity consumption, materials such as concrete have relatively high embodied emissions.

R15.2

Forthcoming reviews of New Zealand’s Building Code should assess whether there is scope to materially reduce peak demand for electricity through the introduction of more stringent energy efficiency standards.

Improving energy efficiency in existing buildings

Any changes to energy efficiency standards in the Building Code would primarily affect new-builds. Improvements in the efficiency of new-builds are likely to make a relatively small difference to the overall electricity consumption because the number of new buildings constructed as a share of New Zealand’s total building stock is very small. In addition, the standards that apply to new buildings have already been raised incrementally over time. By contrast, many older buildings offer significant potential for efficiency improvements (Burgess, 2011).

As noted above, improving energy efficiency of buildings has the greatest impact on electricity emissions to the extent that it reduces peak demand. Concept Consulting (2017c) find that the greatest scope for reductions in peak demand is through more efficient lighting and space heating.

The absence of an effective emissions price presents one barrier to the adoption of energy efficiency measures that would reduce electricity emissions. If the emissions from peak generation were appropriately priced, and those prices were passed on to consumers, it would strengthen incentives on building owners to make energy efficiency investments. As noted in chapter 9, this incentive is weaker for landlords who do not pay electricity bills but face the full cost of efficiency improvements such as the installation of more efficient heating (although improvements in efficiency would presumably make a building more marketable when seeking new tenants).

A further barrier to the adoption of energy efficiency measures is the absence of cost-reflective electricity pricing. If consumers faced the full cost of using electricity at peak times, the incentive to invest in efficiency would be strengthened. As noted in chapter 12, the Electricity Authority has a programme of work underway to update pricing and regulation to facilitate the introduction of more cost-reflective pricing.

In addition to pricing measures, many other interventions can be used to encourage the adoption of energy efficiency. A range of initiatives are already in place to encourage the application of energy efficiency technologies to existing buildings (Table 15.3).

Table 15.3 Initiatives to encourage improvements in energy efficiency (selected examples)

Type of intervention	Examples
Information provision	<p>EECA is a government-funded Crown entity that provides information services about how to improve energy efficiency in New Zealand homes and businesses.</p> <p>Non-government organisations, such as the Sustainability Trust, also provide information and advice about energy efficiency.</p>
Subsidies	<p>The Warm Up New Zealand programme provides grants of 50% of the cost of insulation for low-income owner-occupiers and landlords with low-income tenants (the eligibility criteria for this programme have changed over time, with earlier iterations being less targeted).</p>
Voluntary initiatives	<p>Homestar – a rating tool developed by NZGBC that measures the health, warmth and efficiency of New Zealand houses (NZGBC, 2017).</p> <p>NABERSNZ – a system for rating the energy efficiency of office buildings adapted from the National Australian Built Environment Rating System (NABERSNZ, 2017).</p>
Regulatory approaches	<p>Residential landlords must disclose the extent of insulation in their properties in a signed statement as part of any new tenancy agreement (since July 2016). From 2019, rental properties must be insulated up to the standard of the current Building Code (where retrofitting is practical).</p> <p>Minimum energy performance standards require that only products meeting a minimum standard for energy efficiency can be sold in New Zealand. Importers and manufacturers must ensure products are tested using the correct method, comply with the minimum standard, and are registered before being offered for sale. Certain products must also display an energy efficiency rating label (EECA, 2017d).</p>

In addition to the examples set out in Table 15.3, numerous energy efficiency policies have been implemented in other countries from which New Zealand can draw lessons. For example, from 2009 Australia phased in restrictions on the sale of low-efficiency lightbulbs.

Government should continue to implement energy efficiency initiatives provided that they are assessed based on their costs and benefits. Such analysis requires a good understanding of the relative costs and benefits involved in decarbonising the electricity generation system. Any cost-benefit analysis (CBA) should also consider co-benefits, which for some energy efficiency programmes have proved significant. For example, a CBA of the Warm Up New Zealand programme (which provided subsidies toward the costs of retrofitting insulation and/or clean heating for pre-2000 houses), identified significant health benefits stemming from the intervention (Grimes et al., 2012b).

Any policies to reduce demand for electricity should also be reviewed frequently as changes in technology may change cost-benefit valuations. For example, improvements in technology may lower the cost of efficient products, or widespread adoption of electric vehicles might increase the imperative to reduce demand elsewhere on the electricity network.

R15.3

Government should continue to promote the uptake of energy efficiency in buildings, with a particular focus on reducing emissions associated with peak electricity demand.

Emissions in the disposal of buildings

Life-cycle analysis includes emissions resulting from the disposal of a building at the end of its life. These emissions can be reduced by extending the lifespan of buildings.

To reuse older building structures instead of constructing “virgin” buildings can be looked upon as a strategy to also reduce resource use and the associated EEG [embodied energy and greenhouse gas emissions] of the product and construction process stage. (IEA, 2016b, p. 71)

In addition, re-using or recycling many building materials is possible. For example, New Zealand Steel (sub. 64, p. 15) noted that “steel is infinitely recyclable” and that “the long-life nature of steel, complemented with adequate recovery mechanisms at product end-of-life, can effectively eliminate waste”.

As with most other aspects of reducing emissions in buildings, reducing end-of-life emissions can be incentivised by ensuring that the NZ ETS sets an appropriate emissions price.

15.3 The relationship between urban form and emissions

Around 70% of New Zealanders live in an urban area with a population greater than 50 000. As a result, much of the country’s energy use and transport-generated emissions occur within urban areas. Differences in urban form (the physical characteristics that make up urban areas, including the shape, size, density and configuration of settlements), affect the magnitude of emissions.

Several submissions to this inquiry (for example Tauranga City Council, sub. 126 and Canterbury District Health Board, sub. 16) suggested that higher-density urban forms are more efficient from an emissions perspective. They encouraged the Productivity Commission to consider urban design policies to encourage more compact development, and to prevent sprawl.

The following sections examine the potential magnitude of emissions reductions associated with different urban forms and consider whether urban planning tools should be used to pursue a certain urban form.

How does urban form affect emissions?

Research examining the relationship between different types of urban form and GHG emissions focuses on three main issues:

- transport-related emissions associated with different urban forms;
- emissions associated with how different types of building are operated; and
- emissions involved in how different types of neighborhoods are built.

The relationship between urban form and transport emissions

Many studies have examined the relationship between different urban form variables and transport emissions. While the results of these studies reveal some inconsistency (Robert & Jin, 2010), a growing body of literature shows that residents in more compact and transit-friendly urban areas drive less than those in more dispersed settings. As R. Ewing et al. (2010) note:

For decades, it has been known that compact areas have lower automobile use per capita and greater use of alternative modes of transport than do sprawling areas. They also tend to generate shorter trips. The combined effect is significantly less VMT [vehicle miles travelled] per capita in compact areas. (p. 20)

Robert and Jin (2010) examined 370 urban areas in the United States and found that areas with higher population density typically have lower VMT per capita. This result is primarily due to lower shares of the population auto-commuting, and shorter travel distances. The reduction in vehicle miles travelled in higher-density areas is partially offset because, on average, such areas have a greater concentration of road-infrastructure, which induces more travel.

Drawing on an extensive review of literature (primarily American) on the relationship between the built environment and household travel, the Transportation Research Board (2009), also concluded that developing more compactly lowers VMT.

Both logic and empirical evidence suggest that developing more compactly, that is, at higher population and employment densities, lowers VMT. Trip origins and destinations become closer, on average, and thus trip lengths become shorter, on average. Shorter trips can increase trip frequencies, but empirical evidence suggests that the increase is not enough to offset the reduction in VMT that comes from reduced trip lengths alone. Shorter trips also may lower VMT by making walking and bicycling more competitive alternatives to the automobile, while higher densities make it easier to support public transit. (p. 88)

The review raised some important issues about the relationship between density and VMT.

- Although a large number of studies examine urban form and vehicular travel, “capturing the nature and magnitude of the link between the two has proved elusive” (p. 89). Shortcomings of some studies have resulted in widely varying results regarding the importance of changes in land use and the magnitude of effects. For example, many studies identify statistically significant correlations between urban form and VMT, but few establish causal relationships using longitudinal data.
- Density is often used as a proxy for other urban form variables, but increasing density alone is insufficient to reduce the number of vehicles on roads. For this to occur, increases in residential density must happen in conjunction with other changes such as mixing land uses to bring housing closer to jobs and shopping and increased accessibility of public transport.
- The results of more robust studies show that the effects of increasing density are relatively modest. Most studies indicate that doubling the density of a residential area is associated with a reduction in VMT of between 5% and 12% (Transportation Research Board, 2009).

Among the submissions to this inquiry that discussed urban form, most raised the potential for urban design, including higher-density development, to reduce transport emissions.

Good urban design encourages active and public transport and therefore emphasis should be placed on regulations and policies that facilitate good urban design planning. (CDHB, sub. 16, p. 6)

There needs to be strong coordination between land use and public transportation routes to reduce private vehicle use (e.g. the Auckland Unitary Plan’s impetus on a quality compact urban form should help to facilitate improved and more effective public transport initiatives). (Auckland Regional Public Health Service, sub. 105, p. 11)

Sprawling, low-density development forces people to travel further and makes public and active transport costly or unviable, locking in dependence on private cars. Governments and councils should encourage compact urban form and allow more homes to be built near to where people work, study and play. This means loosening height and density restrictions, rezoning for mixed-use development, and removing detrimental regulations such as minimum parking requirements. (The Morgan Foundation, sub. 127, p. 7)

... if we are serious about achieving a low carbon economy... High density urban areas with high efficiency public transport, cycle ways and footpaths [are required]. (David Lourie, sub. 86, p. 6)

While there is evidence that links higher density urban areas with lower vehicular travel, policies that seek to encourage higher-density development can involve significant costs. For example, the Commission’s inquiry into *Better urban planning* showed that urban limits used in Auckland to contain development within city limits have created an artificial constraint on land supply leading to higher land prices and less affordable housing. Zheng (2013) showed that residential land inside Auckland’s urban limit is almost 10 times more expensive than land outside the limit.

Rigidly enforced densification policies also have the potential to reduce wellbeing by limiting the choice of housing typologies available. A nationwide survey of New Zealanders on their housing and locational preferences revealed strong preferences for stand-alone dwellings and residential space (Howden-Chapman et al., 2015).

- Just over 80% of respondents preferred a stand-alone house (abstracted from other considerations).

- 53% of respondents stated that having residential space was more important to them than having a shorter commute time, while 26% expressed that having a shorter commute was more important than the house they lived in (the remaining 21% stated “other” or did not have a preference).
- All age groups, except 65 years and over, expressed a strong preference for a larger house further away from the heart of the city as opposed to a smaller house/townhouse/apartment closer to the heart of the city.

These findings are consistent with international literature that has shown that as incomes rise, people tend to demand more private space (Cheshire et al., 2015).

Importantly, substantive changes in density are likely to take several decades to eventuate. As noted above, most international studies suggest that density would need to double to achieve a reduction in VMT of 5% to 12%. From at least as early as the late 1990s, planners in Auckland have aspired to significantly increase the density of the city. But, between 2001 and 2013, Auckland’s density (people per hectare) increased at an average yearly rate of just 0.8% or 1.2% (depending on how density is calculated) (Mead, 2013). At this rate it will take several decades to achieve a meaningful reduction in VMT.

In addition, it is not clear that past increases in density that have been achieved in some New Zealand cities are likely to reduce emissions. As noted above, intensification only contributes to lower vehicle travel, and lower emissions, if it occurs in a way that improves access to employment and other travel destinations. The Commission’s inquiry into *Using land for housing* (2015) found that the largest contribution to intensification in Auckland between 2001 and 2013 occurred between 10km and 20km from the city centre. Inner city suburbs made a relatively subdued contribution toward intensification.

Given that changes in density occur slowly, changes in technology are likely to significantly alter the emissions payoff purportedly associated with higher-density urban areas. In particular, the anticipated rise of electric vehicles and other low-emissions vehicles may produce much of the emission reduction sought from reducing vehicle travel. As the New Zealand Council for Infrastructure Development noted:

All available evidence today strongly indicates that electric vehicle prices are reducing, and will continue to reduce, as technology becomes cheaper. ...With the decline of conventional engines, the basis for urban planning to manage down private vehicle use is greatly reduced, yet we have seen very little evidence that shifting energy trends are reflected in planning provisions. (New Zealand Council for Infrastructure Development, 2016, p. 9)

Overall, there is not a strong case to use urban planning policies to reduce emissions. However, transport emissions are a large, and growing, share of New Zealand’s total emissions, and significant reductions are required in order to transition to a low-emissions economy. Chapter 11 recommends a set of interventions to address transport emissions, including the establishment of vehicle emissions standards, incentives to encourage the uptake of low-emission vehicles, and policies to better support low-emission modes of transport.

F15.2

Increasing the density of urban areas, combined with good public transport and accessibility, can reduce vehicular travel and emissions. But intensification of this nature has proven difficult to accomplish and runs counter to the living preferences of many New Zealanders. Urban planning policies are likely to take many years to achieve significant increases in density. By then, reductions in vehicle emissions may have already been achieved through advances in low-emissions transport.

Stephan et al. (2013) note that, even with the widespread adoption of electric vehicles, public transport is still more efficient from an emissions perspective, given the emissions embodied in the construction of roads, parking spaces and other infrastructure. Opportunities to reduce emissions embodied in infrastructure are discussed later in this chapter (section 15.4).

Urban form and building operational efficiency

In addition to the relationship between urban form and vehicle miles travelled, studies have also examined the relationship between urban form and residential energy use. These studies typically find that dwellings in higher-density urban areas use less energy because dwellings in higher-density settings are typically smaller and so require less energy to heat and cool. In addition, an attached house typically requires less energy to heat and cool than a detached house of a similar size because it has less exposed surface area (R. Ewing & Rong, 2008).

NZGBC raised the issue of building size.

New Zealand has the 3rd largest new-build dwellings in the world (as with car ownership second only to the USA and Australia). The average size of a newly built dwelling rose from 110m² in 1974 to 197m² in 2013 ... and this is despite a drop in the average occupancy of each home during the same time. The average space per person has risen dramatically. The BRANZ Heep report shows that floor space and energy use in dwellings is strongly correlated meaning that planning rules that encourage denser development and therefore smaller homes would (as with transport) have the effect of reducing carbon emissions. (NZGBC, sub. 82, pp. 2–3)

Table 15.4 shows that, on average, higher-density dwellings (townhouses and apartments) constructed in 2006 have a much smaller floor area than detached housing. This is only partially offset by detached housing having a greater average occupancy rate. As such, on a per capita basis, higher-density housing is smaller, and therefore may require less energy to operate.

Table 15.4 Size and occupancy rates for different types of dwelling, 2006

	Higher density	Detached housing
Average floor area of new-builds	107.9m ²	215.4m ²
Average occupancy rate	2.0	2.9
Average floor area per person	53.9m ²	74.3m ²

Source: Stats NZ (2008); Stats NZ (2018a).

Notes:

1. 2006 is the most recent year that Stats NZ collected occupancy data.

While higher-density dwellings may be more energy efficient, given New Zealand's largely renewable electricity generation, the effect on emissions of a shift toward more energy efficient urban forms is likely to be minor.

Urban form and emissions embodied in construction

Because the construction of different types of urban environments involves different types of materials and processes, the emissions embodied in construction can vary significantly.

Several overseas studies have examined the emissions embodied in the construction of different neighbourhoods. These typically find that higher density neighbourhoods with multi-story apartment buildings typically embody higher emissions due primarily to the need for greater concentrations of steel and concrete in their foundations (Oldfield, 2012). However, these higher embodied emissions are usually more than offset by the fact that on average, people living in high-density areas occupy smaller dwellings. For example, Norman et al. (2006) examined the GHGs emitted and energy used during the manufacture of construction materials used in low- and high-density developments in Toronto. On a square metre basis, the results show that high-density developments are 1.25 times more energy intensive and GHG emissions intensive, than low-density developments. However, when examined on a per capita basis, the relationship reverses, with low-density developments embodying approximately 1.5 times higher emissions. An examination of different neighbourhood types in Austin, Texas, produced similar results, with higher-density areas embodying less energy per capita (Nichols & Kockelman, 2015).

Stephan et al. (2013) examined the embodied emissions for a typical low-density residential neighbourhood in Melbourne, and compared these with a range of alternative development scenarios, such as a 10% reduction in the floor area of all dwellings, or replacing half the dwellings with various forms of medium-density housing. They found that the emissions embodied in higher-density housing are significantly lower, owing to factors such as fewer materials being used (less floor space), shared walls, and greater use of shared infrastructure.

Assuming that the results of these overseas studies are broadly applicable to the New Zealand context, there would be emissions benefits associated with adopting a more compact urban form for future developments. While land use regulations (such as zoning and urban limits) could be used to achieve these benefits, if emissions are priced appropriately, then individuals will adjust their housing choices accordingly (Glaeser & Kahn, 2010). The proposed changes to emissions pricing set out in Chapter 4 would provide incentives to use building materials and building forms with lower embodied emissions. This would include incentivising the uptake of lower-emissions materials made possible through any technological advances (Chapter 13).

Conclusion on urban form and emissions

Overall, evidence reveals modest emissions reductions associated with a transition to more compact urban forms, provided that this occurs in tandem with changes such as improvements in accessibility and public transport. However, rigidly enforced, urban planning policies that seek to contain growth can be detrimental to housing affordability and run counter to the housing and location preferences of most New Zealanders. In addition, achieving increases in the type of density that reduces vehicle travel is not straightforward. The process is gradual, so any material benefits are likely to take decades to eventuate.

Although the case for pursuing certain types of urban form is weak from an emissions reduction perspective, the Commission's inquiry into *Land for housing* (2015) identified numerous regulatory barriers to both building up and building out. Examples of regulations that act against higher-density development include minimum apartment sizes and balcony requirements, minimum parking requirements and density limits. Other rules, such as height limits and "special character" protection rules, can also act against densification if poorly implemented. To the extent that cities wish to pursue higher density forms, addressing these barriers should be a priority.

A final consideration regarding the use of urban planning as an emissions mitigation strategy is that accurately anticipating the wider effects of changes to urban form is very difficult. Urban areas are complex systems that evolve in response to changes in technology and because of interactions between millions of individual decisions. As people make decisions about location, lifestyle and business, the shape and character of a city can change in unanticipated ways. Some New Zealand cities have plans that promote increased density, but many developers and their buyers have continued to opt for more traditional suburban layouts. The complexity of urban areas means that no single agent or group can control outcomes (NZPC, 2015).

15.4 Construction of infrastructure

Section 15.2 describes the life-cycle emissions associated with the construction, maintenance, operation and disposal of buildings. In addition to the construction of residential and commercial buildings, each year a significant amount of construction activity is dedicated to putting in place and maintaining New Zealand's infrastructure. Budget 2017 included plans for infrastructure spending of \$32.5 billion over a four-year period (Joyce, 2017). Over the same timeframe, forecast capital expenditure across all local governments was \$16.4 billion (Local Councils, 2018).

The emissions embodied in the construction of infrastructure can be significant. For example, the Swedish Transport Administration showed that an estimated 3.8 million tonnes of GHG emissions will be generated from construction (including material extraction, production, and transportation) of planned infrastructure investments for 2014–2025 in Sweden. This represents approximately 6% of Sweden's total yearly GHG emissions (Miliutenko et al., 2014).

Assessing the underlying need to build infrastructure

An important first step in seeking to reduce emissions embodied in new infrastructure is to question the underlying need to build additional infrastructure in the first place.

Reducing carbon is not just about building new assets in a more intelligent way – it's about demanding better performance from what we already have. Most of the UK's infrastructure networks are already mature. Although new infrastructure is needed to meet new social and economic needs, getting more out of existing assets will play a significant part in increasing capacity and meeting customer demand. Many of the carbon reduction opportunities available will be associated with upgrading, adapting and modernising infrastructure currently in operation. (UK Treasury, 2013)

The Commission's inquiry into *Using land for housing* found significant potential for local authorities to use existing infrastructure assets more intensively (NZPC, 2015). Additionally, the Commission recommended greater use of demand management techniques (such as volumetric charges for water and road tolls) to incentivise more efficient use of existing assets. Local Government New Zealand (in their submission to the lower emissions economy inquiry) also advocated for greater use of demand management tools.

Thought should be given to ... increasing the use of incentives such as demand management tools, for example congestion pricing, as a means of driving behavioural change, and how the revenue from such tools could be utilised to support councils and their communities with climate adaptation and mitigation action. (LGNZ, sub. 36, p. 10)

Box 15.1 provides an example of how the construction of additional infrastructure can be avoided if existing assets are used efficiently. Also described is an example from the United Kingdom where more effective use of existing assets reduced the scale of new investment.

Box 15.1 Reducing infrastructure emissions through effective use of existing assets

Wellington City Council

In 2015, Wellington City Council identified Victoria Street in Wellington's CBD as an area suited to a significant increase in residential and commercial activity. The council's preliminary estimates were that the infrastructure costs associated with accommodating this growth could be as much as \$20 million. However, more detailed analysis, making use of the council's asset management systems, showed that the planned level of development could be accommodated entirely with existing capacity. This finding prompted the council to undertake a major project looking at infrastructure use and demand across the city, with a view to optimising the use of previous investments (NZPC, 2015).

Anglian Water

As part of its 2010–2015 Asset Management Plan, Anglian Water identified the need for a 60 km pipeline between the Covenham Water Treatment Works and Boston township. Detailed network modelling led to a solution in which 40% of the 15 megalitres of flow a day could be transferred through existing assets, reducing the size of pipeline required and eliminating an intermediate pumping station. Further gains were made by using standard products extensively. Relative to the original design, these improvements achieved a 12 000 tonne (57%) reduction in emissions during construction and an associated £13 million cost saving (Green Construction Board, 2013).

Infrastructure planning and procurement

Through their planning and procurement decisions, governments have the ability to influence the extent of emissions generated from the construction and use of infrastructure assets.

Life-cycle assessment of infrastructure emissions

As with buildings, emissions embodied in infrastructure accrue throughout the life-cycle of the asset. Life-cycle includes not only the materials and processes involved in the initial construction, but also operational emissions, maintenance and disposal at the end of the asset's life. Further, infrastructure design can also have a significant impact on emissions associated with the asset's use. For example, a smoother road surface

reduces rolling resistance. In turn, this improves the fuel efficiency of vehicles travelling on that road. However, this needs to be balanced against the emissions embodied in the additional materials and construction processes required to build and maintain a smooth surface (T. Wang et al., 2014).

Manzo and Salling (2016) note that for transport infrastructure projects, traditional evaluation frameworks commonly fail to provide a complete picture of environmental costs.

[W]hile the direct environmental costs, such as air pollution from vehicles operation, are normally included in the project evaluations, the indirect environmental costs, such as the energy and emissions associated with vehicle manufacturing, are usually not. (p. 274)

By contrast, a Life Cycle Assessment (LCA) considers the environmental impact of a given product or process throughout its lifespan. The Heavy Engineering Research Association (HERA) (sub. 96) recommended the use of LCAs:

When it comes to embodied energy and associated carbon footprint the application of Life Cycle Assessments (LCA) principles over the whole life of a product including its reuse, recycling or landfill option is in our view the appropriate pathway to describe environmental product performance. (HERA, sub. 96, p. 12)

Box 15.2 provides an overview of how LCAs are used in the planning stages of transport infrastructure in Norway.

Box 15.2 **Life-cycle emissions analysis for Norwegian transport infrastructure**

In Norway, life-cycle energy use and GHG emissions are always calculated as part of the CBA for transportation projects. GHG emissions are treated as an environmental cost in CBA, and GHG emissions caused by a project are calculated using the unit price for carbon dioxide equivalent (CO₂e). Life-cycle energy use and subsequent GHG emissions are quantified using a life-cycle methodology that assesses the direct energy use and GHG emissions from traffic, and the direct and indirect energy use and GHG emissions related to the construction, operation and maintenance.

Source: Miliutenko et al. (2014)

Sustainable procurement

Including environmental objectives in procurement decisions is often referred to as *sustainable public procurement*, although other terms such as green purchasing, environmentally preferable purchasing, or socially responsible procurement are sometimes used interchangeably (United Nations Environment Programme, 2017).

Auckland Council (sub. 97) and Waikato Regional Council (sub. 48) noted the influence of public spending and the potential benefits associated with sustainable public procurement.

[M]any business-as-usual decisions have an emissions impact and reduction potential. In particular, public spending wields enormous purchasing power to influence supply chains and to achieve multiple benefits through sustainable public procurement (SPP). Positive social results from SPP include poverty reduction, improved equity and respect for core labour standards, while allowing governments to improve resource efficiency, support waste minimisation and achieve emissions reduction. (Auckland Council, sub. 97, pp. 16–17)

One area where the national transition to a low-emissions economy can occur is through the government procurement opportunities. Procurement that respects the prudential responsibilities with using public funding can be directed towards purchasing low-emission infrastructure and process related goods and services that take account of life-cycle greenhouse gas emissions. (Waikato Regional Council, sub. 48, p. 8)

Several other submitters to this inquiry also identified the influential role of public procurement in supporting lower-emissions products and services generally (Christchurch City Council, sub. 13; LGNZ, sub. 36; Contact Energy, sub. 29), in the uptake of electric vehicles (Guardians of New Zealand Super,

sub. 32; Motor Industry Association, sub. 51), and to stimulate the development of low-emissions technologies (Export New Zealand, sub. 91).

Box 15.3 sets out an example of how sustainable procurement is used in the Netherlands to reduce the carbon footprint of infrastructure investments.

Box 15.3 Sustainable public procurement in the Netherlands

The Department of Public Works of the Dutch Ministry of Infrastructure and the Environment (Rijkswaterstaat, or RWS) has developed an approach to encourage people to minimise environmental impacts related to infrastructure building. RWS tenders combine two sustainability criteria.

- Companies are rated on a scale of one to five on the basis of energy savings, efficient use of materials and use of renewable energy. Contractors that score favourably on this rating benefit from a discount applied to their tendering price (between 1% and 5%).
- The Sustainable Building Calculator (Dubocalc) is provided to tenderers to assess the environmental impacts of the use of materials specified in a contract. The costs are derived from an authoritative life-cycle analysis of materials (from extraction to demolition and recycling), including CO₂ emissions and ten other impacts. The aggregate environmental cost is translated into a monetary value that is combined with the tender price to award the contract.

Source: Baron (2016).

Effective emissions prices are essential for sustainable infrastructure procurement

Chapter 4 finds that New Zealand's emissions price will need to rise significantly over the next few decades in order for New Zealand to make a significant reduction in domestic emissions. Importantly, New Zealand's Emissions Trading Scheme needs to be accompanied by stable and credible climate policy (Chapter 7).

The NZ ETS should establish an emissions price at a level that reflects the harm from emissions. As part of investment decisions, Government agencies responsible for investment in long-lived infrastructure would be expected to factor this price into investment decisions and consider likely changes in the price of carbon over the life of infrastructure assets.

15.5 Conclusion

Buildings and infrastructure are relatively minor contributors to New Zealand's total emissions. Emissions are generated throughout the life-cycle of buildings and infrastructure including emissions embodied in the production of building materials and building processes; and emissions generated through operation, maintenance and end-of-life disposal. Options to reduce emissions from the built environment are limited by the fact that most buildings and infrastructure are already in place and have long life-spans. But on the contrary, any emissions in new buildings or infrastructure are locked-in for a long time.

The introduction of an effective emissions price, coupled with stable and credible climate policy, is critical in encouraging the adoption of low-emissions buildings and infrastructure. This will encourage the development and adoption of low-emissions building materials and incentivise building design that uses fewer materials or recycles parts of existing buildings. There is not a good case to mandate specific low-emissions materials or building techniques in the New Zealand Building Code.

An effective emissions price will also strengthen the case for astute infrastructure asset management, including maximising the life-span of existing assets, and factoring current and likely future carbon prices into any new investment decisions.

New Zealand's low-emissions electricity system and abundant untapped sources of renewable electricity, means that improving the energy efficiency of buildings does not hold the same importance in an emissions mitigation strategy as it does in other countries. However, electricity generation still generates emissions, primarily through the use of coal and gas-fired stations to meet peak demand – much of which is generated

by residential electricity use in winter mornings and evenings. Government should continue policies and initiatives that encourage energy efficiency improvements to New Zealand buildings – particularly those that reduce electricity use during periods of peak demand. These policies should be complimented by the introduction of an effective emission price and more cost-reflective electricity pricing.

The nature of urban environments can also affect emissions – in particular, transport emissions are lower in cities that facilitate lower levels of private vehicle travel. Many inquiry participants advocated for the use of urban planning policies to encourage more compact urban development as this can reduce vehicular travel and emissions. But to make a meaningful emissions reduction, density needs to increase significantly, and occur in tandem with other changes such as improved public transport and accessibility to employment and other travel destinations. Compact urban form of this nature has proven difficult to accomplish in many of New Zealand’s major cities and runs counter to the living preferences of many New Zealanders. Further, urban planning policies are likely to take many years to achieve significant increases in density. By then, reductions in vehicle emissions may have already been achieved as a result of advances in low-emissions transport such as electric vehicles.

Part Five:

Achieving a low-emissions economy

Through Parts One to Four of this report, the Commission has explored the key opportunities and risks for New Zealand in making the shift to a low-emissions economy, and possible pathways for this transition. Additionally, it has recommended a comprehensive set of policies and institutions to drive emissions reductions while improving incomes and wellbeing.

Part Five summarises the key themes, insights and recommendations from the report.

16 Achieving a low-emissions economy

This inquiry focuses on how to maximise the opportunities and minimise the risks of transitioning to a low-emissions economy. The Commission has explored these opportunities and risks at multiple levels, including sectors, population groups and over different time horizons. But the main risk, and the chief barrier to New Zealand grasping opportunities from change, is very human and institutional and is the same for all countries – namely, the difficulties people face in making decisions in an environment characterised by deep uncertainty about what the future will hold. The reforms recommended in this draft report address this problem through a package of measures aimed at promoting consistent but flexible policy over time, providing clear signals for investment and behaviour change, and filling any remaining gaps through complementary interventions, investments and regulations.

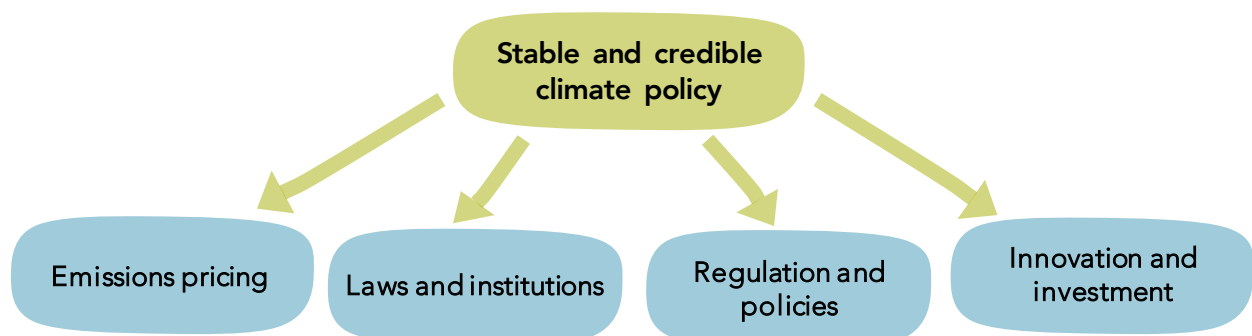
16.1 Overcoming myopia and managing uncertainty

New Zealand has had climate change policies in place for some time but these have not generated the required action to lower emissions. Without durable and ambitious policies, the signals for firms and households to move their production and consumption towards less emissions-intensive options remain weak.

The private sector and civil society must be able to plan and take long-term decisions with confidence. Businesses, households and consumers will be better able to manage the risks of moving to a low-emissions economy and plan for the behavioural and structural changes required in a stable and credible policy environment. The recommendations in this report are designed to provide the enabling environment, which will shape the incentives on producers and consumers, to reduce emissions. They include measures that:

- send a **strong signal** from the Government making a long-term commitment to the transition to a low-emissions economy and providing transparency about future policy intentions to achieve this;
- get **emissions pricing** right, to send the right signals for investment and mitigation;
- create **laws and institutions** that support stable policy settings, with clear targets and accountability for action, and that act as a commitment device for future governments to continue the development and implementation of a long-term policy response to climate change;
- ensure other **supportive regulations and policies** are in place, to address non-price barriers, encourage the transition, and manage serious adverse impacts on lower-income households and affected businesses;
- harness the full potential of **innovation** through significantly more Government resources devoted to supporting research, and the deployment and adoption of low-emissions innovations; and
- support **investment** in low-emissions technology, infrastructure, and other activities, through greater transparency and by mobilising new sources of finance.

Figure 16-1 Achieving a low-emissions economy



16.2 Getting emissions pricing right

An emissions price is the price an emitter pays for each unit of GHGs they release to the atmosphere. Properly designed and implemented, emissions pricing is a powerful policy instrument to reduce emissions. A single emissions price provides a strong incentive to reduce emissions at least cost. It decentralises decisions to invest, innovate and consume across the economy to people who have the best information about opportunities to lower emissions given their circumstances. An emissions price is also pervasive through the whole economy – shaping resource and investment decisions across all emitting sectors and sources. Ensuring that emissions are appropriately priced is an essential step in New Zealand’s approach to climate-change mitigation.

Several tools exist to apply emissions pricing – including taxes, market-based schemes such as ‘cap and trade’, and hybrid combinations – and each tool can be designed in a variety of ways. For the purposes of credibly moving towards a low-emissions economy, gaining certainty over the quantity of emissions that will be permitted is vital. The Commission considers that the New Zealand Emissions Trading Scheme (NZ ETS) should remain the centrepiece of New Zealand’s emissions reduction efforts as it has the potential to provide this much-needed policy certainty. However, the NZ ETS needs to be made credible and effective.

Higher emissions prices, and greater clarity about future prices, are needed

The emissions price created through the NZ ETS needs to rise considerably. Modelling undertaken for the Commission and other available evidence suggests that New Zealand’s emissions price will need to rise to at least \$75 per tonne of CO₂ equivalent (CO₂e) and possibly over \$200 per tonne over the next few decades to achieve the domestic emissions reductions needed to meet New Zealand’s international commitments. Robust and transparent domestic caps on the supply of New Zealand Units (NZUs) (one NZU is a permit to emit one tonne of CO₂e) are needed to drive a higher emissions price to materially influence production and consumption decisions.

Expectations about future emissions prices are important for driving investment in new technologies. To ensure clear and credible investment signals, the Government should introduce mechanisms that provide guidance about the path of future emissions prices. Key steps include setting rolling five-year forward caps for the NZ ETS, to provide certainty about the supply of NZUs. A second important step will be auctioning NZUs to achieve the cap but with mechanisms to discourage prices from moving outside of a wide band. There will be movements in NZU prices to which market participants will respond. These movements will be influenced by the supply of units in the market, which the Government has some control over, but also other influences such as technological changes, over which it has little control. The wide bands proposed should have the effect of limiting “noise” from short-term volatility.

Land-use change, agriculture and emissions pricing

Land use will need to change substantially if New Zealand is to transition to a low-emissions economy. In particular, modelling undertaken for the Commission indicates that land planted in forests will need to increase by between 1.3 million and 2.8 million hectares, mostly converted from marginally profitable beef and sheep farms. Growth in horticulture (from a relatively small base) could also play a significant role in reducing agricultural emissions. The needed rate of land-use change is comparable to the rate at which, over the last 30 years, beef and sheep farming converted to forestry, dairying and other uses.

Opportunities to reduce agricultural emissions, particularly from dairying, will also be important. Scope exists for further modest reductions in emissions intensity, through higher productivity and wider adoption of current low-emissions practices. Research into new technologies has the (uncertain) potential to further reduce agricultural emissions over the medium to long term. Yet the potential payoff to successful research justifies scaling up current efforts.

An emissions price that covers all land use, including agriculture, should become the main driver of land-use change. A well-designed and stable NZ ETS will incentivise land-use change, including more afforestation, as well as a search for, and adoption of, low-emissions practices and technologies in agriculture. To reflect the trade-exposed nature of the sector and current technological limits, the entry of agriculture into the NZ ETS should be supported with free allocation of NZUs for a transitional period.

The Government can best support the rural transition through ensuring emissions-pricing policy is stable, with a measured phase-out of free allowances for agricultural producers. This will improve incentives for adjustment and help avoid significant economic and social dislocation in the transition to a low-emissions rural economy over the next three decades.

16.3 Stable and enduring laws and institutions

New Zealand has lacked clear and stable climate-change policies. This lack of clarity and political agreement about longer-term goals has weakened incentives for change and undermined confidence in existing policies.

If firms and households are to invest in low-emissions technologies, they need confidence that their returns will not unnecessarily be put at risk. Stability and confidence about longer-term objectives and policy settings are therefore a critical foundation to promoting the transition to a low-emissions economy. At the same time, governments will need to have policy flexibility in how they deliver on these longer-term objectives, especially as new technologies emerge that can lower emissions or remove them from the atmosphere. The Commission considers that this balance of stability and flexibility would best be provided through the following legislative and institutional changes.

- Legislated and quantified long-term GHG emissions-reduction targets, to clearly signal the direction of policy travel. Targets should be informed by science, which is central to the credibility of the statutory and institutional framework surrounding climate-change.
- A system of successive “emissions budgets” to translate long-term emission-reduction targets into targets that are clear in the short-to-medium-term. The budgets provide visible stepping stones to achieving the long-term targets and help reinforce steady action on, and accountability for, achieving them. The emissions budgets would also guide the determination of caps in the NZ ETS.
- An independent expert advisory body (a Climate Commission) to provide objective analysis and advice to the Government on the scale of emissions reductions required over the short to medium term (ie, by recommending emissions budgets) to meet long-term targets, reflecting scientific evidence as well as considerations of economic and social impacts. A Climate Commission might also identify regulatory and other barriers or opportunities and priorities to reduce emissions, and will regularly assess New Zealand’s progress towards meeting agreed budgets and targets. Effectively, a Climate Commission would be the custodian of New Zealand’s climate policy and long-term climate-change objectives.
- A statutory obligation on the Government to prepare and publish in a timely manner a long-term, economy-wide, low-emissions strategy in response to the Climate Commission’s recommended emissions budget. This would detail the regulatory, fiscal and other policy actions that it would take to reduce national emissions. Importantly, the Government would retain the right to decide how it responded to the Climate Commission’s advice. This reporting formality on the Government would drive coordinated and coherent policy responses to climate change and promote transparency and accountability. Designing and delivering a credible policy response will require some changes within government machinery to clearly allocate responsibilities and ensure ongoing coherence.

To have their full and desired effect on national emissions levels, the Commission believes these institutional and statutory features will need to obtain broad and enduring political support. Ongoing leadership will also be needed to navigate the long and uncertain journey to a profoundly different low-emissions future.

This report also recommends that mitigation targets should clearly distinguish between short-lived and long-lived GHGs (although there should be a single cap within the NZ ETS). Emissions of some gases (such as CO₂) can stay in the atmosphere for centuries. Emissions of long-lived GHGs must be reduced to net-zero at a minimum. Other GHGs (such as methane, CH₄) dissipate comparatively quickly. They will need to reduce, but not to net-zero, to stabilise temperature.

16.4 Supporting regulation and policies

While stable policy and emissions pricing are needed to change behaviour and promote investment, the Commission finds that these measures will not be sufficient on their own to promote a fair and efficient transition, nor maximise the opportunities from this transition for New Zealand. A range of complementary regulation and policies are needed to support the creation and use of mitigation technologies, assist behaviour change by firms and households, and manage risks.

Transforming New Zealand's vehicle fleet

New Zealand's transport system is dominated by private road transport. Compared to other developed countries, vehicle ownership rates are high, public transport use is low, and the vehicle fleet is old with poor fuel economy. Rapid population growth along with a decline in prices for fossil-fuel vehicles has been associated with a rapidly expanding light-vehicle fleet.

Consequently, transport is one of the largest and fastest-growing sources of emissions in New Zealand. Transport is also a sector where lower-emissions alternatives to fossil-fuel vehicles are both available (eg, public transport, active transport, trains) and emerging (eg, electric and other low-emission vehicles). Further, the transport sector has scope to improve the efficiency of vehicle use (eg, through congestion charging).

Electric vehicles (EVs) offer some of the most promising mitigation opportunities for New Zealand, but their uptake faces several barriers such as high prices relative to fossil-fuel vehicles, anxiety about their limited travel range, and poor public understanding of their benefits. The Government can offset some of these barriers by:

- introducing a "feebate" scheme, through which importers would either pay a fee or receive a rebate, depending on the emissions intensity or fuel efficiency of the imported vehicle;
- providing funding support for EV infrastructure projects, to fill gaps in the charging network that are commercially unviable for the private sector; and
- raising awareness and uptake of low-emissions vehicles through leadership in procurement.

For the bulk of light vehicles to be electric by 2050, nearly all vehicles entering the fleet would need to be EVs by the early-2030s. Yet, even with a rapid uptake in electric and low-emissions vehicles, fossil-fuel vehicles are likely to make up a significant share of New Zealand's private vehicle fleet for some time. To help reduce emissions from these sources, the Commission recommends that imports of new and used fossil-fuel vehicles be required to meet rigorous emissions standards. New Zealand is one of a handful of developed countries without vehicle emissions standards, and risks becoming a dumping ground of high-emitting vehicles from other countries that are decarbonising their fleets. The Commission is also seeking feedback on whether further steps are needed, such as phasing out all fossil fuel vehicle imports by a specified date.

For heavy vehicles, aviation and shipping, electrification is more challenging. Hydrogen vehicle technology is developing and could provide a useful alternative to EVs. Biofuels also have the potential to deliver significant emissions reductions for these modes. Yet, commercial, technology, and coordination barriers pose challenges to the large-scale production of biofuels. A higher emissions price in the NZ ETS would create a greater incentive to develop and then switch to biofuels.

Land transport policy in recent years has prioritised roads over other options. There are restrictions on the types of transport that can receive funding from the NLTF and different methods are used for assessing the value of different transport modes. Future land transport policy should put emissions-reduction goals more centrally in government planning, adopt a more mode-neutral approach to assessing and funding new projects, and make greater use of demand-management techniques such as congestion pricing.

Accelerating afforestation

Afforestation has a critical role (though only over the short-to-medium term) to play in moving towards a low-emissions economy. Significant new forest planting is needed for New Zealand to reduce its net emissions at a lower emissions price than would otherwise be the case. Policy and regulatory settings need adjustment if these ambitious afforestation goals are to be feasible.

Higher NZ ETS prices will encourage more planting but alone they may not be sufficient to mobilise the scale of investment required. The administration of the NZ ETS needs to be simplified to make it easier for forest owners to take part, and to provide recognition for carbon sequestered in harvested wood products. Only a minority of eligible forest owners currently participate in the NZ ETS, as many find participation too costly and risky compared to the benefits of earning NZUs. The amount and pace of new planting required is beyond what New Zealand has experienced over the past 30 years.

Balancing cost, emissions reductions and adequacy in electricity supply

An efficient and well-functioning electricity system will play a central part in the transition to a low-emissions economy. New Zealand's largely decarbonised electricity sector is a major advantage, and considerable scope exists to further increase the supply of electricity from renewable sources, such as wind (the cost of which has been falling rapidly) and geothermal energy (which still produces some emissions). This will create opportunities elsewhere in the economy to replace the use of more emissions-intensive energy sources.

Trade-offs exist between cost, emissions and adequacy in the electricity system. No options currently exist for completely eliminating emissions from electricity generation without creating significant challenges elsewhere. For example, substantially reducing emissions by removing thermal generation would increase costs and reduce security, especially during peaks of demand or shortfalls in hydropower supply ("dry year shortfalls"). If costs are pushed too high, this could discourage other sectors in the economy from shifting away from fossil fuels. Yet, technological development should see cheaper low- or no-emissions generation options emerge over time. By 2050, economic options such as in tidal or biomass generation, or carbon capture and storage (CCS), may have emerged. The price of wind power may also fall to the point where holding surplus renewable generating capacity is an efficient option for reducing the need for thermal generation. On the demand side, evolving technology will enable better management of peaks and incorporation of distributed energy resources (eg, solar, wind and batteries).

Given technological uncertainty and the importance of electricity prices for the adoption of low-emissions technologies in other parts of the economy, the Government should not favour particular electricity generation technologies. It should also be cautious about setting stringent targets for electricity-sector emissions before technology becomes available to further reduce emissions at reasonable cost. The Government should, instead, through the NZ ETS, rely mostly on effective emissions pricing to guide investment in new electricity generation.

As the share of electricity generated from distributed sources increases and demand is more responsive, additional steps may be needed to manage growing complexity and risks to system stability, and ensure a level playing field for different types of service providers. In particular, the regulatory framework governing the electricity market should be updated to allow consumers to become more informed and active buyers and sellers of electricity.

Better pricing and controlling waste emissions

New Zealand has the highest waste emissions per person among countries in the OECD. A higher NZ ETS price should encourage greater efforts to reduce GHG emissions from waste. However, only around one-third of waste emissions are covered by existing waste management or climate change policies. The waste disposal levy should be extended to all known solid waste sites and increased over time to encourage better waste management. Local authorities should also be given greater support to regulate farm dumps and other unknown waste disposal sites, such as through the Resource Management Act and Waste Minimisation Act.

Ensuring regulation supports, rather than frustrates, the transition

Regulation is a pervasive feature of modern life and can either support or frustrate the transition to the low-emissions economy. The Commission identified areas where regulatory reform may be needed to remove barriers to the transition or maximise opportunities to reduce emissions.

- Carbon capture and storage is a rapidly-evolving technology that is potentially significant for reducing the stock of emissions in the atmosphere. Whether and when CCS will become viable in New Zealand is unclear, but current regulatory frameworks are not adequate for managing the risks associated with CCS (such as leakage of carbon from underground storage facilities) or providing sufficient rewards (eg, recognition of CCS activities not linked to industrial processes). New legislation should be drafted to provide better control of CCS and set New Zealand up properly to maximise the possible benefits from the technology.
- Milk processing is one of the most significant sources of process-heat emissions. Under current legislation, Fonterra must accept all supply from shareholders regardless of its impact on the company's or national emissions. The Commission seeks feedback on whether giving Fonterra discretion to refuse new supply where this could inefficiently increase the use of fossil fuels in milk processing would produce a net benefit.
- The Building Code should not present barriers to building technologies and materials with lower embodied emissions. Forthcoming reviews of the Building Code should assess how much the Code enables the adoption of low-emissions construction and materials.

Support for households facing significant transition costs

The mitigation policies recommended in this report could increase the costs of household energy, food and transport. The adverse impact of such increases on the real incomes of vulnerable households can be offset through the tax and welfare system. Existing policies, such as tax credits and benefits, should be adequate to compensate lower-income households for these increased costs, provided both are regularly adjusted in line with inflation. Interventions to raise the quality of rental housing would provide health benefits and create opportunities for lower-income households to substitute away from the use of fossil fuels for heating.

Interventions that respond to significant shocks to communities resulting from emissions-reduction policies (eg, the loss of a major employer) should:

- focus on the labour-market and skills needs of people; and
- target people who will have the most difficulty gaining new employment.

The Commission has previously found that the current education and training system needs reform, as it is not well structured to meet the needs of people seeking mid-career retraining.

16.5 Harnessing the full potential of innovation and investment

New Zealand is already actively involved in research and international efforts to lower agricultural emissions and it could make a valuable contribution to other countries' work to mitigate climate change and raise agricultural productivity. An increasing number of "clean technology" firms are emerging in New Zealand. Innovation policies and processes should give greater attention to these areas, in particular by giving current innovation institutions – such as Crown Research Institutes and Callaghan Innovation – clear mandates and funding to support these opportunities.

The inquiry has found fragmentation and weaknesses in the national innovation system. Government investment in science and innovation to support a transition to a low-emissions economy currently lacks a clear strategic focus and priority commensurate with the imperative to be successful in achieving the objective and to take bold action. Current investments are also inadequate in size and scope.

New Zealand should establish the transition to a low-emissions economy as a high priority within its national innovation system recognising the importance of that goal and that it will require extensive economic

transformation and restructuring. The Government should provide major public backing and funding support for innovation and technology adoption so they can play a central role in the transition, alongside effective emissions pricing. The Government should also take steps to strengthen the weaker parts of the national innovation system (such as its objectives, identification of innovation opportunities and knowledge transfer and sharing) and align the various complementary parts so they work well together. The scope should include not only science and research, but broader innovation, knowledge dissemination and learning, skills, infrastructure, regulation and finance.

New Zealand retains several policies that subsidise the ongoing use of fossil fuels, such as concessionary tax deductions for petroleum-mining activities or research and development funding for the oil industry. These policies run counter to the goal of reducing national GHG emissions and should be abandoned.

Mobilising capital towards low-emissions investments

Transparency of climate risk is fundamental to grow and redirect the investment needed to enable the transition to a low-emissions economy. Without the correct information, investors may incorrectly value assets or investment opportunities, resulting in misdirected finance or stranded assets. The Government can help to encourage disclosure of climate risk by officially endorsing the recommendations of the Task Force on Climate-related Financial Disclosures. It should work to integrate these recommendations into existing government-mandated reporting requirements.

Other actions for Government include targeted grants and loans (which can play an important catalytic role in reducing market risk for the development and deployment of low-emissions technology), and further elaboration of the details of the proposed Green Investment Fund. Other opportunities are less clear-cut. Feedback is sought on whether the New Zealand Venture Investment Fund should identify low-emissions investments as a sector of interest.

The Government should develop a low-emissions investment strategy for New Zealand. A strategic view across public-sector interventions is important to accelerate progress in a coordinated and non-duplicative manner. Further, a strategic view provides clarity about the role of government at different phases of the transition.

16.6 New Zealand will look quite different in 2050

An effective transition to a low-emissions economy will mean that New Zealand will look quite different in 2050. During the transition, action to mitigate GHG emissions will require real and significant changes. Those changes will have disruptive impacts on some businesses and households. Yet, as modelling undertaken by the Commission has shown, many pathways to a low-emissions economy are possible, and many factors could affect the rate and scale of change.

This report has been concerned with how governments can establish the conditions – institutions, laws, prices, policies and regulations – that will encourage the shift to a low-emissions economy and ease the frictions – economic and social – that can accompany such change (Figure 16.2).

The Commission has found that significant local co-benefits can also be expected from reducing emissions in the New Zealand's economy.

- The air will be cleaner, leading to reduced rates of illness and mortality caused by air pollution. Pollutants from fossil-fuel vehicles (particularly those that run on diesel) are associated with respiratory illnesses such as asthma, impaired lung development and function and heart, brain and general health issues. A shift to a low-emissions vehicle fleet would remove these pollutants.
- Water will also be cleaner, reducing harm to biodiversity. As an emissions price is progressively extended to agriculture and farmers take greater steps to use nitrates effectively, water pollution will reduce. Greater afforestation could also help reduce soil erosion and the resulting siltation of waterways.
- The emergence of new technologies and firms, will provide opportunities for employment, exports and productivity gains. A higher emissions price will foster greater demand for emissions-reducing technologies. A reinvigorated and refocused innovation system will put more effort into developing and

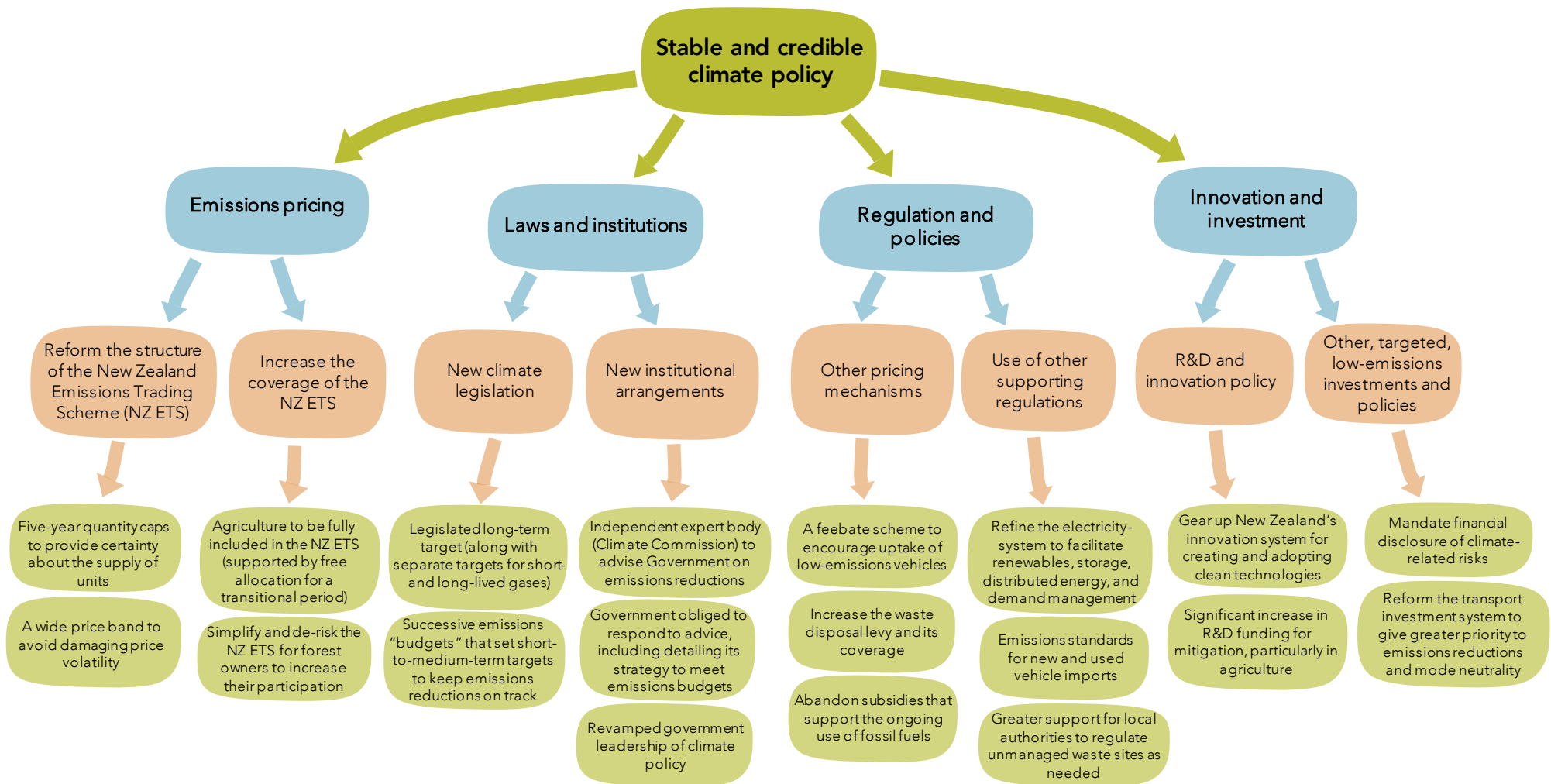
applying new ideas that offset, reduce or remove GHGs. New Zealand has already proven a fertile ground for developing such technologies, and scope exists to considerably expand New Zealand's contribution to global knowledge.

16.7 Finalising the Commission's advice

The analysis contained in this draft report leads the Commission to conclude that while the challenges of achieving a low-emissions economy are large, they are not beyond the will or ability of communities to respond. New Zealand has experienced many economic transformations before, and the scale of change involved in the transition to a low-emissions economy is not necessarily larger than transitions that have occurred before. New Zealand can make economically and environmentally-significant change if it has the right institutions and policy settings in place and the journey is embarked upon without delay.

The recommendations outlined in this report are intended to promote debate and discussion, as well as policy change. The Productivity Commission is keen to hear feedback and receive evidence on its proposed changes to policy and regulation. A final report will be presented to the Government in the second half of 2018.

Figure 16.2 Achieving a low-emissions economy for New Zealand



Summary of questions

Chapter 6 – Investment

Q6.1

Should the investment policy of the New Zealand Venture Investment Fund be updated to identify low-emissions investments as a sector of interest?

Chapter 10 – Land use

Q10.1

What are the advantages and disadvantages of the following options for a point of obligation for agricultural emissions within the NZ ETS?

- Full processor level
- Full farm level, only including farms above a minimum size threshold. A point of obligation at the processor level could be used for farms beneath the threshold and for all horticulture and cropping
- Farm level for dairying, only including dairy farms above a minimum size threshold; processor level for sheep and beef cattle (and other livestock) farming, and for horticulture and cropping.

What other point of obligation approaches should the Commission consider?

Q10.2

With developing technology and aggregation for accounting purposes, is it technically feasible and would it be cost-effective to include small areas of planting (such as riparian planting) within the NZ ETS?

Chapter 11 – Transport

Q11.1

How could New Zealand signal a commitment to a widespread transition away from fossil-fuel vehicles? For example, should New Zealand explicitly aim to phase out the importing of fossil-fuel vehicles by some specified future date?

Q11.2

Should a price feebate scheme cover vehicles within the heavy vehicle fleet? What other policies are appropriate for incentivising the uptake of low-emission heavy vehicles?

Chapter 12 – Electricity

Q12.1

Does decision making under the Resource Management Act 1991 unduly constrain investment in renewable electricity generation, particularly wind and hydro generation? In what ways could the National Policy Statement on Renewable Electricity Generation 2011 be strengthened to give clearer direction to regional, district and unitary councils to make provision for renewable electricity generation in their regional and district plans, regional policy statements and resource management decisions?

Chapter 13 – Heat and industrial processes

Q13.1

Would giving Fonterra discretion to refuse milk supply where this would lead to inefficient land use and/or a significant increase in the company's GHG emissions provide any benefit? What, if any, conditions would need to be attached to the exercise of such discretion?

Q13.2

Does New Zealand need to amend its cement standards to permit greater use of lower-carbon components?

Q13.3

Do any New Zealand-specific factors exist that would make the use of lower-carbon cements and concretes unsuitable (eg, seismic or other geographic conditions)?

Q13.4

Would a higher effective emissions price be sufficient to encourage greater use of lower-carbon cements? Would doing so require more active government policy (such as procurement standards and targets)?

Chapter 14 – Waste

Q16.1

Should the New Zealand Emissions Trading Scheme be extended to cover wastewater treatment plants?

Findings and recommendations

The full set of findings and recommendations from the report are below.

Chapter 2 – Climate change, emissions and the New Zealand context

Findings

F2.1

As a small country, New Zealand's absolute contribution to global emissions is small. However New Zealand's per person emissions are one of the highest among developed countries.

F2.2

New Zealand is yet to see a sustained decline in its emissions. Gross and net emissions have flattened over the last decade after steadily increasing before the mid-2000s. In contrast, most other developed countries have lowered their emissions.

F2.3

Agriculture makes up nearly half of New Zealand's emissions – more than any other developed country. Transport is the next largest source, contributing about a fifth of emissions. Electricity emissions are relatively low in New Zealand due to the country's abundant sources of low-carbon, renewable energy.

F2.4

Forestry offsets just under one-third of New Zealand's gross emissions. Yet, because planting rates have dropped sharply since the planting boom in the 1990s, and many of these forests are shortly due for harvest, carbon offsets from forestry are likely to decline without a significant increase in planting.

F2.5

New Zealand's emissions profile differs markedly to other developed countries, because of its high agricultural emissions and low electricity emissions. While carbon dioxide is New Zealand's most prominent greenhouse gas, over half of emissions are methane and nitrous oxide.

F2.6

Transport has been by far New Zealand's fastest growing emitting source, in absolute terms, followed by nitrous oxide emitted from soils. Strong growth in emissions from dairy farming was partially offset by a fall in emissions from sheep and beef farming. Because of the large growth in transport emissions, carbon dioxide emissions have risen much more than methane and nitrous oxide.

F2.7

Economic and population growth have been important underlying factors in New Zealand's rising emissions. Over the last 25 years, New Zealand's emissions per person and emissions per unit of output have decreased, but the increase in population and output has caused overall emissions to increase.

F2.8

New Zealand is on track to meet its 2020 emission-reduction target. However, its first target under the Paris Agreement for 2030 will be far more challenging to achieve. New Zealand's net emissions are projected to rise in the early 2020s, due to a decrease in forestry offsets.

F2.9

Achieving either New Zealand's current 2050 emissions-reduction target or a more ambitious emissions-reduction target requires a substantial and sustained shift in the trajectory of its emissions compared to past trends. If the Government adopts a more

ambitious long-term target, there is a good case for revising New Zealand's current 2030 target under the Paris Agreement.

Chapter 3 – Mitigation pathways

Findings

F3.1

The modelling depicts, in a stylised manner, three possible ways that low-emissions technologies could develop. First, they could fail to develop or develop only slowly. Second, they could develop faster in ways that disrupt existing industries. Third, they could also develop faster but lower the emissions intensity of existing industries. The differences between these scenarios are profound and fundamental to New Zealand's future as it seeks to transition to a low-emissions economy.

F3.2

New Zealand's transition to a low-emissions economy will be a long journey to a known and desired destination but through very uncertain terrain. It would be foolhardy to try to pin down the best route for this 32-year journey to 2050 in advance. Rather, the situation calls for careful preparation, a capability for adaptation, and a balance between responsiveness to new information and policy stability. This approach will best equip the country to deal well with whatever terrain emerges.

F3.3

Modelling indicates that New Zealand can achieve low GHG emissions by 2050. A pathway relying on a combination of three key drivers – the expansion of forestry, the electrification of transport, and changes to the structure and methods of agricultural production – could see New Zealand reduce its emissions to 25 Mt of CO₂e at an emissions price rising to between \$75 a tonne (t) of CO₂e and \$152/t of CO₂e by 2050. New Zealand could reach net-zero emissions by 2050, with emissions prices rising to between \$157/t of CO₂e to \$250/t of CO₂e by 2050.

F3.4

Land-use change varies across the six modelled pathways. Forestry land expands greatly across the six pathways while land for sheep and beef farming declines. Land for dairy farming increases under those pathways that see the development of a methane vaccine and falls in the other pathways. Without the methane vaccine and with disruptive advances in plant-based meat and dairy substitutes, land for horticulture (and cropping) is likely to expand.

F3.5

Modelling indicates that New Zealand has the potential to decarbonise towards net-zero GHG emissions at emissions prices which, although much higher than the \$21 a tonne of CO₂e prevailing in early 2018, would be comparable to the prices expected to be needed in other developed countries to reduce emissions to levels consistent with the Paris Agreement ambition of keeping global temperature rise to below 2°C.

New Zealand's potential to achieve this goal stems from a confluence of factors, most notably the potential for significant increases in afforestation and its low-emissions electricity system facilitating the cost-effective uptake of electric vehicles.

F3.6

All the modelled pathways show that the reductions in net GHG emissions come mainly from the forestry, agriculture and transport sectors. New Zealand's decarbonisation strategy should therefore focus on these opportunities. The dependence on forestry sequestration is particularly strong in the case of the target of net-zero GHG emissions by 2050.

F3.7

While afforestation provides plenty of scope for reducing emissions cost-effectively in the short term and medium term, it is unlikely to continue to do so in the longer term since achieving such reductions would entail planting more and more land in trees. New Zealand will need to make additional cuts in gross emissions in the longer term. Such cuts will be costly in the absence of technological breakthroughs.

Chapter 4 – Emissions pricing

Findings

F4.1

Carbon taxes and emissions trading schemes (ETSs) are different forms of emissions pricing that have much in common. Each is a potentially powerful instrument that can act across the economy in a decentralised manner to reduce greenhouse-gas emissions at least economic cost.

Yet, carbon taxes and ETSs also have important differences such as whether the emissions price is fixed and the quantity of emissions is uncertain or vice versa. These differences bear on the decision about whether New Zealand should adopt a carbon tax or an ETS as the centrepiece of its transition to a low-emissions economy.

F4.2

The additional benefits of emissions pricing using a carbon tax rather than an ETS would have to be large to outweigh the significant cost of dismantling the NZ ETS and setting up and becoming familiar with a new system. While the two instruments are similar in many ways, a reformed NZ ETS is likely to perform better given that New Zealand has an established ETS and has an urgent need for substantial domestic emission reductions to achieve its targets.

F4.3

Both an ETS and an emissions tax can be designed to protect emissions-intensive, trade-exposed (EITE) firms from emissions leakage by allocating free emissions units or a level of tax exemption to the firms. New Zealand's method of allocating units incentivises firms to reduce their emissions intensity but not reduce emissions through reducing output. Free allocation costs the government revenue. The case is strong to withdraw the free allocation of units to EITE firms over time as competing firms in other countries also face emissions pricing.

F4.4

A carbon tax or auctioning permits (emission units) in an ETS can enable a government to raise potentially large amounts of revenue. Several legitimate options are available to the government to decide how it spends this revenue. Those options include reducing distortionary taxes, investing in specific initiatives to enable emissions reductions at lower cost, and supporting vulnerable households, communities and businesses.

F4.5

Because decisions that impact on GHG emissions often involve a planning horizon of many years, the stability of policy settings and institutional arrangements for emissions pricing is vital. If the stability of policy settings is uncertain, or confidence in them is lacking, then potential investors will hold back from investing to lower their emissions.

F4.6

The choice between abating domestically and through purchasing emission reductions from other countries must be carefully weighed. When international credits are of a high integrity, investing in reductions overseas may provide a way to deliver global emissions reductions at lower cost to New Zealand. Even so, comparing international and domestic abatement costs must be done correctly in terms of capital costs, reputation costs, co-benefits, and future opportunities.

F4.7

An ETS is a better emissions-pricing mechanism to incentivise forestry than a carbon tax. Unless supplemented by a sequestration subsidy, a carbon tax cannot incentivise carbon sequestration. The two would have to work in harmony to mimic the acquisition and relinquishing of units under an ETS, but with no ability for forest owners to bank units as a hedge against future price uncertainty.

F4.8

The point of obligation to pay for emissions needs to achieve a good balance between broad coverage, low administration costs, and effective transmission of emission price incentives combined with effective monitoring, reporting, and compliance. Placing points of obligation upstream or downstream of actual emission sources (as well as at source) and using minimum-size thresholds may help to achieve the best balance.

F4.9

It is preferable to have a system in which emissions are priced at a level that reflects their harm, and will achieve New Zealand's emissions reduction targets. If, however, emissions prices are absent or too low, then a convincing case exists for governments to use a shadow price of emissions to guide their investment decisions.

F4.10

The co-benefits of mitigating GHG emissions can be substantial, such as better air and water quality. The co-benefits increase the value to society of reducing GHG emissions. Policy options that, in addition to emission pricing, could incentivise businesses and people to consider co-benefits include a separate tax or subsidy scheme, a separate permit scheme, direct regulation, or a shadow price in cost-benefit appraisals.

F4.11

The NZ ETS has been ineffectual to date in achieving domestic GHG reductions. The key reasons have been low emissions prices, mainly driven by openness to low international prices, sector exemptions, and policy uncertainty leading to business and investor uncertainties about future rules and prices.

F4.12

Some basic building blocks of an effective ETS are present in the NZ ETS, but lack of others has led to low prices and tepid responses from participants. As a result, the NZ ETS has not reduced domestic emissions or increased domestic removals to anything like the extent needed to achieve a significant reduction in New Zealand's domestic greenhouse gas emissions. A key problem is lack of certainty and credibility about future unit supply and the pathway to achieving New Zealand's long-term targets to meet its international commitments.

F4.13

Reforms of the NZ ETS are ongoing, but the features of the NZ ETS do not yet meet the criteria for a good system of emissions pricing. The further in-principle reforms announced in July 2017 would take the NZ ETS in the right direction, but are insufficient to provide strong or clear enough signals to participants, or to households, businesses and investors who are not direct participants.

F4.14

A well-crafted package of reforms is needed to fix the weaknesses in the NZ ETS that compromise its ability to deliver effective emissions pricing and New Zealand's emissions targets for 2021 to 2030 and beyond. The reforms need to provide a good balance between control over unit supply (ie, an effective cap) and protection against damagingly volatile emission prices. They also need to provide much-needed stability, transparency and forward guidance to support decision-making by investors to lower their net emissions.

F4.15

While risks exist in operating the NZ ETS with a price ceiling and a price floor, the consequences, were these risks to materialise, would be moderate and could be mitigated. The risks are not as serious as the risks of operating a pure ETS – from volatility in price that could impose high costs on emitters who have limited opportunity to adjust in the short term, dis-incentivise investments in low-emissions technology, and inhibit the impact of some supplementary policies.

F4.16

Substantial modelling and other evidence exists to indicate that emissions prices will need to rise far above their current levels if New Zealand is to decarbonise its economy over the next several decades. Even so, it is notable that emissions prices required to achieve a given emissions-reduction target will generally be lower:

- the better the potential for deploying innovative technologies to reduce emissions;
- the higher the credibility of signals about future emissions prices; and
- the greater the flexibility in the economy to re-allocate resources from high- to low-emitting activities and sectors.

F4.17

An effective system of emissions pricing should form the centrepiece of a strategy to reduce emissions. Yet the strategy needs other elements to back up pricing and take the lead in some situations where pricing is not powerful enough because of market or government failures, or distributional considerations.

Recommendations

R4.1

The Government should reform the NZ Emissions Trading Scheme rather than replace it with a carbon tax. The reforms should provide a good balance between control over unit supply (ie, an effective emissions cap) and protection against excessive volatility in the price of emission units. The reforms should also provide the institutional and regulatory underpinnings for a credible and efficient market in emission units, as well as transparency and forward guidance to incentivise long-term investments in lower emissions.

Chapter 5 – Innovation

Findings

F5.1

Innovation in clean technologies is a key enabler of transitioning to a low-emissions economy while growing incomes and wellbeing. Innovation is positively influenced by pricing emissions, by direct government support for low-emissions innovations, and support for its deployment and adoption. Innovation is discouraged by subsidies to emissions-intensive activities.

F5.2

Fossil fuel subsidies act in direct opposition to New Zealand's transition to a low-emissions economy. New Zealand provides approximately \$78-88 million per year worth of government support to fossil fuel production and consumption.

F5.3

The transition to a low-emissions economy will require policies that lean against path dependencies that can lock-in polluting technologies and patterns of production. These dependencies arise from market size, scale economies, the cumulative nature of

knowledge, network effects, sunk investments and political pressures from vested interests.

F5.4

A good low-emissions strategy needs both an effective emission price and support for innovation that creates, disseminates and deploys low-emission technologies. Relying on emissions pricing alone will require higher prices than otherwise needed, which, in turn, will likely impose unnecessary economic and social costs.

F5.5

Delay in supporting clean technologies is undesirable. The productivity gap between polluting and clean technologies will increase during the delay period and make the transition longer and costlier in terms of slower economic growth during the transition.

F5.6

Evidence indicates that policies to incentivise the development and uptake of clean technologies may be highly effective. Impacts can be both large and rapid and, as such, can help economies break from their existing high-carbon trajectories to low-carbon trajectories. Evidence also indicates that low-carbon innovations induce greater economic benefits through larger knowledge spillovers compared to innovations in mature high-carbon industries.

F5.7

The risks of harmful climate change are very serious. Yet the application of research and knowledge offers the prospect of substantially cutting GHG emissions. A convincing case therefore exists for government resources to target low-emission innovation as an exceptionally important part of a country's public funding for science and innovation.

F5.8

The effective creation and application of low-emissions knowledge and technologies depend on different facets of the national innovation system being present and working well together. The facets include:

- clear objectives;
- identification of innovation opportunities;
- domestic and international links between firms, investors, and researchers;
- timely provision of complementary infrastructure;
- adequate risk capital, management capability, skills and training; and
- flexible markets for resource reallocation from shrinking to growing firms and activities.

F5.9

Both the government and the private sector have important roles to play in a national innovation system geared to achieving a low-emissions transition. The government's role includes setting credible and transparent goals and policies, and enabling market forces to mobilise businesses to redirect resources from dirty technologies towards clean technologies. Clearly the government cannot, and should not, substitute for the market.

F5.10

Current government investment in science and innovation to support a low-emissions transition lacks a clear strategic focus and priority commensurate with the imperative to

succeed in achieving the objective, and to taking bold action. Current investments are inadequate in size and scope.

Strong support for innovation as part of an overall low-emissions strategy would be likely to:

- make more emission reductions possible at lower cost;
- lower the emissions price necessary for achieving target emission reductions;
- create economic opportunities in the form of attractive business investments, highly skilled jobs, and the potential for profitable export opportunities; and
- enhance New Zealand’s reputation internationally through developing innovative, low-emissions technologies that help the world as well as New Zealand to reduce GHG emissions.

F5.11

In many areas New Zealand will be a technology taker. From this follows the need for a capacity and resourcing to identify, absorb, adapt and deploy a wide range of technologies from offshore. At the same time, in areas relevant to New Zealand’s emissions profile, and areas of existing research strength in climate mitigation, the country should invest in the full menu of basic and applied research, commercialisation, infrastructure and skills.

F5.12

“Absorptive capacity” is the capacity of firms to learn by using knowledge from their external environment. It appears to be a key driver of a firm’s ability to accumulate knowledge assets and raise its productivity. Absorptive capacity is also likely to be important for learning about, and investing in, clean technologies. This suggests a double benefit from better absorptive capacity – reduced emissions and improved productivity.

Recommendations

R5.1

The Government should phase out all subsidies that support the ongoing production and use of fossil fuels.

R5.2

New Zealand should establish the transition to a low-emissions economy as a high priority within its national innovation system recognising the importance of that goal and that it will require extensive economic transformation and restructuring. The Government should provide major public backing and funding support for innovation so that it can play a central role in the transition, alongside effective emissions pricing.

R5.3

The Government should take steps to:

- strengthen the national innovation system such as by clarifying its low-emissions objectives, and by improving linkages, the identification of relevant innovation opportunities, and knowledge transfer and sharing; and
- align the various complementary parts so they work well together in the transition to a low-emissions economy.

The scope should include not only science and research, but broader innovation, knowledge dissemination and learning, skills, infrastructure, regulation and finance.

R5.4

The Government should investigate and implement any cost-effective institutional models for:

- scanning new low-emissions technologies around the world to identify ones with promise for New Zealand but that may need adapting to suit local conditions; and
- helping firms to improve their absorptive capacity for external knowledge, including new low-emissions technologies.

R5.5

Policy should keep the market environment competitive and flexible to allow “creative destruction” to take place, so that resources can flow from firms that lag in adopting low-emissions technologies to firms that lead.

Chapter 6 – Investment

Findings

F6.1

The fundamental role of government in ensuring adequate investment for the transition to a low-emissions economy is to provide a stable and credible climate policy underpinned by enduring institutional arrangements, and effective emissions pricing.

However, while necessary, these may not be sufficient. To enable an effective transition, these credible and consistent settings need to be complemented by other interventions specifically addressing information and inertia barriers, coordination failures, technology and market risks, and scale of investment barriers.

F6.2

The green bond market has the potential to accelerate the transition to a low-emissions economy. However, the market is growing independent of government assistance. So, the Commission does not consider that specific government intervention into the New Zealand green bond market is required.

F6.3

Green investment banks can efficiently use public capital to mobilise substantially greater quantities of private capital to overcome the scale of investment barriers that low-emissions investments may encounter. These include significant funds for major infrastructure projects, or coordinating funds for more disaggregated activities. They can also stimulate investment by providing information, increasing market confidence, and reducing overall financing costs.

F6.4

Government financial guarantees work by reducing risk for additional private sector investment by substituting the collateral businesses would have otherwise required. The Commission has not uncovered any evidence to suggest that establishing a standalone government financial guarantee scheme is required in New Zealand at present. However, an approach based on financial guarantees may be suitable as part of the proposed GIF.

F6.5

Public grants and loans can play an important catalytic role in reducing market risk for the development and deployment of low-emissions technology. However, how grants and loans should operate in conjunction with other types of Government funding intending to support the transition to a low-emissions economy, remains unclear.

F6.6

The recommendations of the Task Force on Climate-related Financial Disclosures relating to governance, strategy, risk management, and metrics and targets, offer a clear

and consistent foundation for investors to assess the risks and opportunities related to climate change.

F6.7

Existing financial reporting requirements (eg, as contained in the Companies Act 1993) will likely fail to adequately incentivise the disclosure of climate risk in a manner that is consistent and credible.

F6.8

While the guidelines provided by the New Zealand Stock Exchange provide a positive foundation for listed firms to disclose their climate-related risks, their coverage is such that they will not be sufficient to drive adequate investor awareness and behaviour change across the New Zealand economy.

F6.9

Many jurisdictions have enacted mandatory climate disclosure requirements either as part of existing regulations focused on strategic reporting, or as part of new, climate-focused legislation. Government-mandated disclosure requirements are important to provide consistent, comparable and credible reporting for investor decision-making.

F6.10

Central banks play an important role in assessing the exposure of financial systems to climate risk, particularly in terms of effects on financial stability.

F6.11

A strategy on public sector investment is needed in New Zealand to enable aligned, clear, and well-targeted investment that is supportive of the transition to a low-emissions economy.

Recommendations

R6.1

The Government should clearly identify the market failure that the proposed Green Investment Fund (GIF) will address. Analysis should include, its mandate, financing approach and funding source, expected duration, institutional structure (including its degree of independence), desired minimum rate of return, relationship to existing infrastructure and clean technology funding sources, and scale of investment (wholesale or retail).

The Government should also state how the GIF would work in conjunction with any other initiatives relating to the provision of infrastructure or low-emissions technology finance.

R6.2

The Government should officially endorse the recommendations of the Task Force on Climate-related Financial Disclosures.

R6.3

The Government should incorporate mandatory climate-related financial disclosures into existing regulatory instruments as appropriate. The disclosures should be in line with the recommendations of the Task Force on Climate-related Financial Disclosures.

R6.4

The Government should develop, in conjunction with interested parties including the private sector, a low-emissions investment strategy for New Zealand. Relevant topics should include:

- the strategic alignment of direct government investment intended to support the transition to a low-emissions economy (eg, grants, loans and other initiatives such as the proposed Green Investment Fund), as well as the interaction between policies such as disclosure requirements and direct government funding;

- the investment mandates of large public institutional investors (eg, ACC or the NZ Super Fund);
- the role of financial sector regulation in supporting the low-emissions transition; and
- what constitutes low-emissions investment, with the aim of identifying a clear taxonomy of measurable investment flows.

Chapter 7 – Laws and Institutions

Findings

F7.1

The long-term nature of climate change, literally spanning generations, and the deep uncertainty associated with the future, presents a credible commitment problem in formulating and implementing a long-term policy response.

Well-designed laws and institutions can play a critical role as commitment devices to help drive the development and implementation of long-term response strategies.

F7.2

Long-term political commitment and durability is essential to the success of climate change laws and institutions. Substantial cross-party support for the core elements of statutory and institutional arrangements will help provide policy permanence regardless of the make-up of the Government.

F7.3

New Zealand’s current emission reduction response is not “fit-for-purpose” for transitioning to a low-emissions economy. A number of deficiencies exist, such as:

- a lack of stability and predictability in climate change policy, reflecting the absence of political consensus about New Zealand’s transition to a low-emissions economy;
- lack of a clear plan for reducing domestic emissions and meeting existing emission reduction targets;
- inadequate central government leadership to drive the low-emissions transition; and
- poor policy coherence for supporting a low-emissions transition.

New Zealand’s emissions are not yet declining; nor are current policy settings likely to lead to adequate emission reductions in the future, let alone do so in a way that achieves the greatest net benefit to New Zealand.

F7.4

Inquiry participants and others showed strong support for implementing a UK-style Climate Change Act in New Zealand.

F7.5

Key elements of statutory frameworks that promote policy stability and require long-term thinking include:

- clear and explicit high-level, long-term goals and a focus on progress towards those goals;
- core principles of transparency and accountability;
- mechanisms that seek to promote stability but retain a degree of flexibility; and
- mandatory procedural requirements, including reporting obligations.

F7.6

Legislated emissions-reduction targets are important commitment devices that act to bind the political executive to govern in line with the long-term commitment of a low-emissions economy. Such targets would have authority and durability. Well-designed legislative targets are:

- focused on the desired high-level outcome, without being overly prescriptive about how the goal is reached;
- determined through a robust public policy process and achieve broad buy-in from those affected;
- realistic, and require an assessment of the measures needed to achieve the target and an awareness of the policy tools that the government has at its disposal;
- directly related to the underlying climate change problem;
- stable over time, yet have some built-in flexibility to be adjusted in the light of major changes in circumstance, but without undermining their purpose or credibility; and
- clear about the nature of the obligation to meet them.

F7.7

Emissions budgets help to translate long-term targets into clear and specific short-term actions. They provide visible “stepping stones” to achieving a long-term target and help reinforce steady action on, and accountability for, achieving a long-term target. By setting limits on the “stock” of GHG emissions, emissions budgets can also helpfully restrict the total quantity of GHGs released to the atmosphere on the path to a long-term target.

F7.8

Matters to consider when formulating a requirement to prepare a low-emissions strategy include the need for:

- flexibility and responsiveness;
- recognition that strategies for the long term will inevitably be less certain and well-defined than those for the short term; and
- a strategy to not only address policies that achieve the required emission reductions, but also how to maximise benefits and minimise the costs of the transition.

F7.9

Political accountability will be a key driver for compliance with obligations in a climate change law, including meeting emissions budgets and targets. Limits to the legal enforceability of emissions budgets and targets would not negate the status and constitutional significance of putting them in law.

F7.10

Given the long-term nature and time-inconsistency problem associated with climate change policy, an independent institution, at “arm’s length” from government, can play an important role as a commitment device to help insulate policymaking from short-term political pressures, expand climate policy debate, promote stability and predictability, and improve transparency and accountability. Such an institution will be more enduring if established through broad political consensus.

F7.11

“Independence” is multifaceted, and includes regulation independence, operational independence, budgetary independence and institutional independence. No single “blueprint” for an independent body exists: successful design and operation relies on a whole suite of elements.

F7.12

Decisions about New Zealand's transition to a low-emissions economy (including the setting of emissions budgets) are highly political and go to the heart of a Government's development strategy and political priorities.

Independent institutions can be highly influential and play a valuable role without having decision-making powers.

F7.13

Independence is earned as much as granted. The success of an independent body will therefore depend not only on its statutory design, but also on how the institution operates in practice (including the quality of appointments, its culture and leadership, and adequacy of ongoing funding).

F7.14

Inclusion of a Treaty of Waitangi clause in the legislation would acknowledge both the importance of the kaitiakitanga role of mana whenua and the stability and longevity of the fundamental constitutional arrangements on which a low-emissions future would be achieved.

F7.15

The legislative framework could strongly signal a partnership approach between Māori and the Crown in achieving the goal of a low-emissions economy. However, relying on legislative provisions alone will not be sufficient to uphold Treaty principles of partnership, mutual respect and good faith. Much will depend on the quality of leadership.

F7.16

Developing the government response to the Climate Commission's advice will be a substantive and challenging policy process and will present major coordination issues. The organisation(s) responsible for providing advice on the Climate Commission's recommendations will need to:

- have the capability and knowledge to understand and robustly assess the Climate Commission's recommended actions in each sector;
- have the ability to take an economy-wide, strategic view and to consider the full range of benefits and costs;
- be linked to the fiscal budget process, to ensure that Cabinet decisions are suitably resourced; and
- have the mana to bring together the range of portfolio agencies, work through any differences of view to develop a coherent and robust set of policy proposals, and monitor the government's progress against Cabinet decisions.

No single agency within the current public sector has this full range of necessary capabilities and attributes. New arrangements will be required to deliver these capabilities.

F7.17

Developing a robust and enduring cross-government emissions reduction strategy will require coordination across both departments and Ministers.

F7.18

Local government will play an important role in any national emissions-reduction strategy, given the responsibilities it has for regulating land use and managing land transport. The development of a government response to the Climate Commission recommendations would be a convenient opportunity to establish new, more effective

arrangements for local and central government to work together on issues of common interest.

Recommendations

R7.1

The broad principles and framework of the United Kingdom's Climate Change Act should be used as a basis for designing a new architecture for New Zealand's climate change legislation. Yet such a legislative framework should be carefully tailored to fit the New Zealand context.

R7.2

The Government should seek to achieve a high level of political support and consensus for new climate change legislation, with an aim of enacting legislation that has a strong prospect of policy and legislative durability regardless of the make-up of the government.

R7.3

A long-term greenhouse gas (GHG) emissions-reduction target should be set in primary legislation. Legislative emissions targets require careful design and should be formulated following a robust public policy process seeking broad agreement.

R7.4

A new architecture for New Zealand's climate change legislation should provide for a system of emissions budgeting, whereby short-term limits on emissions are periodically set by government, and progress toward their achievement is reported publicly. To be credible and durable, an emissions budgeting system must carefully balance predictability and flexibility, and budgets should be set at a level consistent with achieving the long-term target while imposing least cost on the economy and society.

R7.5

Government should have a statutory duty to prepare and publish a long-term economy-wide low-emissions strategy. The strategy should set out the Government's policies and proposals for meeting both current and future emissions budgets (and with a view to meeting the long-term target), and should be updated after each new emissions budget is set.

R7.6

Mandatory processes should underpin a Climate Change Act. Legislation should include clear reporting obligations, including requiring regular reporting to Parliament on key aspects of New Zealand's transition to a low-emissions economy (such as GHG emissions, progress towards budgets and targets, and the Government's low-emissions strategy). Timeframes for the suite of processes should be set so as ensure regular review and reporting, but avoid over-engineering procedural obligations.

R7.7

The regulatory framework to support New Zealand's transition to a low-emissions economy should include an independent climate change institution (a Climate Commission) that operates at "arm's length" from government.

R7.8

A Climate Commission should take an advisory role. Decision rights should not be delegated to such a Commission.

R7.9

The Climate Commission should be responsible for:

- providing advice on emissions budgets, targets and New Zealand Emissions Trading Scheme (NZ ETS) caps (based on clear statutory parameters for that advice), and other matters materially relevant to New Zealand's low-emissions transition;

- reporting on progress towards emissions budgets and targets, including assessing the performance of policy instruments and identifying emerging risks;
- undertaking and publishing relevant research into transitioning to a low-emissions future; and
- (in carrying out its role) engaging in outreach and public communications.

Legislation should oblige the government to have particular regard to the Climate Commission's advice when making decisions on emissions budgets, targets and NZ ETS caps, and give clear reasons for any material departure from that advice.

R7.10

To properly perform its role, retain credibility over the longer term, and be viewed as independent, the Climate Commission should have a high degree of operational and institutional independence.

The Climate Commission should have:

- broad discretion to exercise functions at "arm's length" from the executive and legislative branches of government or industry; and
- formal distance, and security of tenure for governors and senior management.

The Climate Commission should be set up as an independent Crown entity.

R7.11

The legislative framework for a low-emissions economy should provide for mechanisms for Māori to advise the Government on policy, process, and decisions relating to emissions budgets and the Government's strategy to achieve them.

R7.12

Treasury should update the Regulatory Impact Analysis requirements to explicitly include consideration of climate change impacts, where relevant.

The Cabinet Office should update its circular to require agencies making proposals for regulatory changes with climate change implications to consult with the organisation responsible for developing advice on the Climate Commission's recommendations and ensure that the agency's comments are fairly and accurately reflected in any final assessment.

Chapter 8 – Short-lived and long-lived gases

Findings

F8.1

The contribution of greenhouse gases (GHGs) to warming is a function of their stock in the atmosphere. The stock of both short- and long-lived greenhouse gases is relevant to the likelihood of successfully limiting peak-warming to 2°C or less (as required by the Paris Agreement).

Because of their atmospheric persistence, net-emissions of long-lived gases must reach zero. Emissions of short-lived gases must stabilise by inflows equalling outflows (with a consistent, minor decrease in emissions to achieve a stable temperature).

F8.2

Current scientific evidence shows that global emissions of all long-lived gases must be reduced to net-zero at a minimum to stabilise the climate well below 2°C. The sooner that net-zero long-lived gases can be achieved, the more likely warming will not exceed 2°C. This means giving greater relative priority to mitigation of long-lived gases.

Reductions in short-lived gas emissions will also be required in the context of limiting peak warming to 2°C. Yet because the allowable stock of short-lived gases is a function of the stock of long-lived gases, the level of short-lived gas emissions reductions needed in the context of the 2°C goal is less certain.

F8.3

While the priority must be to reduce emissions of long-lived gases to net-zero, there are benefits to also mitigating short-lived gases over the coming decades. These include to allow a slightly greater carbon budget, to help delay dangerous tipping points in the earth's climate system, to provide further time for adaptation to temperature change, and to help stimulate innovation or land-use change that provides for a more gradual transition to a low-emissions economy.

However, this does not mean that short-lived gas mitigation can *replace* that of long-lived gases and still hope to limit peak warming to 2°C.

F8.4

The choice of emissions metric makes a significant difference to the estimated effect of the different GHGs on warming over a given period; and so can strongly influence mitigation priorities. Choosing an appropriate metric will depend on factors such as attitudes to risk, and which aspects of climate change are considered important. No single metric can accurately compare the consequences of GHG emissions, and all have limits and uncertainties

F8.5

The idea of prioritising emissions reductions of short- or long-lived gases is not new in New Zealand. Researchers and policy officials have previously highlighted the possibility of, or recommended, New Zealand distinguishing between short- and long-lived gases in terms of policy mechanisms and targets.

Recommendations

R8.1

The Government should establish separate long-term domestic targets for short- and long-lived gases, together with a regular series of reviews of progress against these targets. The long-lived gas target should be a net-zero target by a specified end date and the short-lived gas target should aim for a stabilisation level within a specified temperature limit. The short-lived gas target must be underpinned by an explicit quantity goal (ie, maximum emissions rate).

The Government should support these separate targets with a single all-gases target. The all-gases target should be set in primary legislation. The Government should carefully consider the appropriate legislative instrument to express the separate short- and long-lived gas targets.

Chapter 9 – Policies for an inclusive transition

Findings

F9.1

A large number of studies have analysed the impact of emissions pricing policies – such as cap-and-trade or carbon taxes – in developed countries. While the results vary depending on the sources of emissions and the characteristics of household expenditure, emissions-pricing policies are commonly found to be regressive in their impact.

F9.2

In New Zealand, low-income households spend a greater proportion of their income on food, transport and household energy. This suggests that emissions pricing may impact

more heavily on low-expenditure households. But emissions pricing also leads to price increases for commodities on which households with higher expenditure spend proportionally more.

F9.3

Lower-income households are less able to make investments that enable them to reduce the emissions intensity of their consumption.

F9.4

The existing suite of benefits and tax credits should be adequate for offsetting direct impacts of emissions-reducing policies on the cost of living for lower-income households, provided tax credits are regularly adjusted for inflation.

F9.5

Public interventions to promote investments such as home insulation have a number of benefits, especially for individual and household health. The interventions do not appear to increase energy consumption.

F9.6

The shift to low or zero-emissions vehicles may be difficult for some low-income households, given the current high price premia for electric and hybrid vehicles over fossil-fuel vehicles. Depending on the rate of technological and consumer change, this price premium may fall dramatically, minimising any need for government intervention to support low-income households. Uncertainties mean that it is too early at this stage to design effective and well-targeted compensatory transport policies.

F9.7

Providing financial assistance to firms facing closure or decline as the result of policy change would be risky, encourage unproductive lobbying and raise questions of fairness.

F9.8

Interventions that respond to the “shock” of the loss of a major employer in a region should focus on the labour market and skills needs of individuals, and should be targeted to those who will have the most difficulty gaining new employment. This may include helping people move out of the affected region, to areas where employment prospects are stronger.

F9.9

The current education and training system is not well set up to meet the needs of people seeking mid-career retraining.

F9.10

The policy case for hypothecating revenues from the auction of New Zealand Units towards assistance for households is not strong. Hypothecation makes most sense where the link between the taxed activity and subsequent expenditure is strong.

Chapter 10 – Land use

Findings

F10.1

Land use will need to change substantially if New Zealand is to transition to a very low-emissions economy by 2050. In particular, the transition will require a large and sustained increase in afforestation.

F10.2

The rate of land change needed to transition to a low-emissions economy over the next three decades is comparable in magnitude to the overall rate of change over the last three decades. Yet high rates of afforestation will need to be sustained for a much

longer period in the future than happened in the past; and the past movement into horticulture may need to accelerate.

F10.3

New Zealand's agriculture sector achieved steady productivity gains over the last 25 years, leading to a reduction in emissions per unit of milk and meat produced. Yet, because dairy cattle numbers and total production rose substantially, absolute emissions have risen.

F10.4

No mitigation option currently exists for achieving dramatic reductions in New Zealand's agricultural emissions without substantially reducing production. Yet, many farmers can achieve modest reductions (perhaps up to 15%) through productivity gains and shifting to low-emissions practices. Some options can also improve farm profitability. More options are currently available for reducing nitrous oxide emissions than methane. Options for sheep and beef farming are much more limited than for dairying.

F10.5

Despite the present opportunities for mitigating on-farm emissions, New Zealand's absolute agricultural emissions are projected to rise, due to anticipated increases in agricultural production. Reducing absolute emissions will require a combination of constraining production and achieving significant breakthroughs in developing new mitigation technologies.

F10.6

The development of an effective mitigation technology could have a significant impact on New Zealand's agricultural emissions. While options such as a methane vaccine and inhibitor show some promise, the prospects of a successful technology are highly uncertain and the benefits dependent on their suitability to New Zealand's farm systems.

F10.7

New Zealand has sufficient suitable land to greatly expand afforestation to sequester carbon. This land includes over a million hectares of highly erodible land unsuited to pastoral agriculture (though some of this is also unsuited to forestry). The land is both privately and publicly held. The availability of privately-held land will depend on the economics, including the prospective price of New Zealand Units (NZUs) over the growing period and at harvest. The availability of government-controlled land for further afforestation is uncertain.

F10.8

The need for investments in upstream supply capacity, new on-farm productive capacity, and downstream processing, distribution and marketing capacity; and the time taken to acquire skills and knowledge, may delay changes in land use, even when they otherwise appear profitable. Policy uncertainty affecting future profitability is also a cause of delay.

F10.9

Applying a price to agricultural emissions would give farmers more incentives to adopt mitigation options, though the size of the effect is uncertain. An emissions price would encourage more private investment in developing mitigation technologies and also improve the efficiency and equity of mitigation efforts across the economy.

F10.10

New Zealand's trade competitors do not yet face a price on their agricultural emissions. Given New Zealand's agricultural sector is highly trade-exposed, introducing a price for agricultural emissions without support would reduce the international competitiveness of New Zealand farms and potentially result in emissions leakage.

Yet, with adequate support for farmers (eg, provision of free allocations), pricing agricultural emissions will provide incentives to reduce emissions, while lessening any risk to the viability of New Zealand's agricultural businesses. Also, the risk may not be as

severe as some suggest, since New Zealand's core competitors in international trade are likely eventually to face comparable regulation of emissions.

F10.11

The impact of a price on agricultural emissions differs depending on the point of obligation. A point of obligation at the processor level mostly incentivises reduction of output (either through reducing stock numbers where this is profitable, or through changing land use), and therefore provides a blunt price signal to reduce emissions. A point of obligation at the farm level provides stronger incentives for a farmer to change the way they manage their farm as well as to reduce their output.

F10.12

OVERSEER is currently the main tool for monitoring emissions at the farm level, and is already widely used by dairy farmers for nutrient management. While its overall structure is suitable for monitoring farm-level emissions, further work is under way to improve its transparency, the extent to which it captures a wide range of on-farm mitigation options, and to better align the model to the methodology used in preparing the national inventory.

F10.13

A point of obligation at the farm level would require monitoring, verifying, and enforcing compliance for a large number of small emitters. Carrying out this process for all emitters would likely be costly and difficult. Modifying this approach by, for instance, limiting a requirement for farm-level reporting to farms larger than a certain threshold could help to minimise these transactions costs.

F10.14

Forestry offers New Zealand a path to reducing net emissions to a very low level or to zero by 2050 at moderate cost. Yet there is a risk that a low or moderate emissions price will weaken incentives for other sectors to reduce emissions. This in turn, may make it difficult for New Zealand to achieve emissions reductions targets in the second half of the century, when options for new forestry may reduce or run out.

F10.15

Only a minority of eligible foresters participate in the NZ ETS. Many owners of small forests find participating in the NZ ETS costly and risky relative to any benefits afforded by earning NZUs. Simplifying administration of the NZ ETS for small forests, allowing an averaging approach to surrender obligations over time (on a voluntary basis), and providing policy certainty are all ways to encourage more forest owners to participate.

F10.16

Emissions prices above \$20 and rising to \$70 and above for a NZU in the NZ ETS will likely lead to a substantial increase in afforestation rates, mostly on marginal land currently used for beef and sheep farming. A rising emissions price is likely required to incentivise sustained afforestation over future decades.

F10.17

Based on past experience, adoption of low-emissions farming practices and technology will likely be slow and complex. The dairy industry is putting in place peer and industry support for farmers to adopt new practices and this model could be adopted more widely. Industry efforts to reduce biological emissions will intensify when agriculture is brought into the NZ ETS.

Recommendations

R10.1

The Ministry for Primary Industries should commission further expert research into the potential for permanent exotic forests to convert to native forests and the conditions under which such conversion could reliably and economically occur.

R10.2

The Ministry for Primary Industries working, with Land Information New Zealand and Landcare Research, should undertake a complete audit of the availability of government-controlled land suited for afforestation (whether native or exotic), and develop policy options that would cost-effectively establish forestry on such land as is available.

R10.3

Agricultural emissions should be fully included in the New Zealand Emissions Trading Scheme (NZ ETS).

R10.4

To address potential effects on emissions leakage and international competitiveness resulting from including agriculture in the NZ ETS, the Government should provide free allocation of NZUs to cover a large majority of agricultural emissions, based on their historic level. The Government should withdraw these allocations over time as the stringency of agricultural emissions policies increases overseas and the availability of mitigation options increases; and to be consistent with New Zealand transitioning to a low-emissions economy by 2050.

R10.5

Unless and until there is a better alternative, the Government should use OVERSEER to monitor emissions at the farm level. The Ministry of Primary Industries should undertake work with AgResearch and the Fertiliser Association of New Zealand to further improve the capabilities of OVERSEER as a tool for modelling farm-level emissions. The improvements should capture as far as possible the full range of on-farm actions that can reduce emissions.

R10.6

The proposed Climate Change Commission should monitor the effect of forestry on the emissions price and on incentives for emitting sectors to reduce emissions. It should assess whether and how New Zealand can meet its emissions targets in the second half of the century when options for new forestry are likely to reduce or run out. If indicated, it should consider and advise on adjustments to policy settings to deal with this problem.

R10.7

The Government should continue to refine the NZ ETS for forestry to make it easier and less risky for small foresters to participate; and to provide recognition for carbon sequestered in harvested wood products.

R10.8

The Government should increase its yearly funding for research on agricultural mitigation technologies to a level that better reflects the potential value of successful outcomes. Funds could, for instance, be allocated from the proceeds of auctioning NZUs.

Chapter 11 – Transport

Findings

F11.1

At the current low emissions price, the New Zealand Emissions Trading Scheme (NZ ETS) has a small effect on fuel prices, and accordingly, a small effect on consumer behaviour and transport emissions. A higher emissions price would have a greater impact. Yet, because consumers are relatively unresponsive to changes in fuel prices, additional measures will be required to achieve large emissions reductions.

F11.2

Light vehicles entering New Zealand's fleet emit significantly more CO₂ than in most developed countries, and efficiency improvements have stalled since 2013. Evidence suggests vehicle manufacturers are opting to provide less efficient variants of vehicle

models to the New Zealand market compared to markets where CO₂ emissions standards apply.

F11.3

Vehicle CO₂ emissions standards are warranted because buyers tend to discount future fuel savings at a much higher rate than is socially optimal. Domestic standards could also mitigate risks around “dumping” of high-emissions vehicles in New Zealand due to stringent standards and regulations adopted in other regions.

F11.4

The use of electric vehicles (EVs) leads to substantial emissions reductions compared to fossil-fuel vehicles, due to New Zealand’s low-emissions sources of electricity generation. EVs also contribute to reduced air and noise pollution, and involve lower fuel and maintenance costs.

F11.5

A rapid uptake of light EVs will likely be a critical part of achieving a low-emissions economy. To electrify the bulk of the light vehicle fleet by 2050, nearly all newly registered vehicles would need to be electric by the early 2030s.

F11.6

The most significant barriers inhibiting the uptake of EVs in New Zealand are:

- the upfront cost premium compared to petrol and diesel vehicles;
- limited travel range, and associated range anxiety;
- the lack of public awareness and understanding of EVs; and
- the lack of cost-reflective pricing of electricity.

F11.7

A large uptake of EVs would add significant load to the electricity grid. Without measures to encourage off-peak charging, such as cost-reflective pricing and smart metering, electricity emissions could rise significantly. The additional electricity load could also put significant pressure on the existing network, and require large investments to provide additional capacity.

F11.8

Overpricing of off-peak electricity and under-pricing of CO₂ emissions and air pollution from fossil-fuel vehicles means that the running costs of EVs (relative to fossil-fuel vehicles) are higher than they should be. In choosing a vehicle, consumers are also likely to under-value the large emissions that are locked in over the vehicle’s lifetime (eg, due to high discounting of future running costs). This provides a case for Government to provide some form of transitional price support to incentivise EV uptake.

F11.9

A well-designed price feebate scheme based on the GHG emissions of light vehicles entering the fleet would provide the most cost-effective approach to incentivising the uptake of low-emission vehicles. The approach:

- provides a continuous incentive for purchasing lower-emitting vehicles (including fossil-fuel vehicles);
- is technology neutral; and
- can be designed to be revenue neutral.

F11.10

The effective design of a feebate scheme is critical for its success. Excessively high or low feebates can lead to adverse outcomes. Applying a one-off feebate when a vehicle enters the fleet provides stronger incentives than an annual charge over time.

F11.11

The provision of EV charging infrastructure in New Zealand, especially fast charging stations, has been relatively strong with the current level of government support. Yet, some gaps appear to exist in specific regions, and for slow chargers within urban areas.

F11.12

Several advantages of hydrogen fuel-cell vehicles, including the lower weight and greater travel range, make them especially suited to reducing emissions from road freight. The biggest challenge for achieving uptake in New Zealand is the significant investment needed in new infrastructure.

F11.13

Biofuels can potentially deliver considerable reductions in emissions, especially for transport modes that are more challenging to electrify (eg, heavy vehicles, aviation and shipping). New Zealand's current production of biofuels is relatively small. A higher emissions price in the NZ ETS would create a greater incentive to develop and switch to biofuels. However, the biofuel technologies with the greatest promise for New Zealand's context are not yet commercially proven.

F11.14

Increasing the use of public transport, and cycling and walking provide relatively small emissions reductions benefits. On the other hand, shifting to these modes can achieve significant other benefits, including reduced congestion, better health outcomes and overall productivity gains.

F11.15

Moving freight via rail and coastal shipping is less emissions intensive than road transport. However, because a large proportion of freight carried by road is not economically contestable, the potential to reduce emissions from shifting modes of freight is limited. Electrifying rail would enhance the emissions reductions from shifting to rail, but would require significant capital expenditure.

F11.16

Developing demand management and intelligent transport systems provides new opportunities to make the transport system more efficient. A more efficient system can reduce emissions and achieve wider benefits such as lower congestion.

F11.17

New Zealand's current transport investment system is biased towards investment in roading. An efficient transition to a low-emissions transport future requires an investment system that is:

- better integrated across modes;
- more flexible, with greater competition for funding across different transport modes and activities, and greater autonomy for councils;
- more neutral, by removing distortions and biases that favour particular modes or activities, and fully accounting for social, economic and environmental costs and benefits.

Recommendations

R11.1

The Government should introduce CO₂ emissions standards for light vehicles entering the New Zealand fleet, subject to detailed consideration of design options (for example, including or excluding small traders).

R11.2

The Government should introduce a price feebate scheme for vehicles entering the fleet, subject to identifying the most suitable design features for the New Zealand

context. The feebate scheme should replace the existing road-user charge exemptions for light EVs.

R11.3

The Government should provide financial support for charging infrastructure projects to support the uptake of EVs. Support should be limited to specific gaps in the charging network that are not commercially attractive to the private sector (eg, charging stations in lowly populated regions).

R11.4

The Government should encourage government agencies where practical to procure low-emission vehicles.

R11.5

The Government should take steps to amend the pricing system for transport so that a greater share of the external costs associated with private vehicle use are internalised. For example, Government should work with councils to enable and encourage the use of road pricing tools to reduce congestion and emissions in main urban centres.

R11.6

The Government should make emissions reductions a stronger strategic focus in transport investment. This should include changes to the Government Policy Statement on Land Transport to broaden its scope to cover the whole land transport system and make the transition to a low-emissions economy a strategic priority.

Chapter 12 – Electricity

Findings

F12.1

The future mix of electricity generation by 2050 in a low-emissions electricity system and its effect on wholesale prices are both very uncertain. For example, different models envisage different paths for the cost of wind generation for each megawatt hour of electricity produced. This, in turn, leads to a different role for wind versus geothermal generation in the system, and different effects on wholesale electricity prices. In the most favourable scenarios, prices fall; while in other scenarios they rise.

F12.2

Technologies that generate low-emissions electricity are advancing rapidly with falling costs, changing design and new options emerging. If governments favour particular current technologies (for instance through subsidies), they risk locking in higher electricity costs without commensurate benefits in reducing emissions.

F12.3

Under current technology and technology costs, reducing emissions from electricity generation will likely entail an increase in wholesale electricity prices. Rising electricity prices, if substantial, could dissuade adoption of emissions-reducing technology in process heat and in transport, as well as increasing costs throughout the economy. Yet rapid advances in, and falling prices for, low-emission electricity technology may make this trade-off less acute in the future. An effective emissions price will help weigh the efficiency of reducing emissions in electricity against possibly lower-cost options to do so in other sectors.

F12.4

Integrating distributed energy resources (DER) and demand response (DR) into the electricity system will require significant adjustment to the current distribution pricing and regulatory regime. The Electricity Authority is leading or sponsoring a substantial programme of work to address the need for pricing and regulatory adjustment. The

programme covers changes to pricing to better incentivise investment in DER and DR capability; and changes to regulation to provide for:

- consumers to be involved in multiple trading relationships;
- more fluid data exchange between retailers and EDBs;
- a distribution agreement to support competition, efficiency and innovation in retail and related markets;
- consumers to become active buyers and sellers of electricity and related services; and
- equal access of participants to electricity networks.

F12.5

With an effective emissions-pricing system, a statutory objective for the Electricity Authority (EA) to have regard to reducing greenhouse gas emissions in electricity is unlikely to incentivise efficient emissions reductions across the economy as a whole. There may be some case to amend the EA's objectives to include minimising any regulatory barriers to efficient emissions reductions in the electricity sector.

Recommendations

R12.1

Given rapid changes in electricity-generation technology and potential effects of rising electricity prices on adoption of low-emissions technology in other parts of the economy, the Government should not use subsidies or regulation to favour particular technologies that generate low-emissions electricity.

R12.2

The Government should rely on an effective emissions-pricing system as the main instrument to achieve an efficient trade-off between emissions reductions in electricity and emissions reductions in other parts of the economy. The Government should be cautious in specifying targets for emissions within the electricity sector, and make sure that technology is available to meet them without significantly increasing wholesale electricity prices above the levels achieved with current technology.

R12.3

The Electricity Authority should continue its programme of work to update pricing and regulation to facilitate the integration of distributed energy resources (DER) and demand response (DR) into the electricity system. The programme should cover changes to pricing to better incentivise investment in DER and DR capability; and changes to regulation to provide for:

- consumers to be involved in multiple trading relationships;
- more fluid data exchange between retailers and EDBs;
- a distribution agreement to support competition, efficiency and innovation in retail and related markets;
- consumers to become active buyers and sellers of electricity and related services; and
- equal access of participants to electricity networks.

R12.4

The Electricity Authority should, in conjunction with its work programme to update pricing and regulation of the electricity distribution sector, undertake a review of and develop measures to raise the capabilities of the electricity distribution businesses to:

- ensure all power system resources (including distributed energy resources – DER) have competitive access to a well-configured common distribution infrastructure, at a reasonable cost for monopoly assets;
- coordinate DER (including smart, flexible demand) to meet participants' preferences for security, quality and reliability; and
- provide rewards and allocate costs commensurate with the marginal costs and benefits of each load and generating source.

Chapter 13 – Heat and industrial processes

Findings

F13.1

High-temperature heat users have no viable short-term economic abatement opportunities.

F13.2

Operational efficiencies offer scope to reduce process heat-related emissions, although large potential gains are not likely.

F13.3

There are more opportunities for switching to lower-emissions fuel sources for low and intermediate process heat needs for firms in the North Island, reflecting better access to gas and geothermal energy.

In the South Island, switching to electricity may be feasible for firms whose heat needs are negatively correlated with electricity prices.

F13.4

Significant technological and logistical improvements will be needed before biomass becomes a cost-competitive and emissions-neutral alternative to fossil fuels for large industrial heat plant.

F13.5

Rising emissions prices will be central to driving emissions-reducing investments in industrial heat processes.

F13.6

Barring technological breakthroughs, opportunities to significantly reduce emissions from iron, steel and aluminium production remain limited.

Recommendations

R13.1

The statutory functions of the Energy Efficiency and Conservation Authority (EECA) should be changed to make lowering GHG emissions its primary mandate.

R13.2

EECA should refocus its support for business to adopt emission-reducing techniques towards smaller firms. To the extent that EECA continues to work with larger firms, this should be conducted on a cost-recovery basis.

R13.3

New legislation should be prepared to regulate carbon capture and storage activities (CCS).

R13.4

Once new CCS legislation is in place, the New Zealand Emissions Trading Scheme should be amended to make CCS a recognised removal activity, no matter the source of emissions being captured and stored.

Chapter 14 – Waste

Findings

F14.1

Mitigation in the waste sector does not require the development of new technology. Waste emissions can be effectively mitigated by current technologies such as landfill gas recovery systems or anaerobic digestion.

F14.2

Good quality data on waste in New Zealand is lacking. This has major implications for understanding emissions management practices related to waste in New Zealand, and identifying subsequent opportunities to further reduce emissions. In response to these issues, the Ministry for the Environment is developing a project to collect better waste data in New Zealand.

F14.3

There are a large number of solid waste sites that, while known and consented, are technically considered to be “unmanaged”. Reducing emissions from these sites is vital because current data estimates that they comprise nearly two-thirds of all waste emissions. The most effective solution to achieving emissions reductions at these sites is to apply an effective waste disposal levy. The Ministry for the Environment is planning to extend the levy to all 381 known, consented facilities not currently subject to the levy.

F14.4

Emissions reductions at farm dumps and other, unknown, waste disposal sites, could be encouraged by the creation of bylaws as allowed under the Waste Minimisation Act 2008 (and Part 8 of the Local Government Act 2002), or resource consenting processes under the Resource Management Act 1991.

F14.5

The most effective actions to reduce emissions at managed municipal solid waste sites are a reduction in organic waste volumes to landfill and better management of CH₄ at landfill. An effective emissions price will help to achieve both, while giving facility operators (particularly local authorities) the flexibility to determine which strategy is likely to be the most cost-effective at reducing emissions in their own jurisdiction.

F14.6

Waste-to-energy provides an opportunity to reduce emissions by diverting waste from landfill and substituting for fossil fuels. Anaerobic digestion (eg, at wastewater treatment plants) is a current cost-effective approach to reduce emissions, but the potential to incinerate waste (especially household waste) is less clear.

Recommendations

R14.1

The Ministry for the Environment should ensure that, in its project to collect better waste data in New Zealand, emissions-related data is included so as to reduce the very

large uncertainty regarding waste emissions, and to identify opportunities to reduce emissions in the future.

R14.2

The Government should amend the Waste Minimisation Act 2008 so that the waste disposal levy is applied to all known, consented waste disposal facilities.

R14.3

As part of its work to extend the waste disposal levy, the Ministry for the Environment should investigate, for all 426 sites subject to the levy, both increasing the levy rate via a graduated process, and introducing a differentiated levy rate where organic waste is charged at a higher rate than non-organic waste.

R14.4

Local government should be better supported, as needed, to develop effective bylaws or consenting requirements for farm dumps and other, unknown, waste disposal sites, through an overarching regulatory framework for wastes such as agricultural waste. The Ministry for the Environment should investigate whether a national environmental standard relating to waste is an appropriate mechanism to deliver this framework.

R14.5

As part of any analysis regarding the rate of the waste disposal levy, the Government should consider whether a partial levy offset is required to avoid unnecessary overlap with the emissions price under the New Zealand Emissions Trading Scheme.

Chapter 15 – The built environment

Findings

F15.1

Increasing the price of emissions in the New Zealand Emissions Trading Scheme is the most effective way to incentivise a transition toward the construction of buildings with lower embodied emissions.

F15.2

Increasing the density of urban areas, combined with good public transport and accessibility, can reduce vehicular travel and emissions. But intensification of this nature has proven difficult to accomplish and runs counter to the living preferences of many New Zealanders. Urban planning policies are likely to take many years to achieve significant increases in density. By then, reductions in vehicle emissions may have already been achieved through advances in low-emissions transport.

Recommendations

R15.1

Future reviews of the New Zealand Building Code should examine whether the Code is sufficiently flexible to enable practitioners to adopt building materials and techniques with low embodied emissions.

R15.2

Forthcoming reviews of New Zealand's Building Code should assess whether there is scope to materially reduce peak demand for electricity through the introduction of more stringent energy efficiency standards.

R15.3

Government should continue to promote the uptake of energy efficiency in buildings, with a particular focus on reducing emissions associated with peak electricity demand.

Appendix A Public consultation

Submissions

Individual or Organisation	Submission number
ADLS	Sub 007
Adrian Macey	Sub 103
Air New Zealand	Sub 130
Andy Reisinger	Sub 028
Auckland Council	Sub 097
Auckland Regional Public Health Service	Sub 105
Balance Agri-Nutrients Limited	Sub 034
Bay of Plenty Regional Council	Sub 050
Beef + Lamb New Zealand and Deer Industry New Zealand	Sub 098
Bioenergy Association	Sub 037
BusinessNZ	Sub 089
Canterbury District Health Board	Sub 016
Carbon South	Sub 005
Chris Hook	Sub 132
Christchurch City Council	Sub 013
Clare St Pierre	Sub 115
Conrad Healy	Sub 113
Contact Energy	Sub 029
Dairy NZ	Sub 018
David Boyes	Sub 042
David Evison and Euan Mason	Sub 027
David Henley	Sub 090
David Lourie	Sub 086
Deidre Kent	Sub 087
Democrats for Social Credit	Sub 100
Electricity Retailers' Association of New Zealand	Sub 008
Emsol	Sub 066
Energy Management Association of New Zealand	Sub 070
Environment Canterbury	Sub 026
Environmental Protection Society	Sub 038
Evonik Industries	Sub 046
Export New Zealand	Sub 091
Federated Farmers	Sub 039
Fertiliser Association of New Zealand	Sub 061
First Gas Limited	Sub 047
Fonterra	Sub 088
Forestry Leadership Group – Climate Change	Sub 001
Generation Zero	Sub 119
Genesis Energy Limited	Sub 118
Geoff Thompson	Sub 019
GP International Limited	Sub 020
Graham Townsend	Sub 015
Graymont	Sub 033

Greater Christchurch Partnership	Sub 057
Guardians of New Zealand Superannuation	Sub 032
Hamish G Rennie	Sub 022
HERA	Sub 096
Hitachi Zosen Inova Australia Pty Limited	Sub 068
Horticulture New Zealand	Sub 041
Independent Electricity Generators Association	Sub 058
Indigo Limited - Biozest	Sub 092
Indigo Limited - Ecozest	Sub 093
Insurance Council of New Zealand	Sub 104
John Crook	Sub 031
Kirsten, Hikurangi	Sub 011
KiwiRail	Sub 124
Living Streets Aotearoa	Sub 074
Local Government New Zealand	Sub 036
Major Electricity Users' Group	Sub 045
Martin Toop	Sub 002
Massey University College of Sciences	Sub 076
Mercury	Sub 049
Meridian Energy Limited	Sub 055
Metals New Zealand	Sub 120
Methanex Corporation New Zealand Limited	Sub 107
Michael Reddell	Sub 111
Ministry of Transport	Sub 004
Molly Melhuish	Sub 079
Motor Industry Association	Sub 051
Motor Trade Association	Sub 125
Murray King and Francis Small	Sub 094
Nathan Surendran	Sub 106
National Energy Research Institute	Sub 053
Neste Singapore Pte Limited	Sub 128
New Zealand Automobile Association Incorporated	Sub 043
New Zealand Carbon Farming	Sub 095
New Zealand Church Climate Network	Sub 121
New Zealand Green Building Council	Sub 082
New Zealand Institute of Forestry	Sub 073
New Zealand Nurses Organisation	Sub 117
New Zealand Oil & Gas Limited	Sub 056
New Zealand Steel	Sub 064
New Zealand Wind Energy Association	Sub 040
NZX Limited	Sub 101
O-I New Zealand	Sub 085
Oji Fibre Solutions	Sub 071
Oliver Krollmann	Sub 114
Ora Taiao NZ Climate & Health Council	Sub 072
Orion New Zealand Limited	Sub 006
Pacific Aluminium	Sub 021
Parliamentary Commissioner for the Environment	Sub 054
Paul Callister	Sub 099

Pegasus Health (Charitable) Limited	Sub 112
Petroleum Exploration & Production Association New Zealand	Sub 065
Peter Buckley	Sub 023
Pioneer Energy	Sub 044
Principles for Responsible Investment	Sub 080
Rangitikei District Council	Sub 035
Refining NZ	Sub 129
Rick Bazeley	Sub 012
Robert McLachlan FRSNZ	Sub 009
Ross Clark	Sub 024
Roy Purvis	Sub 010
Scion	Sub 067
Shravan Miryala	Sub 017
South Island Regional Transport Committee Chairs	Sub 014
SRD Consulting	Sub 030
Strategic Lift Limited	Sub 060
Straterra	Sub 069
Susan Krumdieck	Sub 084
Sustainable Business Network - Circular Economy Accelerator	Sub 075
Tauranga Carbon Reduction Group	Sub 077
Tauranga City Council	Sub 126
Te Rūnanga o Ngāi Tahu	Sub 083
The Employers and Manufacturers Association (Northern)	Sub 109
The Manufacturers' Network	Sub 052
The Morgan Foundation	Sub 127
Todd Corporation Limited	Sub 122
Tony Banks	Sub 003
Tourism Industry Aotearoa	Sub 123
Transpower New Zealand	Sub 081
Trip Convergence Limited	Sub 025
Trustpower	Sub 059
Vector	Sub 063
Venture Southland	Sub 062
Vision Kerikeri	Sub 116
Waikato Regional Council	Sub 048
Wiremu Thomson	Sub 078
Wise Response Society Inc	Sub 102
Z Energy	Sub 110

Engagement meetings

Associate Professor Ralph Chapman, School of Geography, Environment and Earth Sciences, Victoria University of Wellington

Baroness Worthington (U.K.)

Bioenergy Association

Biological Emissions Reference Group

BlueScope New Zealand

BusinessNZ

Carbon Match

Chiltern Power Limited

Climate Change Iwi Leaders Group
Concept Consulting Group
Contact Energy
Delegation of the European Union to New Zealand
Dr Abrie Swanepoel, Department of Industry, Australian Government
Dr Adrian Macey, Institute for Governance and Policy Studies, Victoria University of Wellington
Dr Dirk Pilat, Directorate for Science, Technology and Industry, OECD
Electricity Authority
Electricity Networks Association
Electricity Retailers' Association of New Zealand and Electricity Industry Representatives
Energy Efficiency and Conservation Authority
Energy Management Association of New Zealand
Enviro-Mark Solutions
Environmental Protection Authority
Federated Famers
Fertiliser Association
First Gas Limited
Fonterra
Foreign and Commonwealth Office
HMI Technologies Limited
Indigo Limited
Insurance Council of New Zealand
Jill Duggan (U.K.)
Jonathan Church
KiwiRail
Landcorp
Local Government New Zealand
Low-Emissions Transition Hub, Ministry for the Environment
Mainfreight
MartinJenkins
Mercury
Meridian Energy
Ministry for Primary Industries
Ministry for the Environment
Ministry of Business, Innovation & Employment
Ministry of Foreign Affairs and Trade
Ministry of Transport
Motu Economic and Public Policy Research
National Energy Research Institute
New Zealand Agricultural Greenhouse Gas Research Centre
New Zealand Aluminium Smelter
New Zealand Carbon Farming
New Zealand Green Building Council
New Zealand Super Fund
New Zealand Transport Agency
Office of the Parliamentary Commissioner for the Environment
Parliamentary Commissioner for the Environment – Dr Jan Wright
Parliamentary Commissioner for the Environment – Simon Upton
Petroleum Exploration & Production Association New Zealand

Portchester Consulting
Professor David Evison, School of Forestry, University of Canterbury
Professor Geoffrey Heal, Columbia Business School
Professor Jonathan Boston, School of Government, Victoria University of Wellington
Rory Christian, New York Environmental Defense Fund
Sapere Research Group
Simon Corbell
Stephen Drew
Sustainability Council of New Zealand
Sustainable Business Council
Te Rūnanga o Ngāi Tahu
The Morgan Foundation
The New Zealand Initiative
The Policy Observatory
The Royal Society of New Zealand
Transpower New Zealand Limited
Victoria University of Wellington
Victoria University of Wellington - Deep South National Science Challenge
Vivid Economics
Westpac
Willis Re

Roundtables

Infometrics, Statistics NZ, Ministry for the Environment, Ministry for Primary Industries and Ministry of Business Innovation & Employment – Data Modelling

E-Mission Possible: Expert roundtables on thorny questions for a net-zero New Zealand –

1. Unlocking our low-emission future (November 2017)
2. Mitigation in the land sector (December 2017)
3. Low-emission investment and ETS reform (February 2018)
4. Directing mitigation policy and action for results (April 2018)

London/Paris engagement meetings

2050 Pathways Platform
Bank of England's Prudential Regulation Authority
Committee on Climate Change
Confederation of British Industry
Department for Business, Energy and Industrial Strategy
Grantham Research Institute on Climate Change and the Environment (LSE)
International Energy Agency
OECD Environment Directorate
Principles for Responsible Investment

Conferences and Seminars

Bioenergy Association Workshop
Climate Change 2017 (Chatham House)
Construction and Demolition Waste: Reducing, Re-using and Reporting on Waste in NZ
EDS Climate Change and Business Conference
Environmental Defence Society: Tipping Points 2017

Electricity Retailers' Association of New Zealand - Talking Heads
EVWorld NZ Industry Conference
Improving Foresight in Government and Safeguarding the Future
Local Government New Zealand - Metro Mayors Forum
Ministry for Primary Industries - Biological Emissions Reference Group (BERG)
Ministry for Primary Industries - Climate Change Forestry Reference Group (CCFRG)
NIWA - The Emergence of Climate Change
Productivity Conference on Technological Change and Productivity

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