Scion's response
to the
New Zealand Productivity Commission (2018) Low-emissions economy *Draft report*

Scion
FORESTS ▪ PRODUCTS ▪ INNOVATION

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1. Executive summary

Scion's role

Forestry is recognised globally as a key part of a low-carbon, bio-based economy. In response to Scion's Statement of Core Purpose, Scion's research is focused on achieving a successful low-emissions economy, ensuring a sustainable supply of wood and other products, while maintaining biodiversity and environmental protection.

As Scion embraces the challenges and opportunities ahead, we conclude that forestry could enable significant outcomes for New Zealand socially, environmentally and economically. Strategically, Scion's has set the following aspirational goals:

In 2050, through the power of forestry, New Zealand will have:

10-fold increase in GDP from forests and manufacturing
Zero net carbon emissions
Erodible land planted in permanent forests
Water quality issues from land use mitigated
Sustainable communities and economies in all regions
High OECD household net wealth ranking
A top five ranking in OECD better life index

Scion's research

Scion has defined three research impact areas for focus, with specified outcomes expected by 2030. These areas define where we will apply our expertise to deliver maximum impact for New Zealand.

Forests and landscapes

To grow healthy, resilient forests that are planted primarily for their standing-forest benefits.

By 2030 social, cultural, environmental, and economic benefits of these forests (exotic and indigenous) are fully valued, for example carbon sequestration, biodiversity (niches for endangered species), erosion and flood control, enhanced water quality, recreation and tourism.

High-value timber manufacturing and products

To grow healthy, resilient forests that produce high-value trees for manufacture into products that capture an increasing share of the global high-end market for timber.

Successful application of current and new forest models producing products for urban applications has the potential to add an extra $10 billion to New Zealand's GDP by 2030. In particular, this is made up of $7 billion in new housing builds and engineered timber applications, 50 per cent increase in new species commercial plantings, harvests and high-value applications, increased exports of processed timber and substitution for imported timber and products.

By 2030, a reduction of 2.5 million tonnes CO_2-e per annum is possible with 1.5 million tonnes increase in CO_2 capture per annum by faster growing trees and greater timber usage in urban buildings.

Biobased manufacturing and products

To grow healthy, resilient forests that replace petrochemicals and non-sustainable materials with products from trees and other biomaterials.

The potential is to create by 2030 an extra $20 billion to New Zealand's GDP, including $2 billion in fuel and plastics substitutions (imports) and $6 billion in exports. This growth will come from an emerging biorefinery sector producing biochemicals and energy products, new fibre-based materials, new cropping forests and manufacturing processes, as well as several hundred jobs in the regions and 10 million tonne contribution in reduction in CO_2-e.

Scion's Summary

Scion's response to the Productivity Commission's low-emissions economy draft report is substantive. This reflects both our appreciation of the domestic and international need for a swift transition to a low-emissions economy and that the report's scope meshes well with Scion's research portfolio as described above.

It also meshes well with the implementation of the One Billion Trees programme, a primary goal of which is to "help meet international climate objectives". There is opportunity to leverage this (not just as carbon sequestration but also through provision of new materials) as well as to explore extension of the target of one billion trees.

However, the vital, valuable, and transformational role of forestry in a widely shaped low emissions economy is largely missing from the report.

Key points

- The restriction of the role of forestry to only carbon sequestration misses the multi-sectoral role of this ecosystem, and the major opportunity to provide alternative feedstocks to petroleum and coal. We believe this risks the Productivity Commission appearing out of step with current government policy and lacking ambition and vision in this regard.

- The report needs to clearly spell out what is meant by a "low emissions economy" (e.g. which emissions are counted and which are not), and the purpose or goal behind seeking to achieve a low emissions economy. Without this, there is confusion about which options are helpful and which are not (e.g. plantation forests versus unharvested native forests; the role of wood products).

- It is worth the Productivity Commission noting that low *net* emissions are not sufficient to meet the aim of the Paris Agreement to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Meeting the Paris targets would require low *gross* emissions and negative *net* emissions, globally. Limiting to 2°C above pre-industrial levels is impossible without substantial 'negative emissions' – also known as carbon dioxide removal, new forms of which likely need to be deployed 2030 – 2050.

    - It is better to regard the stationary goal of "achieving net emissions targets" and the permanent shift of "achieving a low emissions economy" as two separate but linked concepts. A low emissions economy should mean a low *gross* emissions economy.

- The report should highlight that environmental reporting of carbon through its anthropogenic life-cycle can-be inconsistently reported domestically, even more so internationally. This is problematic, as with a market lead approach the most profitable carbon accounting is the temptation and 'green washing' common place with no quantitative accountability. The report should advocate for a set of government guidelines of how carbon emissions should be accounted for, define a consistent carbon life-cycle boundary, and propose or highlight the need for a standardised framework do achieve this.

- We agree that a more proactive response is required by New Zealand to reduce GHG emissions, which is necessary in order to address the threat of global climate change. It is, therefore, commendable that the Government aims to have a more ambitious emissions target set in law. This will require a substantial reduction in gross emissions, primarily by reducing the use of fossil fuels and will be costly if too much reliance is placed on short to intermediate term increases in forest sinks.

- As mentioned in the report, the New Zealand ETS did not help to achieve the desired changes in behaviours. Fundamentally, the increase in New Zealand's population and economic activity, coupled with a decline in the planted forest sinks have resulted in total emissions increasing, and have led New Zealand to have per capita emissions amongst the highest in the OECD.

- We agree with one of the reports main conclusions that forest expansion will be a critical alternative to help in the transitioning to a low-carbon economy according to the modelling performed. However, we believe that there should be two goals in the study:
    1. Meeting Paris Agreement emissions targets, which can be assisted by planting forests in the short to medium term.
    2. Achieving a low-emissions economy, which can be assisted by incentivising harvested wood products, thus locking in the carbon sequestration.

  Meeting goal (2) requires further investment and clearer pathways to support innovation to replace fossil fuel based products and transform negative emission technologies. It can also be at odds with accounting rules and ETS regulations.

- The Productivity Commission is to be commended in its ambition and robust attempt of marrying short-lived and long-lived greenhouse gases (GHGs) complicated by New Zealand's unusual GHG profile, and the emergent climate policy thinking on this topic. This is accomplished by a thorough assessment of the latest thinking citing global leaders in the field, some of whom are based in New Zealand.
    - To frame GHG accounting and policy development GHGs should be classed based on the duration they effect climate as either a stocks (century to millennia) or a flows (decades). There are four general GHG fluxes that matter for New Zealand's climate legacy:
        1. Domestic emissions of CO_2 (stock).
        2. Domestic sequestrations of CO_2 (forestry, stock or flow).
        3. Domestic methane emissions (flow).

4. Domestic purchases of international carbon credits (flow).

Mitigation of CO_2 should be the focus of New Zealand's climate policy, with reduction and stabilisation of methane secondary. To account robustly for long-lived and short-lived GHGs requires embracing creative climate science research and policy thinking. New Zealand's very high share of methane emissions is unique among developed nations, and has resulted in novel research and climate policy framework around the balancing of short lived and long lived GHGs. This unique situation could potentially enable New Zealand to become a global leader in international climate policy if successfully implemented domestically due to methodologies universal benefits.

- Relating emissions to future temperatures remains ambiguous as long as contributions are expressed in terms of CO_2-equivalent emission rates in a specific year defined using a metric such as the 100-year Global Warming Potential (GWP_{100}), as in the case of the majority of 'Nationally Determined Contributions' (NDCs)." This report should seriously consider embracing alternatives like GWP* domestically.

- The report arrives at a well thought through and robust conclusion, specifically to "separate long-term domestic targets for short- and long-lived gases". However, the implementation of this through a "single all-gases mitigation target" needs to carefully address the challenges associated with the de facto GWP_{100} emission metric. In implementing more appropriate alternatives New Zealand has the opportunity to show innovation by helping address the GHG climate policy hurdles required to meet Paris climate goals.

- Scion agrees with the statement that land use will need to change substantially to enable a low emission economy, and that afforestation has a significant role to play. Scion fully supports MPI's submission that the "right trees are planted in the right place for the right reasons". The report however, follows the traditional paradigm of considering various individual primary sectors (horticulture, cropping, sheep & beef, dairying, forestry) and the merits of each in large scale land use, without examining the potential advantages of an integrated land usage approach.

- We are concerned that the report often takes a narrow perspective on what are often complex, multidimensional issues. The report focusses on the financial incentives and impacts of change but lacks consideration of important social and cultural contexts in the context of green growth, the bioeconomy, and Sustainable Development Goals.

- We support the view that, as a signatory in international agreements, the New Zealand government upholds and represents the Treaty of Waitangi commitments.
  - Māori are noted as a significant proportion of the population in lower-income households vulnerable to negative economic impacts; however, the response policies outlined do not consider specific impacts on Māori, connect with discussions about Māori land ownership or explore opportunities for empowerment.
  - A fundamental assumption is that proposed "policies for inclusive transition" can deliver both growth and sustainability when there is no evidence that this has been achieved in the past.

- Scion has the research mandate to address the statement that "transport is one of the main sectors where deep emission cuts are both necessary and possible given existing and emerging technology". We believe that in addition to electric vehicle potential (particularly in the light vehicle fleet), biofuels produced in New Zealand from sustainable feedstocks e.g. plantation forests, have a pivotal role in replacing heavy transport sectors — international shipping and aviation are strategically important for New Zealand's trade and international partnerships and should receive further consideration.

- The built environment chapter requires focus on direct sources of emissions in addition to indirect. Scion conducts built environment research on wood design and construction technologies and distributed infrastructure, the environmental benefits of using timber in future urban developments, and the social and cultural implications of using wood in the design and construction sector.
  - We recommend considering all potential direct emission saving strategies and their implementation pathways in the New Zealand context as the main objective and goal of addressing the built environment.
  - We also recommend increasing focus on implementing international best practices in relation to built-environment emissions mitigation. This will help maintain a balance between people and the natural environment contributions in achieving the United Nations Sustainable Development Goals.

Generally, the report's delivery could be better; currently chapters are mostly presented as stand-alone entities. More cross-referencing would potentially remove repetition and contradictions between and within chapters; some of the findings and recommendations can also appear disjointed. We have also commented directly on each chapter's content.

Finally the report needs to have a clear rules on terminology to avoid the overuse and misuse of terms; these should be added to the commonly used terms list. For example "clean technology" is not the only language to refer to low emission technologies, specific alternatives include: sustainable, green, biobased should be utilised. Likewise the "low emissions economy" is also used interchangeably with: bioeconomy, circular economy, sustainable economy, green economy, and low carbon economy.

However, there is no doubt that this report has the potential be a substantial resource for government policy decisions as New Zealand makes a globally endorsed transition to a low-emissions economy.

2. Climate change, emissions, and the New Zealand context

Scion's role

Scion has been closely involved in the design and implementation of MfE's Land Use and Carbon Analysis System (LUCAS) for planted and natural forests, including training and auditing of field teams, data checking and calculations, including model development for predicting carbon stocks and changes in these forests. The carbon yield tables prepared for MfE are incorporated within MfE's Calculation and Reporting Application (CRA). In addition, the data and models underpin yield tables developed for MPI (default lookup tables in the New Zealand ETS). Scion also has extensive experience in modelling future stock changes in planted forests and wood products and in research on the impacts of climate change on the sector and the potential for low-emissions biomaterials and bioenergy.

Summary

We agree that a more proactive response is required by New Zealand to reduce greenhouse gas (GHG) emissions, which is necessary in order to show global leadership in addressing the threat of climate change. It is, therefore, commendable that the Government aims to have a more ambitious emissions target set in law. In the medium to longer term, this will require a substantial reduction in gross emissions, primarily by reducing the use of fossil fuels, and that delays will be costly if too much reliance is placed on forest sinks.

The New Zealand ETS clearly did not help to achieve the desired changes in behaviours. Fundamentally, the increase in New Zealand's population, the increase in economic activity, coupled with a decline in the planted forest sink strength have resulted in total emissions increasing, and New Zealand per capita emissions are amongst the highest in the OECD—metrics that do not look good from an international perspective. We agree that broader action is required across local government, iwi, businesses, and household, and effective information transfer will be key.

Scion's comments

Key points

Bullet points 5 and 6:

1. It is noteworthy that New Zealand, with its substantial albeit declining forest sink strength, saw a significant increase in gross emissions, which is in stark contrast to the majority of OECD countries without such substantial forest sinks. This is an important lesson for the billion trees programme – vital as it is to sequester substantially more carbon dioxide from the atmosphere, New Zealand must act sooner than later to reduce GHG emissions.

Bullet point 9:

2. We agree that behavioural changes in families is key, particularly in regard to reducing emissions from fossil fuels. To reduce emissions, families need to have increased confidence to make the switch to electric vehicles (EVs), which will require educating the public about "EV thinking" with potentially a set of policies that incentivises EVs and disincentives fossil fuel consumption along with mapping out and communicating options

that will ensure electricity supply will meet the expected increase in electricity demand following the switch from petrol and diesel.

3. Some observations:

    - Commuting distances (and probably the majority of miles travelled by most families) are well within the range of currently available EVs, hire or use a second vehicle for long trips;
    - Fossil fuel emissions from EVs are zero;
    - Solar panels/storage batteries are available now, but cheaper options expected in the near future. Otherwise, families may continue with the status quo, and in effect do nothing to reduce emissions from fossil fuels.

2.3 New Zealand's emissions profile and recent trends

- 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. We have high emissions per capita from agriculture because we export 90% of what we produce; conversely, we have low industrial emissions because we import appliances, electronics, cars, machinery, etc. We are a relatively large country with a low population density which affects public transport, waste management, etc.
- 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. This has been expected for decades. Scion is leading the science drive behind the governments billion tree planting policy, which during the next ten years will reverse this planting decline if the programme is completed.

3. Mitigation pathways

Scion's role

Scion has developed and applied dynamic models of plantation forestry for decades (e.g. Manley et al., 1991; Manley and Wakelin, 1995; Monge and Wakelin, 2018b). This work has included modelling carbon stocks and economics at the stand and estate levels (e.g. Maclaren and Wakelin 1991; Turner et al 2008). Modelling has been used to identify optimal harvesting schedules conditioned to uncertain market prices, to inform policymakers on future trends of forest carbon uptake and emissions, and to identify optimal value chains. Scion is also a leader in New Zealand in the development of state-of-the-art technologies producing wood-based products such as bio-materials and bio-energy. Recent projects such as the Biofuels Roadmap have built on the extensive knowledge and experience built up over time (Suckling et al., 2018). Scion has the models, knowledge and technical skills to link spatially distributed forest resources (using productivity and carbon inventories) to the manufacturing value chain and international markets (Monge and Wakelin, 2018b). This gives Scion an excellent understanding of appropriate approaches to model forests across space and time in New Zealand.

Summary

We agree with one of the draft's main conclusions: that forest expansion will be a critical alternative to help in the transitioning to a low-carbon economy according to the modelling performed. However, we believe that it is helpful to consider two separate goals: (1) meeting Paris Agreement emissions targets and (2) achieving a low-emissions economy. The first goal could be met by planting forests in the short term, as concluded in the study, whereas the second one would be achieved by significant reductions in fossil fuel use and livestock and N_2O emissions. Increased use of forest products as substitutes for higher emission products should be part of this strategy. As such, there is a lot of scope to properly model forestry as a land use and as an industry including the processing of wood products. We have identified clear gaps in the inclusion of the time dimension of forestry, mainly the consideration of the long-term consequences of the carbon sequestered in the short-term: (1) emitted to the atmosphere after harvest or decay, and (2) stored in harvested wood products. The disregard of harvested wood products (e.g. building material, bio-products, bio-energy, etc.) in the analysis is definitely a gap as these products would retain the carbon sequestered by forests or circulate it as sustainable energy material (e.g. liquid and solid bio-fuels).

Overarching comments

The scenario approach is good. However, the reliance on historical industries and their existing emissions profiles is a limiting factor in the modelling. Some consideration should be given to integration of land uses. As referenced in Chapter 10, Reisinger et al. (2017) show there is significant efficiency to be gained by improving our systems through integration of forests, rather than re-shuffling areas in current industries assuming business as usual.

Scion's comments

Key Points

Bullet point 8:

- The draft states that: *"…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."* This misses the point that a large established forest represents a large resource of stored energy as well as stored carbon. A sustained production of forest products is then possible and these can be used to replace emissions-intensive alternatives.

- The potential contribution of forestry is reduced to sequestration only in the report because: (1) cellulose-to-fuel has been dismissed as an option (even though wood waste is already used to generate heat and electricity), and (2) the narrow focus on New Zealand's accounting liability does nothing to incentivise the use of sustainable, low-emissions wood products over imported alternatives e.g. steel or plastic.

The draft refers to "zero net emissions for 2050". The use of single-year targets for net emissions can be misleading due to age class effects in forestry, and is not recommended.

3.1 Overview of key modelling results and insights

- The draft states that: "Along the modelled pathways, the expansion of forestry is central to the achievement of large reductions in net emissions…" We raise the same comment as for bullet 8 in the Key Points above.

3.2 Modelling approach: structure, assumptions and workings

Scenarios of technology development

- The expectation that the Tiwai point smelter will close is something that has been talked about since the day it opened in 1971. It recently contracted another 50MWe out to 2022 and reopened its mothballed 4th pot line. Aluminium from this smelter may well attract a premium or preferential market access due to its low carbon footprint. The assumption that it will close may not be justified. At the very least, the possibility that it remains open should be considered as it consumes 14% of New Zealand's electricity. Assuming that both the steel mill (Glenbrook) and the aluminium smelter will close in 2025 will profoundly affect the results of the modelling.

Box 3.1 Short descriptions of the models used

- There is no clear and thorough explanation of Concept's ENZ model. The report "Modelling the transition to a lower net emissions New Zealand" (Vivid Economics 2018) does not provide a clear explanation of the ENZ model in the report or appendix. A more explicit description of Concept's ENZ model would be helpful. In contrast, the Motu LURNZ model is well described including supporting science behind the model with additional references to Motu working papers. It is difficult to review the modelling results without even a reference to the class of models ENZ belongs within.

- The ENZ section on forest processing in the Vivid Economics (2018) report says: "The modelling for the emissions from the forestry processing sector is very limited, in large part because the process heat to undertake such processing is now largely provided by biomass – and thus low-emissions" (p. 59). That is a fair statement. However, we think that considering the carbon locked into Harvested Wood Products (HWP) would have been critical in the modelling exercise as it would have provided a more holistic picture of the trajectory of the carbon sequestered in the resulting afforestation of the various scenarios. With forestry being a centre piece of the results, the accounting of HWP would be crucial to suggest potential policy modifications.

- The authors state that LURNZ is a “partial-equilibrium model”. After reading the Vivid Economics (2018) report and the various references to the Motu working papers, it seems that LURNZ belongs to the revealed-preferences, econometric category of land-use models according to Stavins and Richards (2005) and van Kooten and Sohngen (2007). We would suggest the authors clearly state the differences between the “partial equilibrium” component of LURNZ and the “partial equilibrium” component of the sector optimization category of land-use models defined by Stavins and Richards (2005) and van Kooten and Sohngen (2007).

Figure 3.4 How the models and sectors are linked

- There is no clear explanation on how the models link to each other to generate an emissions price. We suspect that both LURNZ and ENZ generate supply curves of emissions offsets (i.e. marginal abatement curves), which then are matched to potential offset demands from agriculture and other net emitters. However, there is no clear explanation as to how this protocol works. We suggest the authors to include the mathematical structure of how such a price is discovered as it is a critical component of the entire exercise.

Table 3.2

- There is no mention of forestry at all in this table, e.g. no indication of the sequestration rates assumed for difference types of forests. It is highly likely that changes to forestry practice could substantially increase growth rates and amounts of carbon sequestered per hectare. For example, recommended optimal final crop stocking for unpruned regimes has gone from 350 stems ha-1 (Whiteside et al., 1997) to 603 stems ha-1 (Watt et al., 2017), and this is without attempting to optimise for carbon sequestration.

- In the transport section, there is apparently no consideration of biofuels in the scenarios. This ignores the potential of liquid biofuels associated with the afforestation. More modelling should include this opportunity as shown in Suckling et al. (2018). If they are not considered to be available as a source of bioenergy then this is a substantial oversight.

3.2 Modelling results

- As mentioned above, it is misleading and potentially dangerous to report net emissions in a single year without considering the future implications, such as any increased harvesting as a result of an afforestation programme.

- Page 57. The reliance on sequestration by forests means that these are not pathways to a low or zero emissions economy—they are pathways to achieve short- to medium-term net emission targets. There is a limit to land that is available for afforestation.

Electricity, transport and industry

- There is no mention of the potential for bio-electricity from combined heat and power (CHP) systems. There is a substantial opportunity here. Further, there seems to be no recognition of the looming gas shortfall as New Zealand’s existing gas fields decline

(MBIE, 2018). If we run out of gas the closure of the CCGTs will be enforced. As a consequence of low gas supplies a possible scenario is that Huntly continues to run on coal for a substantial period. The closure of its two remaining units has already been delayed.

- Although biofuels are mentioned as a part of the "stabilising decarbonisation" scenario (page 49, numeral 3), there is no mention of the potential of liquid biofuels to fuel the continuing demand from ICEs in the results. If this is the case, there appears to be a significant gap in the analysis as we believe that biofuels would be a key component in the transition to a low-carbon economy.

Fig 3.10 Forestry sequestration increases from current levels

- The report needs to provide the assumptions made (e.g., the type of forestry, reasons for the plantation/native proportions, sequestration rates, and rotation lengths) and also extend the graph beyond 2050 to show the full consequences of the afforestation program.

3.2 Modelling insights

- Saying that sequestration from afforestation puts New Zealand on a pathway consistent with zero-emissions is misleading. It is better to separate the goal of zero-emissions (to which forestry contributes via products) and the short to medium-term net emission targets (for which sequestration by forests is useful).

- Since forestry is a clear key component in the transition to a low carbon economy according to the models' results, we see a gap in linking emissions prices to various forest management alternatives, including extending rotations (Monge et al., 2016) or other more integrated systems including native species (e.g. agro-forestry or silvo-pastoral systems) (Monge et al., 2016; 2017; 2018a). We believe that at high emissions prices, permanent forestry would become an acceptable alternative to help in the transition. Such permanent forests would be a clear candidate in steep, remote and erosion-prone areas such as the East Coast.

- As mentioned above, the analysis ignores the issue of the potential of the new forests to provide products of any kind, including biomass for bioenergy.

- The report states that iron, steel and aluminium manufacture will be lost and presumably replaced with imported substitutes (which are 'emissions-free' as far as New Zealand's accounts are concerned) rather than New Zealand-grown wood products. How does this mitigate climate change?

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4. Emissions pricing

Scion's role

Scion has generally supported the ETS concept, contributed to development of ETS policy and regulations, and worked with government and industry on ETS issues as they relate to forestry. Scion has not carried out any specific work on the relative merits of a carbon tax compared with an emissions trading scheme.

Summary

A global, all sectors, all gases emissions trading scheme appeals as the theoretically most economically efficient way of tackling the emissions problem. The question is whether a partial, domestic ETS is still efficient given all the compromises that are made to take into account objectives other than reducing atmospheric GHG concentrations. In this respect, it is important to consider whether driving emissions out of the NZ economy by shifting them offshore is a sensible outcome.

The problems experienced to date with the ETS are clearly laid out. The ETS is the cornerstone of New Zealand's climate change mitigation response, so it is concerning that it has had little or no effect on New Zealand's emissions. It is acknowledged that political uncertainty and interference in the emissions market is viewed negatively by potential participants, yet this chapter also explains why ongoing interventions are necessary. There is a danger that we are trying to deal with a case of 'market failure' by propping up another failing market, which may incentivise behaviour that results in no overall climate change mitigation benefit.

The overall problem is that the ETS (and this report) is only concerned with achieving New Zealand's domestic net emissions targets. Emissions pricing is discussed in this context. This explains why forestry is only seen as a short-term solution and wood products are not considered.

Scion's comments

4.2 Controlling emissions: permits versus an emissions tax

Some of the advantages of an emissions trading scheme are perhaps theoretical given that the ETS is not 'pure' and requires manipulation to avoid leakage and to meet other objectives.

4.3 Specific issues in emissions pricing

Emissions leakage and free allocation

- This covers the issue of how "low" do we really want New Zealand's emissions to be, since we don't want to simply encourage leakage.
- Scion supports the conclusion that it is better for agriculture to be included in the ETS with some level of free allocation, rather than to remain excluded.

International emissions trading

- The international carbon price is much too low. If the Paris temperature targets are to be achieved then an explicit carbon-price of at least US\$40-80/tCO_2 by 2020 and US\$50-100/tCO_2 by 2030 is required (High-Level Commission on Carbon Prices 2017)
- Here it is demonstrated that theoretically efficient markets do not necessarily deliver the outcomes sought, and that there is likely to always be government intervention in favour of one co-benefit or another.
- Page 88. The report notes that "*Measures that reduce domestic emissions may create other environmental benefits, social benefits, or both"*.
- It is good that other additional benefits such "better air and water" are considered here. Other important environmental benefits could be mentioned, such as reduced soil erosion (especially when trees reach full canopy closure), flood mitigation, water flow and temperature regulation, improved land-use productivity and provision of habitats for native species (Yao et al. 2013). Other environmental benefits are listed at MPI's Afforestation Grant Scheme website (https://www.mpi.govt.nz/funding-and-programmes/forestry/afforestation-grant-scheme/) and Waikato Regional Council's tree planting guide (https://www.waikatoregion.govt.nz/assets/PageFiles/3354/section1.pdf)
- We note that measures may also create environmental or social costs, e.g. leakage.

Carbon sequestration

- Page 90. The report states that: "*The NZ ETS currently assumes that a high proportion of the carbon is released at harvest and the rest is released within ten years*".
  This is true for an even-aged stand of trees, but misses the point that the creation of a forest of mixed age classes can represent a shift of CO_2 from the atmosphere that lasts much longer than "rotation + ten years". E.g. Kaingaroa forest which has maintained a significant carbon stock for > 50 years, despite ongoing harvesting.
- Page 90. Finding 4.7 states: "*A carbon tax itself cannot incentivise carbon sequestration unless supplemented by a sequestration subsidy*".
  Carbon sequestration by forests can be incentivised by any tax that improves the profitability of forestry as a land use compared with alternatives, or improves the relative

cost of locally grown wood products compared with alternatives. It is true that such a tax would not incentivise forests that are not intended to be harvested.

- It would be helpful to emphasise the broader values provided by forests, stating that it does not only provide the landowner with revenues from selling carbon credits, but a number of market and non-market ecosystem services listed in relevant websites including Planting one billion trees, Native planting programme, and Top 22 benefits of trees.

Points of Obligation

- It would be useful to discuss the point of obligation for wood products here. As with dairy, meat and wool, a high proportion of New Zealand's wood products are exported. However, as with oil, wood products are exported with the embodied CO_2 intact. Apart from manufactured products that are re-imported back into New Zealand, release of CO_2 takes place outside New Zealand. Accounting using one of the IPCC approaches (Atmospheric Flow) acknowledges this by accounting for these emissions where they occur. The accounting approach used in the Kyoto Protocol (Production Approach) does not.

Using a shadow price for emissions

- This appears to be another example of intervention in the emissions market because it isn't working in practice.

Pricing co-benefits and co-harms

- It would be helpful to mention specific co-harms e.g. to trade-exposed businesses or ecosystems. In terms of co-harm, afforestation can lead to a reduction in water yield at the catchment level (Ausseil and Dymond, 2010; Ausseil et al., 2013)
- Co-benefits such as avoided nitrogen leaching now has a market price in the Lake Taupo Nutrient Trading Scheme where a nitrogen credit (e.g. avoided N leaching of 1 kg per ha) had a starting price of $400 per kg (price then went up to more than $600 and then somewhat stabilised at $300 per kg (Monge et al 2015). Non-market values of other co-benefits for planted and native forests are listed in Table 5 of Yao et al. (2013). Indicative co-benefits values can be incorporated in undertaking an extended benefit costs analysis or a more generalised trade-off analysis than in Yao and Velarde (2014). Other co-benefits include recreation, biodiversity and avoided erosion (Dhakal et al. 2012; Yao et al. 2014).

4.4 New Zealand's system of emissions pricing

- The report states that: *"…after New Zealand's projected emissions against its Kyoto commitment changed from overachievement to underachievement…"*

Although this was only as a result of deliberately adopting "worst case" modelling scenarios, as borne out by subsequent revisions.

4.5 Emissions pricing objectives

- It is clear that the report is only interested in an emissions market that drives down New Zealand's domestic emissions, and that issues such as co-harms and leakage will have to be dealt with separately. This half page is key to interpreting the whole report, and explains why forestry is only seen as a short-term measure.

- Point-in-time gross emission targets are okay but net emissions targets need to be averaged over a longer budget period recognising the different timescales of the sources and sinks.

Findings

F4.2

- There are ongoing costs in maintaining and 'tweaking' the ETS as well, and in implementing other measures that will be required to avoid perverse outcomes.

F4.3

- It should be recognised that while a free allocation allows firms to compete with overseas products that do not face an emissions charge, but also allows them to compete unfairly with low emissions products produced in New Zealand. This suggests that subsidies may also be required.

F4.7

- Carbon sequestration by forests can be incentivised by any tax that improves the profitability of forestry as a land use compared with alternatives, or the use of locally grown wood products compared with alternatives. It will not incentivise forests that are not intended to be harvested.

F4.10

- Co-harms will also need to be taken into account if the ETS is to be supplemented with other measures.

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5. Innovation

Scion's role

Scion's role as a CRI is to create new opportunities for New Zealand in trees and forests and manufacturing products from these when harvested. Key elements in our Strategic Intent include development of manufactured biomaterials, bioenergy and ecosystems services – not only in trees and forestry. Scion's focus is on opportunities in the Bioeconomy and Circular Economy which in turn deliver low carbon emissions. Some of these are being enabled through work with forward thinking and globally connected companies.

Examples of innovations that support this drive include development of natural fibre plastic and bioplastic composites (also known as Woodforce), a new fully biobased glue for plywood with low emissions in housing, development of the Zespri biospife and biobased and biodegradable plastic clips for holding netting on vines prior to harvest of grapes, use of trees as a biorefinery feedstock to make chemicals, energy and plastics, tracking systems to prove that packaging and products encased conform to standards requirements (for claims), biotechnology solutions to modify trees, new ways to grow forests including short rotations to provide fibre or chemicals or energy and ecosystems services provided to the community by trees and forests. Climate change projections and environmental needs have driven much of Scion's approach to research projects.

Summary

We support the report's view of innovation that goes beyond physical technologies and includes innovations of process, governance, social institutions and other intangibles; however, this should be more explicitly stated to acknowledge the important role that these may have in enabling economic transitions and the adoption of low-emissions technologies.

We note that the language of clean technologies should not be adopted as the only descriptor, as many other words are used to describe the same thinking – e.g. circular economy technologies, bioeconomy technologies, biobased technologies, low carbon technologies. We also note that there are also many technologies (e.g. building in wood) that are already low carbon emission technologies, although there is also room to improve these too.

The chapter would benefit from discussion of how the shape of New Zealand's economy—with a high percentage of small to medium enterprises and strong influence of primary industries—, and how it is "measured" influences the amount and focus of innovation investments and the ways that policies interact in this context.

We would add a comment that comparing costs to current well used technologies will always work against innovations – due to the time needed to embed a new technology. For example the current petroleum industry made very expensive new chemicals 100 years or so ago, which are now relatively cheap due to incremental improvements. This is a hurdle Scion often finds it needs to overcome (in response to resistance to uptake by a currently successful business) to get new technologies adopted, especially in New Zealand.

Scion's comments

Key Points

We agree with the comments in the Key Points and they appropriately point out that Innovation is not a simple or easily predictable process. We endorse the comments on New Zealand's low investment and poor record with innovation, and comment also that many of New Zealand's approaches to investment rely on competition rather than collaboration. Many New Zealand research organisations and employees are structured and judged also on competitive success. As stated, resources and policy attention should shift to a focus on enabling low emissions technologies investigations and uptake to become eventually status quo.

A very useful book to read on the challenges of innovation is that by Calestous Juma: *Innovation and its enemies: Why people resist new technologies.* In it he describes the factors hindering acceptance of innovation historically with excellent examples (eg cars, electric lights, telephones, personal computers). In essence the incumbents (business and legislative) are normally threatened by disruptive change, indicating how critical strong strategies and support are required in order to make such change. He outlines how the simple rules of supply and demand do not apply when new technologies change the character of the economy, such as when we are discussing a low emissions economy. He demonstrates how pseudoscientific evidence is more easily accepted than scientific evidence if the new technology differs from status quo, and shows how these human traits are exploited by the vested interests of incumbents, who are the 'losers' when their technology is replaced.

5.1 Innovation for a low-emissions future

Box 5.2 Institutions and policies that support knowledge creation and use (p.112)

Intellectual property rights (p.112)

- The limitations in intellectual property rights identified are a major barrier in co-investment in innovation by industry. The government faces a quandary as it simultaneously drives to deliver benefit to New Zealand and request additional R&D funding directly from industry. Broad benefit to New Zealand often impacts on benefits derived for the business/ industry co-funding a specific project.

- A number of contestable funding mechanisms in New Zealand have a pre-requisite co-funding component. For example, the Waste Minimisation Fund administered by the Ministry for the Environment will not fund the full cost of a project and requires an element of cash co-funding, yet the intellectual property rights in the deed of funding are restrictive to co-funders so as to broaden benefit to New Zealand.

- The Sustainable Farming Fund administered by the Ministry for Primary Industries has increased its focus on projects driving innovation, has a 20% cash or in-kind co-funding element, and any intellectual property created during the project becomes the property of MPI. This makes co-investment in these funds unattractive for manufacturers and other companies who are looking to gain competitive advantage from their investments in R&D.

Public subsidies for private R&D (p.113)

- This section needs to be updated to take into account the new R&D tax credits announced in the May 2018 Budget.

Direct government purchase of research (p.113)

- The government no longer directly funds research organisations such as CRIs but operates all investment as a fixed term contract.

Subsidies to emissions-intensive activities discourage innovation (p.113)

- This section should be clarified to make explicit that research into biofuel technologies used as replacements for fossil fuels or as partial replacements should not be inhibited.

Box 5.4 Key elements of a good innovation system (p.118)

We endorse the comments and examples used in this section.

An additional feature not commented on is that critical mass is needed and is generally relatively close by, and New Zealand is challenged in this with a low population and population density and distance to nearest neighbours/markets. Hence global partnerships relationships and markets are even more important for New Zealand than many other OECD countries (including those used in examples). This may challenge perception of a low emission economy.

Risk and uncertainty management (p.119)

- A mechanism that can be added to the R&D tax credits is to consider relaxing co-funding requirements for funding mechanisms that are missioned to deliver broad benefit to New Zealand. MBIE implemented this change partially when the new Endeavour Fund came into effect (MBIE 2017) and there is scope for other funding mechanisms to follow suit.

Absorbing knowledge from other countries (p.120)

- The report describes an overly-simplistic dichotomy between knowledge production and consumption from abroad that does not reflect the reality of modern research. A significant proportion of the research undertaken at Scion involves collaboration with overseas researchers. A better question would be to ask how New Zealand can continue to be involved in international research discussions and ensure that we maximize the value received from our contributions.

The key overall message (p.120)

F5.8: Bullet point 3: Domestic and international links between firms, investors and researchers.

- The report should consider what role the MBIE administered Catalyst Fund could play in supporting international research linkages to support clean technology innovation. The Catalyst Fund "*supports activities that initiate, develop and foster collaborations leveraging international science and innovation for New Zealand's benefit*". Calls for proposals for strategic funding under this mechanism typically align with joint research priorities arising from MBIE's international science partnerships. For example, the May 2018 budget announcement included $54 million over the next four years to support a bilateral ‘Enhanced Partnership’ with Singapore including data science and future foods research. A similar approach could be taken targeting partnerships with countries with a shared focus on innovating for a low-emissions economy.

5.2 Current support for low-emissions innovation in New Zealand

Support for public-good research and business R&D (p.121-122)

- MBIE is not a research organisation – this is misleading and should be reshaped to reflect what the National Science Challenges (and other “programmes”) are.

- The scope of Scion’s research into ways to reduce or absorb emissions is broader than forestry as it spans innovations along the forest value chain from the gene through to manufacturing biobased products from a range of resources. It is not all applied research (as in other CRIs as well). Both Universities and CRIs (and private research institutes/organisations) carry out both fundamental and strategic research as well as applied research.

- Callaghan Innovation also carries out research as a Government Agency (not a CRI or University or private organisation).

Box 5.5 The Endeavour Fund and low-emissions research (p.123)

- There is scope in the next iteration of the MBIE Endeavour Fund Investment Plan, which is due to be refreshed ahead of the upcoming round, to tie investment priorities more closely to science priorities listed in roadmaps supporting low-emissions research such as the Primary Sector Science Roadmap (MPI 2017) and the Conservation and Environment Science Roadmap (MfE & DoC 2017).

Figure 5.5: New Zealand’s science and innovation public funding landscape (p.124)

- Needs to be updated to include the new R&D tax incentives and the Provincial Growth Fund.

Table 5.1: Mission-led and industry-led research support schemes funded or co-funded by government (p.124-125)

- Strategic Science Investment Fund (SSIF): This is contracted rather than providing funding. Even though low-emissions innovation is not specified as a priority, there is research in this area supported by the specific platforms funded. For example, one of the SSIF platforms contracted to Scion focuses on manufactured products from trees, which includes a number of research areas supporting low-emissions research. Examples include sustainable energy using forest biomass, use of more wood and fibre in the built environment, new technologies in packaging and development of biorefineries.

- Callaghan Innovation and business R&D grants: Needs updating to include the budget 2018 R&D tax credit announcement.

- Several mission-led funding mechanisms are missing. These are:
    - The Provincial Growth Fund, in particularly the Billion Trees initiative

- The Waste Minimisation Fund, the scope of which has broadened to include projects in support of a circular, low-emissions economy
- The Sustainable Land Management and Adaptation to Climate Change funding mechanism administered by MPI
- The Sustainable Farming Fund administered by MPI which had and increased focus on innovation in the 2017/2018 round.
- The Catalyst Fund administered by MBIE targeting international science partnerships with countries with shared priorities (this could be in low-emissions innovation).
- The Green Investment Fund is on the horizon and should be included in the report

Assessment of New Zealand’s support for low-emissions innovation (p.126)

- *p. 126*: “*Other primary industry areas also receive some emphasis – for example forestry and horticulture through the CRIs Scion and Plant and Food. […] These efforts are modest relative to the potential and probable need for these sectors to expand and make a significant contribution to reducing emissions*.” The report needs to acknowledge the increased focus on forestry by the government as a climate change mitigation strategy, including the billion trees initiative. However, with the accelerated planting it is important that funding for R&D is proportionally accelerated, not only to ensure that the right trees are grown in the right locations, but also to fund research into clean technologies and products derived from trees to enable longer-term climate change mitigation benefits from forestry to be realised.

- *p. 127: “Research strengths exist in materials science…”.* Scion should be listed alongside the MacDiarmid institute and GNS as R&D into the production of biomaterials is a requirement within Scion’s strategic intent and has significant effort.

Strategic fit and conclusions (p.127)

Bullet point 2:
Scion is required in its statement of strategic intent to research into bioenergy as well as to research biomaterials. The production of biofuels could also be included here as another example, referencing the Biofuels Roadmap (Suckling et al 2018).

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6. Investment

Scion’s role

Scion directs its Strategic Science Investment Fund (SSIF from MBIE) funding into research and development according to our Statement of Core Purpose as a CRI. Scion also successfully prepares proposals for contestable, and commercial funds. All cover a focus on bioenergy solutions, ecosystems services, forest/tree research from gene to product, including biomaterials not derived from trees. These activities support the growing circular and bioeconomy, which also requires consideration of low carbon emissions and trade-offs between various choices such as carbon capture and carbon usage, and origin of carbon in New Zealand.

Summary

- We endorse the key recommendation on the need for a New Zealand specific investment strategy that enables confidence, speed, and alignment of low emissions investment landscape. However the importance of the investment signals in enabling the low carbon transition across most of the sectors does not come through as strongly as it could and in particular the need to move quickly. New Zealand’s Venture Investment Fund – should have a priority (not sole focus) on low carbon technologies. The Government Science Investment Funds should also have a priority on R&D in low carbon technologies.

- While the general and more standard mechanisms for “green” investment are discussed, active preferred purchasing by government should also be included as a driver of change and provision of market pull.

- More details and suggestions for direct government investment, e.g. in the electric vehicles fleet as mentioned in the transport section, but also in public transport and infrastructure that sometimes falls between councils and central government would be beneficial.

- The role of Local Government investment wasn’t addressed. Urban planning/transport/public transport investment should be a direct government investment priority and addressed in investments.

- It would have been helpful to have a more detailed assessment of key areas that New Zealand must change in order to accelerate to a low carbon economy – e.g. transport and agriculture and industrial heat and investment decisions/mechanisms that could support this.

- The health of the wider forest processing/products industry wasn’t really addressed – and its influence on afforestation. In particular, the impact of offshore investment/decision making that may not be so readily influenced by local policy/incentives, e.g. the price of logs versus processed products, lack of incentive/investment motivations to grow alternative processing against status quo.

- The financial stages of low-emissions technology development in Figure 6.3 are unrealistic given the risks for private investors and the noted comment on page 138: ‘there is a disconnect between standard commercial decision-making and the public interest of avoiding dangerous climate change'. Government needs to play a greater role in providing financial support during the risky stages of technology development (tech research, technology development and a portion of the scale-up).

- This chapter would benefit from emphasising (currently referred to only lightly) that the system will break down if differing models and boundaries are used to calculate carbon origin (current CO_2 versus stored), impact of processes and materials, including whole of life benefit analysis versus short term immediate impacts. This has been an issue in Life Cycle Assessment reports for different products and activities currently, and would impact significantly on green investment; system consistency is needed, and will need to be agreed.

7. Laws and institutions

Scion's role

Scion's role in policy analysis focusses on how policies and institutions influence the delivery of research outcomes to communities and sectors. Key research has been undertaken on understanding the impacts and implications of climate change to the forest sector and to affected communities; identifying factors influencing decision-making and change; and innovation systems analysis, which includes institutions at the governance scale. Some of the current research being undertaken involves evaluating the impact of Ministry for Primary Industries Sustainable Land Management and Climate Change funded research on adaptation planning at a catchment scale.

Summary

Scion generally supports the recommendations in this chapter.
We note, however, that discussion of laws and institutions is focused solely on those addressing low carbon emissions directly. The other legal and institutional repercussions raised in the rest of the report and beyond are missing. For example:

- Chapter 5 describes how innovation plays a large part in addressing wicked or ill-structured problems and recommends several policy and institutional changes to support the desired change, yet this chapter does not acknowledge or address these legal, policy or institutional changes.
- Chapter 9 discusses changes that may be necessary to support communities negatively affected by economic changes, but these are not acknowledged in Chapter 7. Though the impacts of dealing with, and adapting to, inevitable climate change are regressive, there is no explicit mention of potential institutions or legislative responses to this issue. We note that the UK act explicitly addresses adaptation and climate resilience with five yearly cycles of risk assessment and adaptation plans.

We would recommend that all recommended or potential instruments that are discussed in other parts of this report are consolidated in this chapter, so that the entire regulatory response to a low carbon economy can be developed coherently.

Scion's comments

Overarching comments

We agree in general with the findings and recommendations in this chapter; however, we note several omissions from the discussion and have concerns about the scope and perspective used in undertaking the analysis.

- Though the chapter highlights a lack of policy coherence as a barrier and recommends a comprehensive framework for change, the chapter itself takes a narrow perspective that focuses on laws and institutions that directly relate to carbon emissions and New Zealand's commitments under UNFCCC and the Kyoto Protocol. The chapter does not consider the wider vision of, and repercussions from, transitions to a low carbon economy.
- We suggest that the discussion of Laws and Institutions must go beyond just a focus on a potential Climate Change Act and potential Climate Commission and must also address

policies and institutions necessary to support economic transition, climate change adaptation and social justice; i.e., the ability of individuals, communities and businesses to be able to thrive under climate change and a transition to a low carbon economy.

- For example, as discussed in Chapter 5, innovation will play a significant role in transitioning to a low-carbon economy. Chapter 5 makes a series of recommendations that include significant legal and institutional changes to encourage innovation that will support transition. However, these recommended changes are not acknowledged or discussed in Chapter 7. There are no institutions identified in this chapter that may address Government led transition management; the support and development of innovation 'niches'; or the structural changes required in the economy.
- Furthermore, there is little discussion about how the process of accomplishing these cumulative legal and regulatory changes may have impacts in terms of resource and opportunity costs for central and local government agencies that must change their own policies and plans in response. There is also limited discussion of the bureaucratic burdens created by requirements additional strategies, monitoring and reporting within central government agencies. The chapter notes that reporting requirements must not be overly burdensome but provides little further consideration of what costs and impacts such requirements may have.
- The report takes a perspective of economy that is overly focussed on monetary value with little attention paid to other aspects of wellbeing. The perspective has pervasive limiting influence throughout on the nature of the analysis and recommendations. The concept of a low-carbon economy is inherently one that recognises a natural capital perspective, but this has not been carried through to other aspects of the report.

Specific comments

7.1 The role of laws and institutions

- We agree with the premise that cross bench support and the co-development of a comprehensive and progressive legislative response will "help provide policy permanence". We note, however, that cross bench support should not be at the expense of developing and enacting substantive goals towards a low-carbon economy over the next 35 years.
- Anecdotally, we note that there was considerable time taken in the UK to develop climate change consensus. MMP can require smaller parties to take alternative positions to get 'air time' which may differ from an earlier consensus. With MMP it would be very surprising if new parties do not emerge over the next 35 years which have had no input into long-term policy and, hence, have no obligation towards it.

7.10 An independent climate change institution

- We support the recommendation that an independent Climate Commission should be created and agree that operational independence is essential to its function. As such, the legislation should explicitly enable the commission to develop its own work programme.
- The independence of the Climate Commission is critical and, as a proposed independent commission, it must be able to work closely with all political parties, in part, to ensure there is cross party support and political consensus.

- The chapter should include further discussion of where boundaries should be drawn between the role of a Climate Commission and the existing role of the Parliamentary Commissioner for the Environment.

7.11 Recognising the Treaty of Waitangi

- Discussion about the Treaty of Waitangi lacks linkages with related areas of discussion from elsewhere in the report. Connections should be made, for example, to governance arrangements and statutory obligations created by Treaty of Waitangi settlements, to Māori ownership of forestry lands and tensions against their development aspirations, and to the likelihood that Māori may face disproportionate social and economic harm from transitions.
- The report makes vague recommendations that mechanisms should provide for Māori input into policy but offers no suggestions for how this could be accomplished in a practical yet meaningful way. These considerations cannot be addressed successfully in isolation but will require policies and institutions to be designed with a holistic view.

8. Short-lived and long-lived gases

Scion's role

Scion has an extensive role in the research, accounting, and policy framing of short-lived and long-lived greenhouse gases (GHGs). Being a forestry research institute much of our research focuses around carbon dioxide (CO_2). Domestically, our strategic focus is around the application of forestry in the New Zealand Emission Trading Scheme (ETS). Internationally, our strategic focus is through the IPCC for GHG accounting and monitoring for the UN climate goals.

Summary

This chapter has the ambitious task of marrying short-lived and long-lived gases and the associated policy hurdles. "Relating emissions to future temperatures remains ambiguous as long as contributions are expressed, as in the majority of 'Nationally Determined Contributions' (NDCs), in terms of CO_2-equivalent (CO_2-e) emission rates in a specific year defined using a metric such as the 100-year Global Warming Potential (GWP_{100})." (Allen, et al., 2018). The importance of cumulative CO_2 emissions has long been recognised (Allen, et al., 2009; Pierrehumbert, 2014; Reisinger, et al., 2013; Sterner, et al., 2017; Zickfeld, et al., 2009), but climate policy has continued to focus on CO_2-e emission rates. Alternatives to CO_2-e and GWP_{100} such as CO_2-e* and GWP* have been proposed by Allen, et al. (2018), the leading minds in the climate science of GHGs and climate policy. The adoption of these starred metrics would likely result in a nominal fall for New Zealand's annual emissions. More important however they would provide a more accurate indication on progress towards climate stabilisation through NDCs and even more important 'mid-century, long-term low GHG emission development strategies' (Sterner, et al., 2017).

The Productivity Commission have made a robust attempt to collate the often contentious and emergent climate mitigation policy thinking, further complicated by New Zealand's unique GHG profile. This is accomplished by a thorough assessment of the latest thinking involving global leaders in the field that are based in New Zealand. The chapter arrives at a well thought through and robust conclusion outlined in the last bullet (eight) of the 'Key points' section, specifically "separate long-term domestic targets law for short- and long-lived gases", the chapter should lead with this statement. However, the implementation of this through a "single all-gases mitigation target" fails to rise to the challenges associated with current emission metrics and risks government doing the least possible to meet GHG accounting requirements and misses New Zealand's opportunity to be global trail-blazers in GHG climate policy. The gas-based split target approach (two basket approach) is our preferred option. The long-lived gas target should be a net-zero gross emissions target by a specified end date as the chapter concludes. The wording for some of the other key points needs refining for clarity and in some cases to not contradict domestic and global climate policy objectives.

Under the current single-basket GWP_{100} approach, offsetting potential is limited by the available area for planting because a forest does not remain a carbon sink indefinitely, whether harvesting takes place or not. There is potential to explore the way that a split-gas approach may allow a better fit between the short net sink period of forest stands and the short lifespan of methane in the atmosphere. It may be that short rotation afforestation has a real opportunity to balance short-lived and long-lived gases during the life time of methane (CH_4) inside the farm gate. There is a real appetite within the New Zealand Beef and Lamb community to incentivise these sorts of mitigation options. Several of these are outlined at the end of this response, with appropriate policy incentives this could be embraced nationwide.

Scion's comments

Overarching comments

The background and context on the need for this chapter, which may seem abstract and niche to non-specialists is centred on the concept of CO_2-e emissions. This metric is deeply embedded in climate policy (Myhre, et al., 2013) despite long-standing criticisms (Pierrehumbert, 2014) of its application to short lived climate pollutants (SLCPs) like CH_4 when converted to CO_2-e using GWP_{100}. Scientific and climate policy ambiguity arises because emissions of cumulative pollutants (such as CO_2) and SLCPs translate into impact on global mean temperature in fundamentally different ways: for CO_2, radiative forcing largely scales with the cumulative emissions to date, while for CH_4, it scales with a combination of the emissions rate and SLCP lifetime. (Lauder, et al., 2013; Reisinger, et al., 2013; Shine, et al., 2005; Smith, et al., 2012). The differing climate impacts of CO_2 and SLCP emissions become particularly problematic under ambitious mitigation scenarios such as those needed to meet the Paris climate targets. Falling SLCP emissions lead to falling global temperatures on a decadal time scale, while nominally "equivalent" CO_2 emissions, whether computed using GWP, global temperature-change potential (GTP), (Myhre, et al., 2013; Shine, et al., 2005) or any other conventional metric, would incorrectly suggest that these falling emissions would cause further warming. As well as being misleading, using GWP to calculate CO_2-e emissions has practical consequences: if "balance" is defined as net zero CO_2-e emissions, balanced emissions result not in temperature stabilisation, but an indefinite cooling trend, with the rate of cooling determined by on-going emissions of SLCPs (Fuglestvedt, et al., 2018).

Key points

Bullet point 1

- The first bullet point would benefit from stating these timescales explicitly here, e.g. CH_4 and other 'short lived climate pollutants' (SLCPs) influence global mean temperature on decadal timescales while long lived GHGs such as CO_2 influence the global mean temperature on centennial timescales.

Bullet point 2

- The second bullet should make it clear that reduction of SLCPs are vital to the Paris 1.5°C and 2°C goals only because climate projections unanimously agree that these thresholds will be met within decadal timescales and hence the same frame of reference as SLCPs.

Bullet point 3

- A country should carefully chose the appropriate emission metric to align with their domestic and international climate policy objectives.

Bullet points 4 and 5

- While New Zealand does indeed have an unusual emissions profile this does not mean that we should reject global thinking on this issue. For example, the current default emissions metric the GWP_{100} is known to prioritise SCLP to the detriment of CO_2 emission targets. So the any reductions in SLCPs must follow CO_2 targets and not be used as an intermediate accounting tool. Explicitly, while the report rightly states that “priority must be given to reduce emissions of long-lived gases to net-zero”, this is diametrically opposed to the statement a few sentence later where the report states that a “greater budget for long-lived gas emissions” should be allowed. Just because New Zealand’s emissions profile allows more flexibility for intermediate UNFCCC Nationally Determined Contribution (NDC) goals with SLCP reductions does not mean that this should be enabled because of or with a “greater budget for long-lived gas emissions”.

Bullet point 6

- Although true, the statement adds no value to the key points. The recommendations for bullet three could be used or combined here. Note that the current standard of GWP_{100} was incorporated as a "simple approach … to illustrate the difficulties inherent in the concept" in the first IPCC report, that approach ended up sticking not due to its own merits. New Zealand should use the appropriate metric domestically as the NDC guidelines permit and report internationally using the internationally approved metric.

Bullet point 7

- We agree; however, domestic targets can still use other metrics as long as domestic targets align with the international de-facto standards.

Bullet point 8

- We strongly agree.

8.1 Short- and long-lived gases

- Page 200: “*This is because recent research shows that a very minor ongoing warming effect occurs after atmospheric concentrations of CH_4 have stabilised (Andy Reisinger, pers. comm. 27 January 2018)*.”

  Although undoubtedly correct, a published reference is preferable to a pers. comm.

- Finding 8.1: “*Emissions of short-lived gases must stabilise by inflows equalling outflows (with a consistent, minor decrease in emissions to achieve a stable temperature)*.”

  This sentence and elsewhere in this chapter would benefit from largely ignoring the outflow of SLCPs as they are just a lagged function of SLCP inflow. Instead a specific emission or temperature target should be set for SLCP emissions (inflows).

- Page 201: “*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 statement should cite peer-reviewed literature, for example: Peters (2018); Rogelj, et al. (2018); van Vuuren, et al. (2018).

8.2 Should short-lived gases also be mitigated in the short and medium term?

- Much of the discussion under the subheading 'Allowing a (slightly) greater budget for long-lived gas emissions' is worrying. The idea that reducing SLCPs could allow for a greater budget for long-lived gas emissions is correct. However, this does not mean they *should* be viewed in that way. Policy around the reduction of SLCPs and long-lived gas emissions should be constructed completely separately from each other as they accomplish two completely different policy goals, namely the future of the generation alive today, and the lives of future generations.

Reducing short- and medium-term temperature change

- Page 204: "*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)*." The scientific literature is full of references to climatic tipping points and the great level of uncertainty around the triggers. This sentence requires a formal peer-reviewed citation. Note that tipping points are almost always related to the oceanic and cryospheric system and not the atmosphere.
- Climatic tipping points are more formally aligned to long-lived gas emissions and not SLCP which operate on the same time scale as internal climate variability; this generally applies to perceived environmental benefits from SLCP reductions.

Health co-benefits

- The sub-section titled 'Health co-benefits' is talking about SLCP that directly impact health and is a detour from the main discussion of the chapter. We suggest the sub-section should be placed in a different chapter.
- Page 204: The term 'soot' should be replaced by the term 'black carbon'

Finding 8.3

- 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.*"
    1. Allowing more CO_2 to be emitted is never a benefit in the context of a low-emissions economy, global climate change, or in society as a whole.
    2. Unless there is substantial peer-reviewed evidence for SLCPs reduction delaying tipping points this should be removed from the report and certainly shouldn't appear as a key finding.
    3. They will not provide further time for adaptation, just delay the transient climate change effects of long-lived gases by a decade or two.
    4. Appropriate policies incentivising the reduction of SLCPs WILL stimulate innovation AND land-use change providing the necessary swift transition or a low-emissions economy.

8.3 Using emissions metrics to direct mitigation efforts

- On page 205: "*Emissions metrics help to show how powerful GHGs are in terms of their cumulative effect on warming and their atmospheric lifetime (NIWA, 2017).*"

  We suggest using an appropriate peer-reviewed reference, such as Allen (2015); Allen, et al. (2016); Lauder, et al. (2013).

- On page 205: "*In other words, compared to CO_2, the warming effect of CH_4 is powerful but short*".

  This sentence should clarify that the warming effect of *a pulse emission of 1Gt* of CH_4 is powerful but short.

- Box 8.3 presents thinking from some of New Zealand's leading minds on greenhouse gas policy outlined in Hollis, et al. (2016). The Commission wishes to steer clear of recommending alternatives to or variations of GWP_{100} due to increased complexity. While this may be the case, an example of the increased complexity would be useful, otherwise it looks as though the advice from Hollis, et al. (2016), the authors of which will certainly have an appreciation of this complexity, is dismissed because of implementation complexity; this is especially true given the unusual mix of GHGs New Zealand emits; GWP_{100} was designed for the average country, not necessarily New Zealand. Further consideration to the advice of Hollis, et al. (2016) or an example of this insurmountable difficulty may be warranted.
- Finding 8.4 follows on from the last point and discusses 'choosing an appropriate metric'. When in reality it appears that little attempt has been made to choose an appropriate metric for New Zealand and status quo prevails. If any country should adopt an alternative metric for domestic climate policy goals New Zealand should be with its combination of GHG emission and advanced standard of domestic knowledge on climate policy.

8.6 A New Zealand approach to short- and long-lived gases

- On page 218, the report states: "*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.*"

  As this chapter has made clear, the difference in time scales between the GHGs in each of the two baskets is significant and effects temperature and, hence, climate policy on completely different time scales. Therefore, it is not beneficial that GHGs be traded between baskets. The statement that the "same temperature goal could be achieved" also omits the explicit or implicit time horizon that temperature goals will have associated with them and the policy motivation behind these goals. So no the same goal could not be achieved with a cheaper mix as the mix fundamentally alters this time horizon and the policy motivation.

- The report advocates for Option 1: 'Separate targets and regular tracking of progress'. The impression the reader is left with is that of listening to the latest scientific and policy advice on the treatment of GHGs and then ignoring this advice and voting for an option that is easiest to implement. It is not clear how setting targets and tracking will incentivise the desired behaviour in the way that option two and especially three would. Option 1 relies on undisclosed incentives for emitters to change or a presumed marked based demand for such behaviour; history teaches us to the contrary.

Appendix A: Stocks and Flows of GHGs in New Zealand

The following contains thoughts following a roundtable between Dave Frame at Victoria, University of Wellington and Scion on dual basket accounting including contributions from Adrian Macey, Luke Harrington, and Nathanael Melia.

Introduction

The following note sets out different potential emissions sources, sinks and mitigation investments in terms of a "stocks and flows" distinction.

Scientifically, very little of this paper is new, but it is the first attempt at a comprehensive description of how different potential mitigation investments fit within a "cumulative emissions" framework.

The intention of the note is to offer a coherent, geophysically-grounded lens which can assist with problem definition for New Zealand's climate policy. Without a coherent lens, there is a risk of using a stock-flow distinction in some parts of climate policy without applying the distinction consistently, which may lead to unintended consequences, misallocation, and reputational loss.

In terms of the first-order elements of climate mitigation policies, the matrix of possibilities for New Zealand can be represented as:

Stocks		Flows
Domestic CO_2 emissions		Domestic CH_4 emissions
International CO_2 purchases	←------→	International CO_2 purchases
Permanent forests	←--------	Temporary forests

Geophysically, we can in principle offset our stock CO_2 emissions via the things in the left-hand column, and we can in principle offset our flow GHG emissions via the things in the right-hand column. All the things in the right-hand column are ways of temporarily addressing domestic climate obligations, but don't address the need to reduce domestic CO_2 emissions. They may be ways of meeting (in a given period) obligations to reduce CO_2e emissions, or our radiative forcing perturbation to the climate. Dashed lines represent those elements that could be placed either in the stock box or the flow box, depending on norms, choices and other policy settings.

Climate policy is, in the first instance, about reducing CO_2 emissions to net zero. Permanent forest sinks are well-matched with this goal. International CO_2 emissions reductions could be, if the international accounting system were able to digest these as permanently buying down a country's emissions, such that the initialization of the next period would include those reductions, carried forward, instead of the domestic emissions inventory data.

But in essence flow sinks/reductions buy off the political heat while we haven't reduced CO_2 emissions sufficiently on their own to achieve our targets. As long as we emit significant net positive CO_2 as a stock pollutant, we will be expected to continue to reduce emissions.

Motivation: why two baskets?

As we have seen, methane is a flow pollutant and CO_2 a stock pollutant. The difference is shown in the figure below: flow pollutant emissions do not persist, so emissions in period one, and the same emissions in period two lead to a constant amount of the pollutant in the atmosphere (or river, and so on). With stock pollutants, concentrations of the pollutant accumulate as emissions continue.

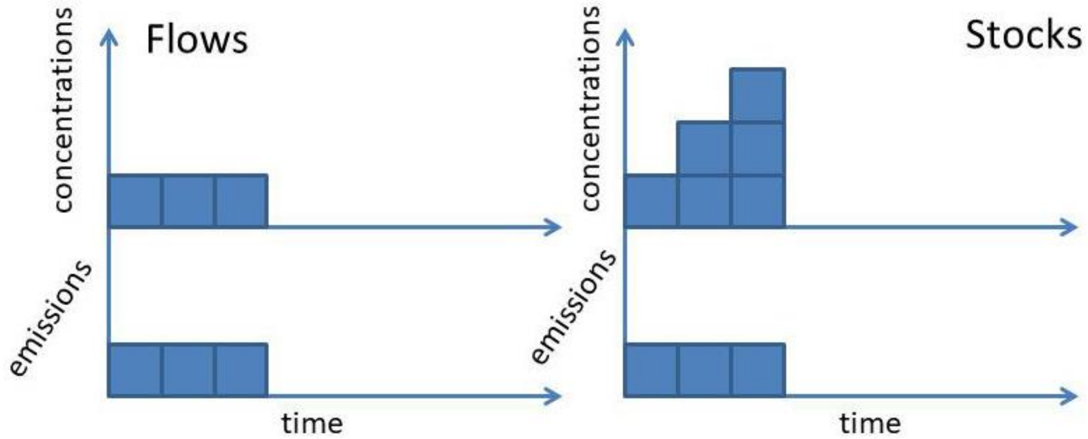

Figure 1: Flow and stock pollutants over time. In the first period, one unit of each pollutant is emitted, leading to one unit of concentration. After each period, the flow pollutant decays, while the stock pollutant remains in the environment.

The economic theory of pollution suggests different approaches for these. The marginal social cost of flow pollution is constant over time, because the next unit of pollution is just replacing the last, recently decayed unit. This justifies a constant price on flow pollutants. In the case of stock pollutants, the marginal social cost of pollution increases with constant emissions as concentrations of the pollutant rise. This justifies a rising price on stock pollutants. Conceptually, there is a difference to note between fossil methane and biogenic methane: the former contains both flow elements (while it is methane) and stock elements (since CH_4 oxidises to CO_2); the latter is, in essence, a flow pollutant since $CO_2 \rightarrow CH_4 \rightarrow CO_2$ via the cycle of photolysis, digestion, emission, oxidisation. In this case, no new CO_2 is added to the atmosphere. For many parts of the world, “methane” refers predominantly to fossil methane from gas wells, while in many other parts of the world.

It is a necessary condition of achieving the aims of the Paris Agreement to hold global temperatures to under 2°C more than pre-industrial levels that net CO_2 emissions decline to zero.[1] This is not the case with biogenic CH_4 and other SLCPs. To stabilise temperatures, emissions of these species do not need to get to zero, but they do need to stabilise.[2] So biogenic CH_4 emissions imply a flat social cost, and CO_2 emissions a rising social cost. Therefore, the two should not be pegged.[3]

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[1] In principle the same is true of the other stock GHG like N_2O and SF_6.

[2] Fossil methane does, in principle, need to get to zero, since it is a new source of CO2.

[3] One defence of pegging could be the interpretation that in the first period, agricultural methane producers receive a certain amount of free allocation. Over time, pegging could imply that they are paying for a larger and larger share of their emissions. But this should saturate when they get to 100%. Beyond that point, their costs

Options for methane

Biogenic methane is a flow pollutant, and fossil methane is not. Reducing biogenic methane can reduce our CO_2e burden, and meet obligations, but from a physical point of view does not alter the centrality of reducing (net) CO_2 emissions to zero as the main object of climate policy.

We could address biogenic methane by pricing it according to a range of strategies. One way is to use separate treatments for stocks and flows. Other approaches based on a range of price-equivalence strategies are sketched in the appendix.

Two instrument approaches

1. Separate out CH_4, plantation forestry, and create an exchange rate between the two based on the radiative effects of the two over 30 years.
    a. Pros: Avoids the use of an explicit metric but reflects the stock/flow nature of different pollutants/sinks.
    b. Cons: Will be challenged by those who have strong faith in allocative efficiency gains associated with multi-gas instruments.
2. Sectoral targets, including a land-sector target which would imply xMt CH_4 and –yMtC sequestered through forests so that the net radiative effects of each sector were to drop by some specified percentage.
    a. Pros: Avoids the use of an explicit metric but reflects the stock/flow nature of different pollutants/sinks.
    b. Cons: Will be challenged by those who have strong faith in allocative efficiency gains associated with multi-gas instruments. Sets, rather than backs out, sectoral targets. Is this the role of government?

It should be noted that anything other than a GWP100-based approach will require significant support from scientists abroad to show that the approach is scientifically reasonable, i.e. has environmental integrity. We need to be able to show that we are acting consistently with the best climate science, and meeting our existing obligations.

Options for forestry

Forestry could be treated either through the stock instrument, or through the flow instrument, or in both, depending on the forest.

A stock treatment of all forests could involve treating sinks as permanent, and then requiring the same price on emissions from forestry logging as would be incurred if the same quantity of CO_2 were released from a fossil source.

An alternative would be to treat permanent forests as stocks, and plantation forests as flows. A flow treatment of plantation forests could involve treating all sinks as temporary, whereby some payment is made for offsetting biogenic methane emissions. Permanent forests would be treated as stock sequestration. Potentially, this would place a lot of pressure on the regulatory scheme, and potentially on price mechanisms, too, since opportunities for arbitrage between the stock and flow instruments would be expected simply through naturally

should no longer rise. So that defence of pegging fails beyond a certain point, and that point is set by the initial choice to say that agricultural emitters only pay for x% of their pollution.

occurring volatility. Arbitrage could be discouraged by the imposition of large fees[4] for the conversion of forests from one type to another, especially for the conversion of “permanent” forests into plantations.

Forestry can go in either column, because some forest carbon sequestration is permanent (permanent forests, as well as the flux of carbon from forests that is permanently retired into the soil) and some is temporary (that which is sequestered in one period and then released to the atmosphere following the felling of plantations and the processing of wood products). If we were to create two instruments, then we should try to understand the relative roles of permanent and the temporary sequestration of carbon in forestry.

The role of international markets in mitigation

Markets could be seen as stocks or flows. Buying permanent reductions overseas is a permanent reduction in CO_2 emissions (grey shaded text). Geophysically, it is reducing stock emissions against a baseline, just as domestic stock emissions reductions are. From the perspective of developed country national mitigation, the question of which column to put this in depends on the international norm: if the international norm is constructed around getting domestic emissions of CO_2 to zero, then these credits are, in effect, a flow, since they meet emissions reductions obligations in the period in which they are purchased, but they do not lower the future obligation to reduce domestic emissions. If the norm were that countries' emissions reductions outside their borders were permanently counted against their baseline emissions, then these would amount to CO_2 emissions reductions at home. This would imply that future baselines consider not New Zealand's net or gross emissions, but our net or gross emissions minus the CO_2 emissions reductions we have created elsewhere. Because (I think) the expectation most people have is that countries domestic emissions will continue to form the baseline, I have put international credits in the flow column. If the norm changes, then it should go in the stock column. Either norm is geophysically fine, as long as the accounting behind it is coherent and has environmental integrity.

The stopping point

In the very long term the world will need to have a conversation about what level of CH_4 emissions are sustainable in the context of climate policy. In effect, any fixed level of CH_4 emissions from non-fossil sources is compatible with “stabilisation”. But given that higher levels of CH_4 result in higher warming, there will be pressure to reduce CH_4 emissions from current levels both before and potentially after temperature stabilisation has been achieved. At the point where global CO_2 emissions are net zero, it is difficult to see where policy should go next, but three choices seem possible: (1) stay there; (2) reduce CH_4 (and other non-CO_2) emissions; (3) make CO_2 emissions negative. The politics of negative emissions may not resemble that of getting to zero emissions, because of the lack of an obvious focal point in the negative emissions case.

Pressures for these approaches are likely to come from different sources. Countries which experience impacts that follow temperatures may be satisfied with temperature stabilisation, since adaptation to peak warming implies that there are few further changes to adapt to. Those who need to adapt to changes which scale with the integral of forcing or integrated temperature change (such as SLR, glacier changes, and potentially some ecosystem impacts) would be expected to argue for further mitigation. At this point forcing could be reduced by mitigating CH_4 and other SLCP, or by drawing down atmospheric CO_2. A stocks

[4] These fees could vary with the (several times) price of carbon so as to stay ahead of the arbitrage gains.

and flows interpretation of New Zealand's inventory would allow us to tune our response at this point to the policies that emerge at that time.

Pricing methane options

GWP100 options

1. Put CH4 in the ETS at GWP100 at 29 (or latest IPCC estimate).
    a. Pros: This is probably the "default" way of going, given developed world practice, since this approach is used for fossil methane in the EU ETS. But since no one actually has agricultural emissions in their ETS, its status as "default" is unreflective and untested, as well as demonstrably scientifically suboptimal.
    b. Cons: GWP100 lacks strong physical justification as an exchange rate between the effects of CH_4 vs CO_2. Lack of precedent elsewhere, and other agricultural exporters are unlikely to follow this practice. If we do this, there's a risk we will take on an onerous and isolated position, that may be costly to unpick.
2. Put CH4 in the ETS at 29 (or latest IPCC estimate) with a transition phase, or with farmers only paying some fraction of their "obligation".
    a. Pros: Precedent in terms of using GWP100; precedents in terms of partial obligations.
    b. Cons: Unhappy compromise, since it appears to imply that GWP100 is the "right" way to compare gases (which is not obviously the case) but then it implies that farmers aren't paying their "full" share. So it leaves the implication that it's a weak policy and that agriculture isn't doing its bit.

GTP100 options

3. Put CH_4 in the ETS at 5 (or latest IPCC estimate).
    a. Pros: About as much justification as GWP100. Approach could be popular with other agricultural exporters, such as Brazil and other Latin American countries. Politically feasible domestically.
    b. Cons: not what Europe would expect, and people from there have threatened to go after New Zealand if we innovate around metrics. There would have to be a clear scientific demonstration that our intentions/INDCs remain at least as stringent as they currently are.

GWP* options

4. Flat option: Farmer has emitted the blue line in Figure 2. The counterfactual is the purple line, along which he does not add to climate change. If he moves to the orange line, he receives a payout because he has lowered warming. The payout/charge a farmer receives in a given calendar year would be proportional to the emission changes across the preceding N years – whereby each of these previous individual years would be considered in isolation, treated as an instantaneous change in emissions under GWP*, followed by a constant emissions profile thereafter. The charge/payout for each of these

discrete years would be then multiplied by 1/N, before the sum is taken across N years.

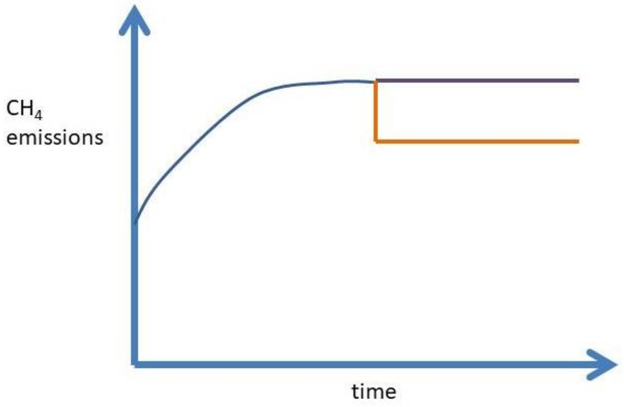

Figure 2: The Flat Option.

So if a dairy farmer sold off his herd overnight, the payout of this would be spread evenly over a period of N years. The implications of the fact that the last 20 years of methane emissions have not been flat. In a hypothetical scenario, if there was a change to a GWP* framework for emissions trading, then the preceding 20 (or so) years of emissions might suddenly become relevant. Though, as a corollary to the suggestion I've made above, a GWP*-based system could actually be phased in from today, with the first twenty years of the new system just taking into consideration only those X years since 2017.

a. Pros: Reflects fact that stable methane emissions do not warm the climate.

b. Cons: Pays farmers for reducing pollution; which is a different approach to that taken elsewhere/within ETS. Seems overly generous to farmers, and has very strong grandparenting allocation

Rampdown option

5. Farmer has emitted the solid blue line in Figure 3. Policy specifies that methane emissions are expected to reduce over time to an agreed level (dashed blue line). If the farmer reduces emissions faster he receives a payout because he has lowered warming and exceeded the policy expectation. If the farmer fails to meet the policy reduction rate he is penalised. A grace period where no action is taken to allow the farmer to adapt to the policy and also to recognise that although not meeting the policy reduction rate, they are still reducing CH_4 emissions and so reducing warming. Payout/fine depends on the magnitude of the departure from the dashed line.

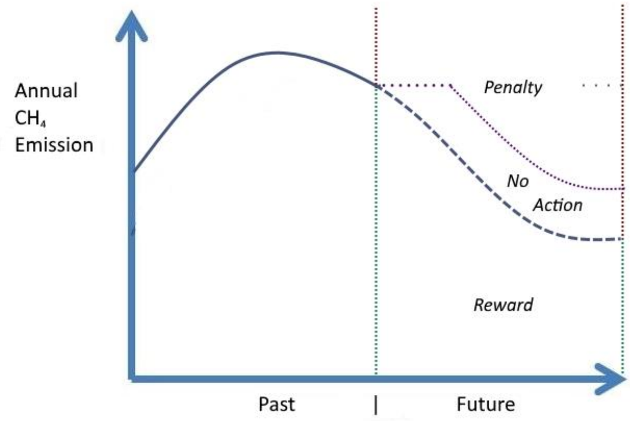

Figure 3: The rampdown option.

Pros: reflects stocks vs flows distinction used immediately above. Probably more financially sustainable and less vulnerable to the claim that farmers are claiming pollution rights in perpetuity, while others do not have those rights. Allows for methane reductions to be part of policy expectations.

Cons: hasn't been stress-tested.

Short rotation afforestation has a real opportunity inside the farm gate. On a paddock scale a farmer can balance out their herds CH_4 emissions by planting a fast growing resilient species such as radiata pine to sequester the CO_2-e amount. A fast rotation of say 20 years would allow the farmer to marry planting and CO_2-e fluxes to the herd size and maturity and their CO_2-e fluxes and hence become zero CO_2-e within the farm gate. There is a real appetite within the New Zealand Beef and Lamb community to incentivise these sorts of mitigation options (Victoria Lamb, Environment Policy Manager, Beef and Lamb New Zealand, pers. comm. 22 May 2018).

Appendix B: Low-emissions economy and transitioning

What is a "Low-emissions economy"?

Implications if we are only concerned with reducing New Zealand's accounting liabilities:

- Current and likely future UNFCCC GHG accounting rules are key
- Only emissions that enter our accounts are relevant - e.g. international marine and aviation fuels are excluded; non-forest woody vegetation sequestration is excluded; offshore emissions are irrelevant, etc.
- Offshore rather than domestic production, processing and disposal is preferred.
- There is little or no incentive to use sustainable New Zealand-grown wood products to replace imported steel, plastic and aluminium products.

Implications if we are concerned about reducing atmospheric GHG concentrations:

- Removal of atmospheric GHGs and reduction of emissions is a priority, regardless of where this occurs.
- Marine and aviation fuels are included; emissions from production of essential inputs to New Zealand processes are included; 'exporting emissions' is not a solution.
- Consequential Life Cycle Analysis approaches are relevant rather than UNFCCC 'limited list' accounting

Section 4.5 of the report suggests that we expect the ETS to target the former and that is the focus of the report. Elsewhere in that chapter it is suggested that other means might be used to deal with benefits and harms not otherwise captured.

What is "Transitioning"?

The idea that afforestation sequestration helps us "transition" to a low emissions economy is arguably false – if anything, afforestation has been proven to do the opposite. It *does* allow us to meet intermediate net emission targets while the rest of the emissions-intensive economy may carry on as before. In that case the forest eventually becomes carbon neutral (in terms of biomass in the forest), so it no longer acts as a sink to offset emissions. Meanwhile no 'transition' has occurred. This point is made in the report – as long as afforestation exists as a low or zero cost abatement option, there is no incentive to make the step-changes required elsewhere.

In short: having a strong forest sink that helps us to reach Paris Agreement net emission targets is no indication that any move has been made towards a low emissions economy. It is better to regard "achieving net emission targets" and "achieving a low emission economy" as two separate concepts. A low emissions economy should mean a low *gross* emissions economy.

The contribution of forests in the long-term towards a low emissions economy is in the use of wood products. This means that while afforestation with both natives and exotics provides a short-to medium term benefit in terms of offsetting emissions, only commercially harvested forests make a long term contribution towards low gross emissions. However, this is only if accounting recognises the benefits of substituting locally grown wood for imported emissions-intensive products, even though the emissions associated with producing imported products happens outside New Zealand's economy.

Carbon benefits from establishing a 1 million ha forest

Plantations

Planting 35,715 ha each year for 28 years would create a strong carbon sink during the 2021-2030 and 2031-2050 commitment periods (Fig 1), which would help towards reaching our *net emission targets*.
After 28 years there would be a 1 million ha forest, with an equal area in each age class. From that time onward, the annual harvest of 1/28th of the forest would be offset by the increment in the remaining 27/28th – the forest would be in a steady state with a constant stock of about 500 Mt CO_2.

In other words, the permanent forest created has taken 500 Mt CO_2 out of the atmosphere but is no longer a carbon sink, so (without further expansion of area) the forest itself makes no further contribution to a *low emissions economy*. However, the annual harvest from 1 million ha of radiata pine would be at least 20 million m^3. This could substitute for fossil fuels or for fossil fuel-intensive products, which therefore could make a contribution to a low emissions economy – but only if accounting recognises this.

Native forest

Establishing the same forest area at the same rate but in indigenous forest would contribute comparatively little towards net emission targets before 2050. Eventually a steady state forest stock would probably be reached, and this would be at a higher level than the plantation forest steady state stock. However it would take much longer to take 500 Mt of CO_2 out of the atmosphere. The native forest would continue to offset emissions for longer, but would not produce wood products in significant quantities to substitute for fossil fuel-intensive products – the contribution to a low emissions economy is limited to carbon uptake by the maturing forest.

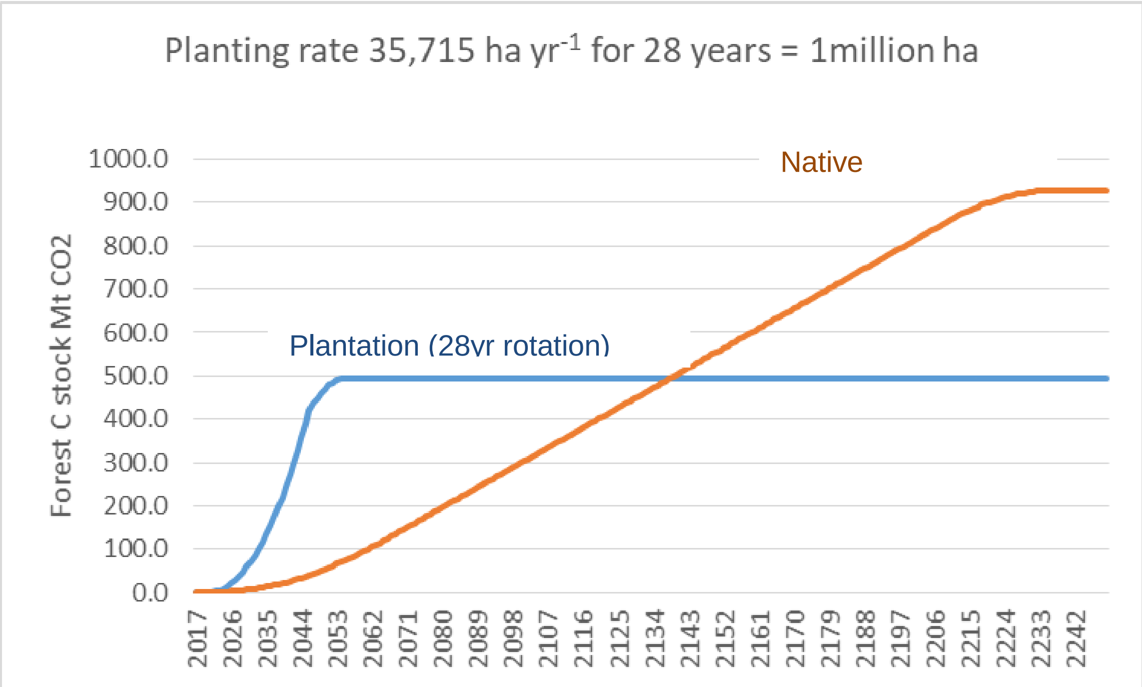

Fig 1. Forest carbon stocks in 1 million ha plantation and native forests.

Assumptions

- Chart shows stock – stock change (sequestration) is the difference between successive years' stocks.
- Plantation sequestration rate is mean from LUCAS post-1989 planted forest plots.
- Native forest sequestration rate from MW-LCR analysis (secondary forest @ 5.1 t CO_2 ha^{-1} yr^{-1}, until mean stock of current tall indigenous forest is reached (928 t CO_2 ha^{-1}).
- In both forests soil C loss has been taken into account. The wood products pool is not included in the chart.

Establishing the plantation forest at a faster rate (e.g. over 10 years rather than 28) would increase short term sequestration but would result in a resource that fluctuated between being a net sink and a net source. This could be masked by the accounting approach e.g. crediting up to the long-term average. Selection harvesting from natural forest is unlikely to generate significant volumes.

Plantation forests versus native forests – carbon implications

	Permanent rotational plantation forests	*Permanent unharvested native forests*
Carbon sink – can offset gross emissions?	Yes - during maturation phase.	Yes - during maturation phase.
Displace livestock?	Yes	Yes
Active sink rate:	High	Low
Active sink rate uncertainty:	Low	High
Active sink period:	Short (~30 years)	Long (>200 years?)
Sink gains partially offset by soil C loss and albedo effect?	Yes	Yes
Forest is carbon neutral at maturity?	Yes	Yes
Contribution to achieving net emission targets during maturation phase	High to 2050, then low or nil.	Low to 2050, then continuing low for >200 years
Production and processing emissions	Low	Nil
Contribution to a "zero emissions" world at maturity	Wood products: direct via substitution for fossil fuels; indirect via for emission-intensive alternatives	Little or nil
Contribution to a "zero emissions" New Zealand economy at maturity	Direct via substitution for fossil fuels; indirect only via substitution for New Zealand made alternatives	Little or nil

Co-benefits vary but are difficult to quantify and perceptions do not always match reality.

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9. Policies for an inclusive transition

Scion's role

Scion has a team of social scientists with a track record of publications and expertise in policy and governance, environmental economics, bioeconomy transitions, impact assessment, risk and resilience, Māori education, health and development, behavioural change, social justice, social license to operate, socio-technical innovation, complex systems and knowledge integration.

Summary

The fundamental assumption of the chapter is that proposed policies under the current neo-liberal economic model can deliver both growth and sustainability when there is no evidence that his has been achieved in the past (Challies and Murray, 2008). New models are emerging and will be required for a successful transition (Liu and Hanauer, 2011).

The chapter notes that Māori are a significant proportion of the population in the bracket of lower-income households; however, the response policies outlined do not consider specific impacts on Māori. Responses should be explored as an opportunity for encouraging empowering dynamics for and with Māori (e.g. Te Arawa climate change working group). References should be made to discussions in other chapters regarding Treaty of Waitangi obligations and Māori land ownership.

We identified the following gaps in the analysis:

- Lack of a high level framework for inclusive transition policies based on existing literature on green growth, green economy, bioeconomy and circular economy, Sustainable Development Goals, including a robust monitoring, learning and evaluating framework to assess and learn from the ongoing impacts.
- Lack of balanced analysis across scales and issues. The chapter currently focuses on the household/consumer level economic aspects, disregarding the regional level and, hence, the need for integrated planning across scales. It ignores the social and cultural impacts on households that are not captured nor can be reflected in a solely-focused economic assessment. There is no consideration of different (but still potentially generalisable) political climates in the next 30 years. International trade as a key driver for NZ is not mentioned either, hence related policy responses to support individual in potentially most affected sectors (potentially those with larger emissions such as agriculture) are missing.
- No clear connection with multidimensionality of issues, such the links of changing employment opportunities and the development of artificial intelligence with psychological and socio-cultural issues (e.g. sense of identity), the impacts of aging, migration on the transition (consumer preferences and choices), and awareness of the transition itself which influences efforts in building capacity for opportunities and agile responses. While tertiary mid-career training is mentioned, the education system as a whole needs to be explored.
- No mention of innovation and the need for investment in locally based and culturally appropriate solutions designed by the groups potentially affected.

Scion's comments

Overarching comments

The chapter lacks of a high level framework for inclusive transition policies based on existing literature on green growth, green economy, bioeconomy and circular economy (e.g. see OECD, 2011, UNDP, 2017, Bauen et al., 2016, Ellen Mac Arthur Foundation, 2018) and how these transition can support achieving Sustainable Development Goals that New Zealand Government is obliged to report on, in particular Goal 8 that 'seeks to promote sustained, inclusive and sustainable growth, full and productive employment, and decent work for all'.

There is a clear incentive here for NZ to provide international leadership and potential guidance for other small economies and the more inclusive these developments the more likely they will meet with the approval of the international community. However, enabling conditions for transformations—such as adequate finance and governance arrangements and socio-cultural elements—are lacking in New Zealand (Wreford et al., 2017).

The chapter also needs clear signposts to other chapters and sections within the chapter, e.g. to discussion of public transport in Chapter 11. Overall, the chapter needs a better focus on what the priorities for an inclusive transition are. For example, in a report on inclusive and sustainable growth, UNDP (2017) highlights the following three broad priorities:

- Integrated planning for inclusive and sustainable growth
- Supporting employment creation, decent work and redistributive programmes to address poverty, inequality and exclusion
- Mobilizing and scaling up financing for enabling transition to inclusive and sustainable growth.

Specific comments

Key points

Bullet point 1: Economic transitions are nothing new, but the world is

- The 'dynamic economy' examples of economic transitions but these transitions spanned under radically different circumstances from today's highly globalised, socio-technical, economic and political environment, where New Zealand strongly depends from international markets. While the Overview chapter (p. 1) mentions that the timeframe for transition is 30 years, the speed of required policy changes, learning and adaptive governance is unprecedented (Oram, 2016).
- A review of empirical evidence from 92 cases of adaptive governance shows key principles to lay the foundations for an inclusive transition: meaningful collaboration across actors and scales; effective coordination between stakeholders and levels; building social capital; community empowerment and engagement; capacity development; linking knowledge and decision-making through data collection and monitoring; promoting leadership capacity; exploiting or creating governance opportunities (Sharma-Wallace et al., 2018).
- Social and collective learning frameworks initiated through adaptive governance can help equip stakeholders with the tools required to deal with future unexpected environmental shocks or events (Sharma-Wallace et al., 2018), addressing the need for a higher

capacity for learning and hence more systemic awareness and our governing models (while challenged and adapted to emergent problems.

- Learning in a dynamic environment is challenging, we need to know how the effects of multiple interacting causes can be captured and influenced in a positive way or a way that supports the growth of incomes and wellbeing that is inclusive.

Bullet point 2: Need for a real focus on low income households

- What measures will be put in place to ensure that low-income households are considered? For example, in 2018, Government announced social housing at an entry point of $650k, resulting unaffordable for low income households, rather benefiting middle income households (Tibshraeny, 2018).
- Low income families need assurances. Bennet et al (2014) report that in addition to food prices rising, there will also be an impact on health and wellbeing within communities. The measures to be put in place need to be clear, in particular for Māori as a disproportionately low income group.

Bullet point 3: Mitigation policies should go beyond compensation

- There will be many stressors and some deeply psychological. We need to look at the population dynamics (e.g., aging, migration) as well as opportunities to support more agile community responses. How will communities including households and businesses be supported to realise innovations and opportunities in the way they live and make a living?

Bullet point 4: Low income households need clarity on what is envisioned as ‘public assistance’ given the lack of access to knowledge and resources

- We agree that the focus should be with low income households where Māori are a significant proportion of the population in this bracket. The question posed is what will ‘public assistance’ look like in reality? (see comment regarding bullet 2 on unaffordable housing).
- How do we generate the capacities of communities to support those in need, and to help those who might not have access to knowledge and resources to make changes towards low emissions lifestyles?
- Attention will need to be given to those areas of daily life that are impacted – heating, cooking, buying affordable food, getting to work (or seeing to family). If people are already compromised by lack of employment or economic pressures—how will they be supported to do these basic living tasks?

Bullet point 5: Responses need to be systemic, not just economic

- While the point highlights economic assistance and tax adjustments over time, awareness on how people are adjust to the changes is as important. How people can identify changes they can make themselves to reduce the impact of a low emissions economy on their ability to meet basic life needs? A wider systemic response and awareness of what impact the transition is having on different groups and types of people is needed.

Bullet point 6: Adequate control & monitoring is required for ‘conditioning’ investment such as household insulation

- Caution is needed were incentives may lead to perverse behaviours such as quick wins from insulation programmes that create markets that need the right checks and balances to ensure that opportunities are not exploited to the detriment and wellbeing of others.
- For example, the household insulation programme in Australia backfired badly on the government when rouge tradesman set up businesses that created employment conditions that were seriously inadequate, including deaths. Those involved in implementing the programme need to be adequately 'controlled' to ensure they do not compromise on the safety of people brought into employment. Research and knowledge on public policy (especially interventions) and the intended and unintended effects that needs to be taken into consideration.

Bullet point 7: Rigorous accounting of baselines to assess the impacts of technological and consumer changes based on preferences and transport choices are needed

- If technological and consumer changes are not predicable, then need to set up research that is rigorous in accounting for these impacts. What are the implications of transport needs on the current and future transport systems.
- People do not only drive cars for getting from A to B: the journey, different types of identity people align with, the way they value their vehicles are all impacting the choices and desires people have in relation to transport. Innovations in transport and fuel will need to be considered in relation to transport options people have—and how that can be broadened rather than narrowed.

Bullet point 8: Strong need for re-skilling and revitalisation of local knowledge

- Skills will be needed on a range of scales and in multiple innovation areas. How can a re-skilling or new skilling of working populations meet this diversity in a way that increases opportunity for current and future generations of employees?
- More in job training will need to be developed and such innovations are under development internationally. They entail 'how to…' using online or multimedia approaches—but some skills and their improvement will need face to face learning.
- Future generations will be more adept at using online and self-directed learning approaches. They will also be program developers. Issues of access and inclusion will be needed to support these techniques and technologies.
- Traditional knowledges that may benefit the consequences of zero carbon—such as a reduction in plastics in consumption with locally produced domestic resources such as soaps, food and other consumables made from locally available products—will create new opportunities. Skills of this type should not be discounted by being valued against information and communication technology innovations.

9.1 Transitions in a dynamic economy

Economic transitions are nothing new (p. 221)

- The examples provided appear to have happened slowly over decades. Consideration and modelling of the timeframe(s) over which this low carbon transition is to take place (30 years) would allow some flexibility in responses. Slow transitions would likely call for different policies than an abrupt shift.

- The infrastructure lock-in of some sectors such as dairy, drives business as usual in land use, industrial processes, products and markets. The dairy sector has a large body corporate in Fonterra, and Dairy NZ provides extension services while research assistance is almost solely from AgResearch and Massey University and Lincoln University.
- This lock-in impacts the emergence of niche sectors due to a lack of sectoral support structures to enable growth, and the dominance of existing sectoral institutions (Wreford et al., 2017). Griffiths (2015) found that having no sector business plan, and more importantly, the lack of an industry body hampered sheep dairy sectoral growth.

Jobs are constantly being created and destroyed (p. 221)

- There needs to be discussion of how this change may disproportionately affect vulnerable and low-income households with less financial reserves and resilience. This is mentioned in section 9.4 but belongs here with more discussion.
- The section also needs to acknowledge that jobs are not interchangeable commodities, but can be an integral part of an individual's or community's identity, culture and lifestyle. Even when a person can transition seamlessly into new employment, there will still be significant social and psychological costs. For example, transitioning a multi-generational farm from sheep and beef to forestry has implications for a farmer's (and family's) self-conception, sense of mastery, social standing, sense of history and sense of attachment to the place (Burton, 2004). The impacts of job change, therefore, go far beyond economic concerns.
- The low emissions transition has the potential to create new job opportunities, but only if niche industries (low-emissions) are enabled to become more mainstreamed. The multi-level perspective (Geels, 2002) indicates a need for the mainstream industries to diversify, adjust to make room, and absorb technologies of the niche industries. Without planned transition pathways for niche industries to emerge and be mainstreamed, low-emissions sectors will struggle to make an impact.

The low emission transition will create new opportunities (p. 222)

- The question is who will benefit from these opportunities and what skills will be needed. Evidence of outsourcing low skilled jobs from New Zealand (e.g. to India, China, Korea) may impact Māori disproportionally as many are in low skilled work (Brown et al., 2008).
- Some key questions that this section should address are: Where will jobs be created and for whom? What will be the nature of the positions available and who is likely to gain from them? While the international trend for low skilled labour has been to outsource to countries with lower developed economies, how will that be reversed or addressed by policies or interventions?
- Critical importance of monitoring creation of new jobs and who benefits/ reskilling of adults requires different learning models and opportunities

9.2 Impacts of emission-reducing policies on households.

Food, energy and transport make up the bulk of household emissions (pp. 222-223)

- Even if the government is able to respond to the cost of low emissions vehicles (this pertains more to EV), what will be done to address any number of the road pricing options that government is considering? This could be particularly concerning given that most lower income people have to travel farther from home to work or leisure.

- This section assumes that the individual vehicle will continue to be necessary. This section should discuss how low-income communities are being pushed out of urban centres, increasing commuting distances or reference these discussions in Chapter 11. It is also important to discuss how urban and town planning could be used to reduce the need for private transport in the first place and how urban planning affects communities differently.
- A discussion of improving/rethinking public transport is missing in this section, especially given that NZ is highly urbanised. It is understandable that individual vehicles will remain necessary in rural areas. There is some discussion of changing to public transport in the Chapter 11, but essentially none here.

Household emissions do not rise proportionally with growing incomes (p. 223)

- While this might be true for heating and car use etc., improving wealth in society leads to greater overall consumption of goods. Higher consumption of goods (food, household goods, clothing, housing) will increase the manufacturing of such goods (Keynes, 2016; Diacon & Maha, 2015)
- In NZ case, higher consumption would lead to importation of these goods, as we don't make them locally and potential higher emissions. Hence, greater consideration should be given to concepts of embodied energy and emissions (Baker, 2018).
- The impact of a low emission economy on housing and employment is a critical issue. There is an expectation that returns on investment for emissions-intensive industries, primarily agriculture and transport, are likely to hit communities or families reliant on these businesses. If agriculture is transformed, what will be the fallout? How will those impacted respond to the need to reskill or change consumption patterns?
- Impact of higher food prices or dependency on food imports/ potential local market development for fresh food/ consumption patterns of different demographics need to be considered.

Pricing emissions can be regressive as lower-income households spend a greater proportion of their income on food and household energy (pp. 223-225)

- The authors don't seem to consider that (in particular food) is highly influenced by global prices/markets (Waterlander et al., 2018), and this needs to be taken into consideration when designing responses. Overall the report doesn't really acknowledge outside/ global influences.
- The impacts of globalisation and transnational companies play a significant role in the labour market. A UK study (Brown, Lauder and Ashton, 2011) reports that marginalised groups are most impacted by Transnational Companies, this includes women and single parents. This report also discusses the myth of jobs and the relationship to education. That is, if you attain qualifications there will be a job for you. This has links to labour market and the capacity of low SES groups to source work.

Lower-income families may be unable to substitute to lower-emitting consumption (p. 225)

- It seems unusual that the only discussion of impacts on Māori are in this subheading. There should be a wider discussion of if and how Māori (and/or vulnerable communities) may be impacted by the transition (both positively and negatively). There should also be references to the discussions elsewhere in the report concerning the Treaty of Waitangi, the role of Māori as landowners, Māori perspectives on waste, etc.

The possible scale of impacts on consumer prices (p. 225-226)

- Estimates for how electricity prices may rise (p. 226) should be reported in terms of household costs rather than wholesale costs.

9.3 Potential responses

What types of assistance are available for households? (p. 226)

- Direct financial incentives are not the only ways to reduce or mitigate the impacts of transition. Other means should be considered.
- Table 9.1 says that increasing the minimum wage reduces demand for low-wage labour. Evidence of the contrary has been recently published: a) Under a highly dovish monetary policy, a minimum-wage hike would cause an economic expansion (Sauer, 2018), b) introducing a 10 dollar minimum wage suggest large positive effects on capital (4.0%) and output (1.8%), with a decrease in employment by 2.8%, whereas the introduction of a 9 dollar minimum wage would instead produce similar effects on capital accumulation without harming employment (Bauducco and Janiak, 2018).

Assisting households to substitute away from high-emissions consumption

Housing (p. 230)

- The text implies that finances are the primary barriers and incentives for change. Other factors shape these decisions. Dolata (2009) shows that the ability of technologies to transform a sector relies not only on the transformative capacity of the technology, but also on how adaptive a sector is to such change. Sectors that are adaptive and remain flexible to new approaches, technologies and emergent new sectors are much more likely to adapt and encompass transformative technologies, such as low-emissions technologies. Many of the (particularly primary) NZ business models have become highly intensified and specialised, making them less flexible to adapt and incorporate newer technologies.
- Technologies that can sit across multiple sectors and industries have the most power to enable transformation (Dolata, 2009). Low carbon technologies or technologies that can enable lower emissions across multiple sectors should be those encouraged and incentivised first.
- Income-based assistance to lower income households may not be enough. What is required is a raft of infrastructural and social support mechanisms to support change. In a white paper to the NZ Business Council for Sustainable Development on sustainable consumption, besides perceived control (i.e. finance). Bayne (2006) highlighted the following aspects that account for sustainable consumption action by consumers: Media messaging and the source credibility of same; social norms, attitudes and perceptions around the behaviour; values and moral obligations and concerns for inaction; the performance merits of the technology itself; and the convenience by which to make a change and uptake more sustainable consumptive behaviour.

- A gap in the chapter is on people's behaviours. People's behaviours may not correspond with the rationale given, e.g., with transitioning to alternative to fossil fuel transport and reducing GHG emission from agriculture. The changes in transport choices and diets may be more difficult because of individual's association with identity factors. Not just about education but a learning journey through cultural transformation. A major challenge to support the transition of cultures or what people have come to take for granted is at issue.

Transport (pp. 231-232)

- Understanding the impacts of transportation opportunities arising from changes in types of transport or fuel on people's mobility is critical. Demographic changes such as aging populations, migration and mobility will have flow on effects to other areas of the economy including consumption, range of social interactions, education and livelihood opportunities.
- The unintended consequence of subsidies should be considered. For example, providing a low-e subsidy to low earners could be that low earners such as students would now have the funds to purchase a cheap, very high emitting vehicle rather than using cycling or public transport.
- A better investment by government than to provide individual tax cut or low-earner credits would be to heavily invest in scale up of the low-e vehicles industry in NZ (including e-bikes). One way would be through subsidising the abilities of motor vehicle dealers and e-bike firms to import desirable vehicles cheaply, and therefore to make these vehicles available to car buyers at lower price/ comparative price to existing. In addition to fund greater levels of charging sites at petrol stations or charging stations such that the infrastructure is in place to support more large-scale usage of these low-e vehicle technologies.

Direct assistance to affected firms? (p. 232)

- Direct assistance to firms has been largely unsuccessful as evidenced by the experience of the West Coast region that received regional development assistance and sectoral financial assistance to transition away from extractive industry (coal, cement, beech forests) (Scott and Pawson 1999).
- If assistance is to be provided to affected firms, early lessons from the Direct Action subsidy in Australia indicate that "it is preferable to design schemes that do not rely on difficult-to-observe information such as counterfactual project baselines" (Burke, 2016, 225).

Additional assistance to communities facing large shocks (pp. 232-233)

- For this to work effectively requires significant regional development input in terms of infrastructural scale up opportunities. Identify new niche businesses, and enable and support these opportunities through subsidies, rather than a large government handout. The New Zealand Council of Trade Unions initiatives presented in this section need to be incorporated within strong regional development policy. Kiernan (2013) also highlights the vulnerability of certain regions, such as Otorahanga with 24% employment in the dairy sector.
- It can also take a long time to transition regions - many regions are associated with certain industries (e.g. mining, forestry, horticulture) and people living there have an

innate sense of 'belonging' to the sector. This makes it more difficult for people to transition employment.

- An important gap in this section is discussion related to the impact of a transition to net zero or low carbon economy on trade. Since New Zealand is a price-taker, this key to understand what industries could be more affected and where the interventions should focus in terms of employment strategies.
- More detail on policy options outlined in this section should be provided, including investment policies, for example on techno-entrepreneurship, innovation-driven solutions (De Mello & Dutz, 2012) and culturally appropriate local solutions. For example, Te Arawa iwi has established a Climate Change working group in January 2018 to ensure Te Arawa whānau, hapū and iwi are best placed to respond to climate change, prioritising coastal whānau and the need to support marae as places of refuge (Te Arawa Lakes, 2018). Also, in the current landscape of NZ businesses with < 20 employees contribute to 29% of GDP (MBIE, 2017).
- The social and cultural impacts and implications of the transition, are not sufficiently addressed in this chapter. The importance of identity and how that influences people's choices, including to accept welfare payments as a reasonable recompense for loss of employment, mobility and social interaction needs consideration.

Labour market and skill-based interventions have the highest chance of success (pp. 233-234)

- Surprisingly, this section does not mention migration, ageing, lifelong learning, and the needed overhaul of the NZ education system (beyond mid-career training), and the impacts of artificial intelligence and rapid technological development on employment.
- A principles-based approach to overhauling education and learning was suggested Bolstad et al., 2012. These include: Personalising learning, new views of equity, diversity and inclusivity, a curriculum that uses knowledge to develop learning capacity, "Changing the script": Rethinking learners' and teachers' roles, a culture of continuous learning for teachers and educational leaders, new kinds of partnerships and relationships: Schools no longer siloed from the community.
- Innovations on training such as on-job learning and using mobile educational tools are likely to alter the types opportunities people can realise. While a focus ought to be given to future generations or those who will make up the workforce in 2050, what other conditions of support are needed for the population being cared for including aging parents and relatives and growing children?

There is not a strong policy case for hypothecating ETS revenue (pp. 234-235)

- This statement seems contradictory considering the evidence shown in this chapter. The case for compensation of low income households is strong, NZUs are directly related to lower emissions, so making the link between NZU to compensation of low income households more evident should be a priority.

9.4 Conclusion

- Capturing lessons from existing issues—such as homelessness and social housing—can accelerate learning on the impacts of transition and realising benefits for an inclusive transition.

- Robust systems of monitoring, learning and evaluating the impacts of an emerging low emissions economy will be necessary, in particular to assess emerging aspects from lived experience. The framework for assessing these impacts should include broader social, cultural, economic and environmental aspects, not purely economics.
- These systems will allow to build an ability to appreciate and understand the desired and undesired effects of economic development and any interventions chosen to ameliorate impacts on disadvantaged groups.
- Inclusive transitions will occur under paradigm shifts as the current model of economies is failing worldwide (Oram, 2016). Liu and Hanauer (2011) highlight a set of conceptual shifts in various spheres of knowledge (including economics) currently underway, that will influence our thinking on transitions: Simple → Complex, Atomistic → Networked, Equilibrium → Disequilibrium, Linear → Non-linear, Mechanistic → Behavioral, Efficient → Effective, Predictive → Adaptive, Independent → Interdependent, Individual ability → Group diversity, Rational calculator → Irrational approximators, Selfish → Strongly reciprocal, Win-lose → Win-win or lose-lose, Competition → Cooperation.

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10. Land use

Scion’s role

Scion’s research is relevant for Chapter 10 in a number of areas including; tree and soil carbon sequestration, tree species propagation, right species right site selection (site species matching), bioenergy, ecosystem services, primary sector GHG emissions and primary sector impacts on the environment, economic assessment of land use options, developing the low emission economy and the economic and social impacts, Māori land use and development, and climate change.

Summary

- Scion agrees with the statement that land use will need to change substantially to change a low emission economy and afforestation has a significant role to play.
- Scion fully supports MPI’s submission that the “right trees are planted in the right place for the right reasons”. However, the authors of this chapter focused on *P. radiata* and indigenous forests. Scion’s submission outlines the range of exotic and indigenous tree species and the positives and negatives as carbon forests. Different types of carbon forests are outlined and non-traditional income streams from carbon forests are outlined.
- Scion has highlighted a number of concerns of using soil to sequester carbon. It is not as clear and as simple as some of the previous submitters have suggested. The science in Box 10.3 needs to include the uncertainties to be more balanced.
- An emissions price incentive alone is unlikely to bring large change due to institutional barriers and inertia in the system. If agriculture comes under the ETS then a series of policy initiatives and practical support are required to facilitate those who wish to convert land to other uses.
- The document chapter is in the traditional paradigm of various individual primary sectors (horticulture, cropping, sheep & beef, dairying, forestry), and the merits of each in large scale land use, rather than parcels of land with unique opportunity for emissions reduction. An integrated land usage approach is not examined in this chapter. Such an approach as the ability to reduce emissions via integrated land usage/ industrial symbiosis – growing both niche and emerging new primary sectors, and cross-sectoral and multi-sectoral land usage.
- The document does recognise that institutional lock-in and lack of governance (policy and financial incentives) inhibits land use change and a stronger low-emissions economy, despite the large potential for NZ in both our biological heritage and large areas of available land for afforestation and conversion to lower-emission farm systems.
- Scion has included a number of references that we think are relevant for the various sections of the chapter.

Scion's comments

10.2 Changing land use in New Zealand

Figure 10.2

- The land use change numbers listed in Figure 10.2 and on page 241 do not balance by a substantial margin. There seems to be a missing area of around 1.7 M ha. To what land use did the 1.7 M ha of former pasture land go to?

Figure 10.4

- Figure 10.4 seems to contradict the strong statements that reducing pastoral farming and afforesting land is what will lead to lower emissions and is, therefore, misleading. This figure shows that pastureland has reduced and forested land has increased over 25 years, but NZ's emissions has had a very large increase over the same time period (see Figure 1 below). Thus, it would be helpful to have Figure 10.4 to include the more types of agriculture and pastoral farming, especially dairying. The paragraphs on this page does explain this, but Scion recommends to include some more detail in this figure. Considering the impact of farming intensification on GHG emissions and water quality, Scion recommends that this needs to be mentioned in Section 10.2.

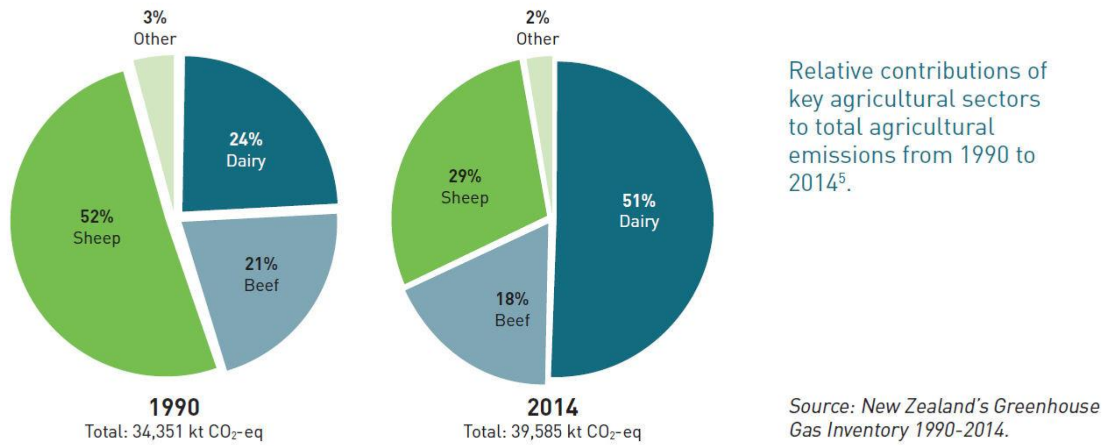

Figure 1: Relative contributions of key agricultural sectors to total agricultural emission from 1990 to 2014 (Ministry for the Environment, 2016).

- On page 241, the report states: "Relative trends in commodity prices are the primary driver of changes in profitability (section 10.6)." The afforestation rate has also fallen because of the rise in land price.

Planting of new forests peaked in the mid-1990s

- Deforestation by landowners (farmers and foresters) was also triggered in part by the warning that property rights were about to be negatively impacted by the imposition of a deforestation liability under the new ETS.

10.3 Land use emissions and emissions trends

Box 10.3 Carbon sequestered in soil

- Soil does hold substantial amounts of carbon as stocks or reservoirs. However, the term "sequester" in this box is used incorrectly as it used to describe soil carbon storage, as well as sequestration. For example, the first sentence. The term "sequester" should be reserved for use as a verb to add to existing soil carbon stocks, which may or may not be the case for NZ soils.
- Although Scion agrees with Meduna that soil carbon is an important stock for carbon, it is not as simple as Meduna suggests to increase carbon sequestered in the soil. To have a net increase in soil carbon stocks, you need carbon inputs to be greater than carbon outputs—known as carbon turnover. Soil carbon turnover occurs in different pools on daily, weekly, monthly, yearly, tens, hundreds, or thousands of years, time scale (Richter and Markewitz, 2001). Thus, quantifying the net carbon sequestration gain is difficult to measure in short term New Zealand studies (e.g. Smaill, 2013). Further, there is increasing evidence in the scientific literature that increasing temperatures may increase soil carbon turnover (e.g. Lukac et al., 2008), decrease soil carbon stocks (e.g. Pan et al., 2012), and even potentially be a positive feedback loop to global warming (e.g. Kirschbaum, 2004). Biochar addition would be the most promising option to add carbon to the soil for carbon storage, but more research is required. Scion recommends substantial more research in this area to quantify soil carbon turnover and potential ways to sequester soil carbon for long term storage.

10.5 Sequestering more carbon in forests

This section would benefit from laying out the accounting approach(s) for sequestering carbon in forests, detailing more the direct and indirect benefits of afforestation, and different carbon forest management regimes. For example:

a. displacing livestock, reduced fertiliser application/soil cultivation;
b. raising the performance of the less efficient farms with a focus on the worst emitters and what can be done to reduce their emissions- change land use, tech uptake, less stock or more afforestation etc.;
c. sequestering carbon to help meet short- to medium-term net emissions targets;
d. creating a sustainable resource of low-emissions products to substitute for fossil fuels directly (via bioenergy) or indirectly (via biomaterials, wood products etc.).

Which species, which planting regimes?

- Scion agrees with MPI's submission that the "right trees are planted in the right place for the right reasons". Unfortunately, section 10.5 has mostly focused on *Pinus radiat*a. Previous and current research at Scion has demonstrated that site tree species selection is key. For any given site a range of different exotic or indigenous tree species may be suitable depending on stakeholders needs. *P. radiata* is not ideally suited for long term carbon sequestration as it is a pioneer tree species that has a life span of less than 100 years and dominant trees typically start dying after 50 years.
- Due to the dominance of *P. radiata* in the forestry sector, information on site species suitability for non-*P. radiata* tree species is limited until recently. Research over the last 10 years has helped identify areas throughout New Zealand where non- P. radiata tree species best perform on a regional scale. These include *Eucalyptus fastigata* (Meason et al., 2011), *E. regnans* and *E. globoidea* (Meason and Herrmann, 2015), *Cupressus lusitanica* (Watt et al., 2009), and Sequoia sempervirens (Palmer et al., 2012). On

specific sites non- *P. radiata* tree species can be more productive than *P. radiata*. The Ministry for Primary Industries is funding the Growing Diversity project that will identify sites within regions that are most suitable for growing five exotic and four indigenous planted tree species. This project will help quantify the carbon sequestration rates for each species spatially throughout the country.

- Planting *P. radiata* and leaving it in the hope that it will revert to indigenous tree species is a poor choice and there is no certainty on the desired outcome. There are more options than those outlined in the section. For example, if the landowner wants an exotic forest as a permanent carbon sink, then other exotic species such as *S. sempervirens* and *Pseudotsuga menziesii* would be more suitable as such species outlive *P. radiata* by centuries. If the landowner wants to have a store of carbon in indigenous tree species then manage for that. Introducing indigenous species under *P. radiata canopy* may work, but it is unlikely to happen passively at large numbers in the near or medium term. There will have to be a plan and active management of both *P. radiata* and the indigenous vegetation. To achieve substantial volumes of carbon stored per hectare, climax tree species with a high dominant canopy is required. Indigenous scrub species will not hold as much carbon per hectare as a beech or podocarp forest.
- On page 252, the report references a submission by the Environmental Defence Society that afforestation with exotics “can destroy landscape quality”. Afforestation with exotics may “destroy landscape quality” for some people but not for others. There may be negative views of *Pinus radiata* from some segments of the public, but other exotic tree species do not have the same degree of negative views and could have positive aesthetics. It is by no means clear that exotic forests would diminish the experiences for international tourists.

Other types of forests and species not covered by emissions accounting

- On page 252, the report states: *“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.”*

  The relevance of this statement about carbon stocks is unclear, since native forests are already largely protected from deforestation and the large stock of native forest carbon makes no contribution to offsetting annual emissions and no contribution to a low carbon economy through harvested products.
- Page 252. *“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).*

  This is relevant for a low emissions economy as it could substitute for fossil fuels, but it will not contribute towards net emission targets via sequestration. Whilst *Miscanthus* grows quickly, it does not sequester large volumes of carbon. It grows to a height of around 4m, maximum. To harvest with current technology it needs to be grown on land with a slope of less than 20 degrees. *Miscanthus* could be regarded as a perennial plant as it develops a rhizome, but it requires annual harvest as the above ground dry matter dies off every winter. Even if non-forest vegetation qualified, the annual harvest of *Miscanthus* severely limits ongoing carbon sequestration. Dry matter accumulation is unlikely to be two times that of a well-managed forest.
- The type(s) of tree species, forest type and structure, age, and site productivity all influence carbon sequestration potential of a forest (Paul et al., 2008, Turner et al., 2008). It is not a one size fits all strategy. Figure 2 (below) is a good example of the differences

in carbon sequestration between different species. *Pinus radiata* may be fast growing but does not necessarily sequester the most carbon (Figure 2). However, *P. radiata* may be suitable for sequestering carbon if the forest stand is harvested for timber (long term carbon storage) and is replanted (new seedlings sequester more carbon). Conversely, *Agathis australis* and *Podocarpus totara* have a life cycle of hundreds of years, but they typically sequester carbon at a lower rate than many exotic tree species (Figure 2). *Sequoia sempervirens* sequesters carbon at a slower rate than some exotic species, but it is able to sequester carbon at rate higher than most exotic species well after age 50 (Figure 2, Meason et al. 2012). The right type of carbon forest will depend on the stakeholder's short and long objectives and site. Figure 3 provides an overview of 11 New Zealand planted forest types and the range of economic, social, and environmental benefits.

Availability of land for forestry of different types

- Scion agrees that there is pastoral land that is economically marginal and erodible that is potentially suitable for large scale afforestation. However, the definition of "marginal pastoral land" and what land is suitable for afforestation does vary, and what is "marginal" will vary regionally and farm to farm. Watt et al. (2011) developed three different afforestation scenarios for non-arable land in New Zealand and identified areas that could be suitable for planting ranging from 0.7 million hectares (Scenario 1), 1.1 million hectares (Scenario 2), and 2.9 million hectares (Scenario 3). The issue of where to plant is more complex than the section suggests. For example, some otherwise suitable land is currently off-limits because of concern about catchment water flows and landscape values.

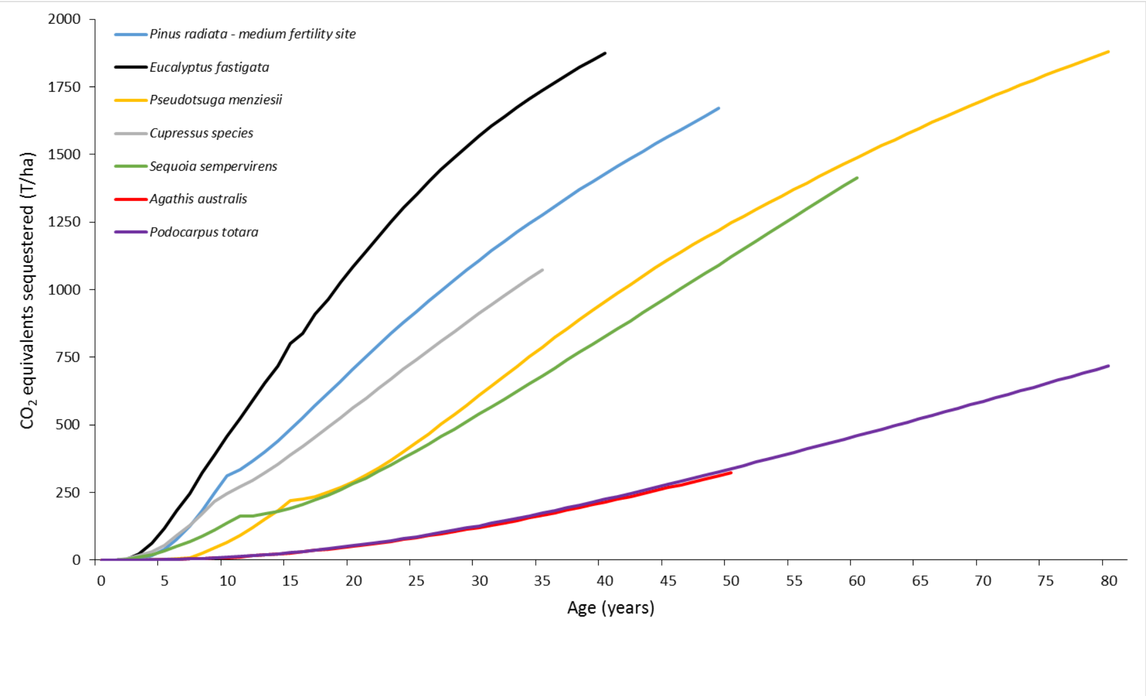

Figure 2: Indicative carbon sequestered by selected exotic and indigenous tree species. Adapted from Paul et al., 2008.

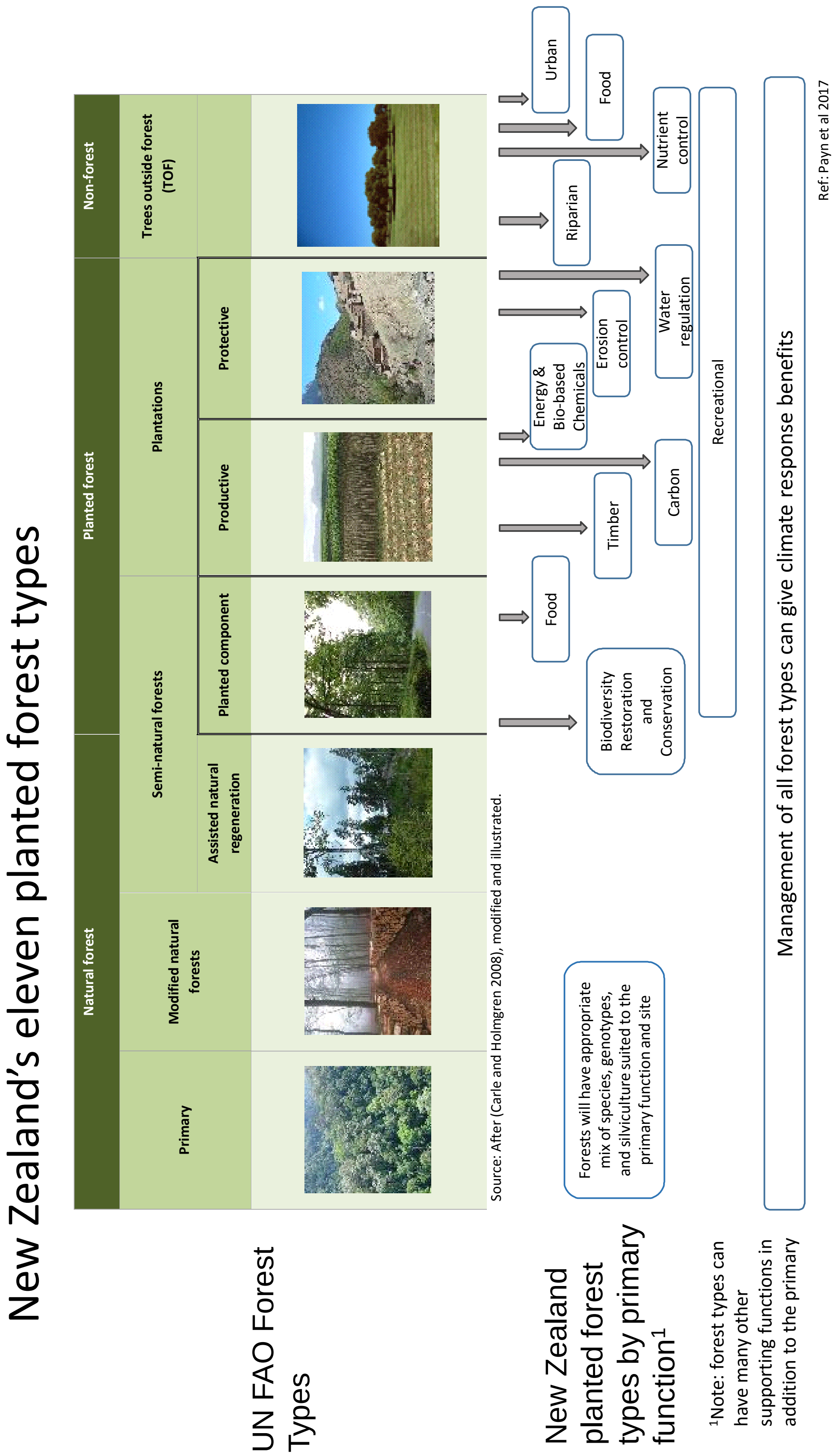

Figure 3: Classification of New Zealand's eleven planted forest types

10.6 What influences land-use change?

- On page 254, the report states: *" Planting forests for harvesting carbon sequestration…means that land will not be available for other uses for many years…"*

  Scion disagrees: carbon forests can generate revenue and be "productive". There are other economic uses of carbon forests including undercropping, recreational value and use, diversified land use such as the Ernslaw Keewai revenues. The authors of this section appear to have a traditional viewpoint of forests and what they can contribute. Figure 3 (above) outlines the 11 planted forestry types and the range of economic, environmental, and social benefits.

10.7 Putting a price on all land-use emissions

Complementing pastoral agriculture with forestry

- On page 266, the report notes: "*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."*

  Beef and Lamb NZ would need to quantify the woody vegetation—species, age, growth rate—to determine if this type of woody vegetation is a significant carbon sink. The total area only does not quantify carbon sequestration rate. It is unknown if this woody vegetation is a significant net stock overall, given that farmers also clear woody vegetation, and native forest remnants on farms may be losing carbon.

- Page 266. *"Reisinger et al. (2017) investigated the economics of on-farm forestry options… Generally, the study concluded that forestry (on between 10% and 30% of land) reduced the profitability of the average sheep and beef farm."*

  This report has not been released, so it is hard to comment. In practice, the impact on the 'average farm' may be less relevant than the total area for which forestry is a more profitable land use. In general, it is not the relative profitability of forestry that deters sheep farmers, but rather cashflow and social/cultural issues.

- Forestry also provides a number of non-market ecosystem services that could be highly valued by landowners and government (Yao et al., 2016). Yao et al. (2014) compared forestry land use with other productive and non-productive land uses in the Bay of Plenty's Ōhiwa catchment and found that forestry had the third highest market value behind dairying and horticulture. However, when forestry's direct and indirect ecosystem services were taken into account, e.g. mitigated erosion and improved water quality, forestry had a far higher positive ecosystem service value than the other productive land uses.

- Page 267. *"NZ ETS accounting rules should be amended to include smaller areas of planting…"*

  This is being addressed in a project for Biological Emission Reference Group conducted by Manaaki Whenua-Landcare, NIWA, Scion and AgResearch. It is likely that many landowners do not think it is worth registering even large blocks of fast-growing trees in the ETS, so the costs and risks may outweigh the benefits unless there is a substantial increase in carbon price.

10.9 Maori and land in a low-emissions economy

- Page 271. The prospect of extensive new native forests managed under a selection harvesting system to provide high value products of high cultural value is appealing, but needs to be kept in perspective. The final version of the Timberlands West Coast Beech Scheme proposal was going to do just that on 100,000 ha of forest land that already contained trees aged over 300 years. Harvesting was to involve on average one tree per ha per year over 35 years - 100,000 trees/year or perhaps 100,000 m^3/year. At that rate, a new one million ha native forest would eventually generate 1 million m^3 per year, after a 100-300 year wait. The same area in *Pinus radiata* could generate 25-30 million m^3 annually, after only a 28 year wait to start harvesting. The undoubtedly high co-benefits of native forest must be set against this high opportunity cost. Stakeholders will need to balance multi-generational goals with current generation needs to generate cash flow from their land.

10.10 Complementary policies to reduce emissions from land use

- Page 275. *" landowners may not know about or understand how to put in place alternative land uses, may be uncertain about the hidden costs…face skills barriers…".*

  Scion agrees. There is a great need for extension services and advocacy around both technology adoption for low-emissions farm systems, and also educating land owners around how to practically go about land use change, most urgently in afforestation – both in planting and establishment, as well as education in forest management if trees are to survive and reach productive maturity. While extension services are operating well in agriculture and horticulture, there is a notable lack of extension services provision within the forest sector for most non-commercial forested land, something that the Te Uru Rakau will need to address.

10.11 A fair and prosperous transition to a low-emissions rural economy

- A number of the key issues of transitioning to a low-emissions rural economy are being addressed in the proposal development of Our Land and Water National Science Challenge Second Tranche with multiple research institutions (http://www.ourlandandwater.nz/).
- Page 276. *"…large-scale afforestation could have (possibly adverse) impacts on the population and prosperity of local rural communities"*

  Scion agrees. Government needs to ensure there are no unintended consequences…need to fund feasibility studies and associated linkages around regional impacts (schools and depopulation are mentioned in report for example). However, optimum farm size and land value would be expected to change in a world in which environmental costs are no longer externalised.

Box 10.10. How will climate change affect agriculture and forestry in New Zealand?"

- The box describing the effects of climate change on forests omits a large amount of research that has been published over the last 10 years. Although uncertainties around the effects of climate change on forests still exist there is far more known than is conveyed in the text. The summary below provides the authors an overview of climate change research with New Zealand forestry with the relevant publications.
- *Pinus radiata* is the main commercial forest species grown in New Zealand, and currently covers 90% of the 1.7 million hectare plantation resource (NZFOA, 2016). Assuming that radiata pine fully responds positivity to increasing CO_2, predictions show productivity

increases across almost all plantations, with average increases of 19 and 37% by 2040 and 2090, respectively (Kirschbaum et al., 2012). However, it is unlikely that *P. radiata* will fully respond to increases in CO_2 (Dunningham et al., 2012). Recent research suggests that future growth enhancement of *P. radiata* plantations may lie half way between no response and the above values (Meason and Mason, 2014; Kirschbaum and Lambie, 2015) which would result in mean productivity gains of ca. 10% and 19% by 2040 and 2090, respectively.

- The general temperature and rainfall impact of climate change is unlikely to have significant negative impact on growth and productivity of *P. radiata* and other commercial tree species, even with a 4ºC rise in global temperature (Renwick et al., 2013). Indeed climate change may have a positive effect as the reduction of frost days will likely provide more tree species afforestation options for frost prone regions (Dunningham et al., 2012; Meason and Mason, 2014).
- Although fire risk is projected to increase in the future (Watt et al., submitted) for New Zealand, most damage in forestry plantations is likely to ensue from the greater vulnerability to wind damage, that result from increased height growth. This increase in the risk of wind damage under future climate is greatest in unthinned stands that are grown for maximum biomass production and carbon storage. For this silvicultural regime the mean annual probability of damage by 2090, assuming no further increases in wind speed, is projected to be more than triple the value at 1990 for the same stand age (Moore and Watt, 2015). Currently, the most significant biotic disturbances of New Zealand plantations come from two needle cast diseases, for which climate projections show very little change in damage over the course of this century (Watt et al., 2011 and 2012). However, climate change may make favourable climatic conditions for other *P. radiata* pathogens to spread if they established in New Zealand (e.g. Ganley et al., 2009).
- The effects of climate change on New Zealand plantation forests that are documented in Chapter 25 of the latest IPCC report are consistent with the predictions outlined above (IPCC, 2014).

Comments on Findings

F10.1

- Scion agrees. However, carbon sequestration by trees alone does not lead to transformation – it is a tool for achieving net emission targets. Afforestation combined with other changes in land use and energy use will lead to low emission economy. This includes reduction in stock units with afforestation, development of high value timber and non-timber forest products, bioenergy crops, and the full integration of forests in the farm and in the primary sector landscape. Carbon forests shouldn’t be an either or option for the landowner.

F10.2, 10.3, 10.9

- Scion agrees.

F10.4

- Scion generally agrees although the export earnings per hectare from sheep and beef have been consistently low for decades, and lower than for forestry which is generally on worse quality land. Forestry has demonstrated to provide constant return to landowners over the last 20 years and it is low cost to manage once established. Forestry is generally undervalued by the farming sector.

F10.5

- Scion generally agrees although changes in land use, like afforestation, will likely reduce emissions without the need for new technologies.

F10.7

- Scion generally agrees. However, land use economics is driven by land price, which reflects not only the productive potential of the land, but also the lifestyle utility that especially sheep and beef farmers derive from living on the land, and capital gains.

F10.8

- Scion agrees. Also a history of policy favouring some land uses over others (e.g. grand-parenting N emissions for dairy farms in sensitive catchments) is also delaying change.

F10.12

- Scion acknowledges the importance of OVERSEER in the farming sector for monitoring emission at the farm level. However, there are a number of issues with the OVERSEER model that needs to be addressed. OVERSEER needs to include forestry to help farmers assess their land management options.

F10.14

- Scion generally agrees. However, by then it could have created a considerable sustainable resource that can contribute to a low emissions economy by substituting for fossil fuels directly (via bioenergy) or indirectly (via wood products and biomaterials substituting for aluminium, steel and plastic).

F10.16

- Scion believes that emission prices greater than $20 NZU will start encouraging afforestation. Large scale afforestation for carbon forests will likely occur well before $70 NZU. It is important to comment that forestry can be profitable in its own right – the issue is land price which is inflated because buyers of agricultural land can afford to pay high prices knowing that their environmental costs will be externalised.

Comments on Recommendations

R10.1

- Scion is leading a research programme on this currently under the MPI SLMACC Steeponomics project lead by Scion.

R10.2

- Scion believes that we can significantly contribute to this audit, especially with Scion’s experience with leading MfE’s LUCAS program.

R10.3

- Scion agrees, but it should include a free allocation to help with the transition.

R10.4 & 10.7

- Scion agrees.

R10.5

- Scion acknowledges the importance of OVERSEER in the farming sector for monitoring emission at the farm level. However, there are a number of issues with the OVERSEER model that needs to be addressed. OVERSEER needs to include forestry to help farmers assess their land management options. In particular, OVERSEER must be able to model nutrient requirements of forests and their carbon uptake rates. Scion can readily contribute the improvement OVERSEER.

R10.6

- Scion agrees. The Commission should also investigate the contribution that forest products can make to a low-emissions economy and advise on policy settings that recognise this.

R10.8

- Scion agrees. There is also considerable scope for research aimed at improving mitigation benefits from forests, and/or improving other co-benefits such that afforestation becomes a more attractive option for landowners.

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11. Transport

Scion's role

Scion has an active programme of research and development on the production of liquid biofuels, largely from plantation forests – including being the author of the Biofuels Roadmap report referred to in this chapter. Scion also represents New Zealand on IEA Bioenergy.

Summary

- We strongly support the comment that "transport is one of the main sectors where deep emission cuts are both necessary and possible given existing and emerging technology" and believe that biofuels produced in New Zealand from sustainable feedstocks, such as those from our plantation forests, have a role to play in achieving this.
- International shipping and aviation are strategically important for New Zealand's exports of both goods and services (e.g. tourism). It is important that decarbonisation of these sectors be considered more comprehensively as part of a low-carbon economy / future for New Zealand.
- EVs are a good option for decarbonisation of much of the light vehicle fleet, particularly in urban areas. However, we would question whether total electrification of light vehicle fleet is really the best/most cost-effective option for decarbonisation of the light vehicle fleet in New Zealand, particularly in remote locations and/or if consumers prefer PHEVs. Drop-in biofuels would be an attractive complementary option for such situations.
- Greater consideration needs to be given to how to reduce fossil fuel use in sectors other than the light vehicle fleet. This should include not only heavy duty vehicles, but also fossil fuel used in international travel and off-road uses such as in the agricultural, forestry, fishing, construction and mining sectors.
- There is a need for a more balanced and comprehensive evaluation of the different decarbonisation options, particularly for the heavy duty transport, where there are not yet technically-proven solutions. We do not believe the report, as captured by key point 5 on p. 281, provides a balanced assessment of the options.
- Technologies for decarbonising the transport sector are still technically immature, advancing rapidly with falling costs, and new options emerging. For these reasons the main policy interventions should be focussed around decarbonisation targets, rather than facilitating specific solutions or options. This will minimise the risk of locking in what turn out to be sub-optimal solutions.
- The draft report does not adequately recognise that plantation forests can be grown on a sustained yield basis, where only a small portion of the forest is harvested in any one year (our largest forest Kaingaroa is an example of this). Grown this way, forests will reduce new Zealand's gross emissions by providing an on-going low carbon feedstock for bioenergy and timber for low-carbon buildings.

Scion's comments

Overarching comment

The draft report seems to miss the link between it's advocacy for the establishment of new forests to accumulate and sequester carbon, the limits on this due to land area and the opportunity to manage a plantation forest estate for a sustained yield for biomass that can be used to produce low carbon fuels (solid, liquid and gaseous) and significantly reduce gross carbon emissions.

Comments on specific sections

11.1 Transport emissions in New Zealand

p. 283: Given the strategic importance of international shipping and aviation to New Zealand's exports of goods and services, it is important that decarbonisation of these sectors be considered as part of a low-carbon economy / future for New Zealand.

- While international aviation and shipping currently lie outside international reporting frameworks and commitments, there is a real risk that as climate change becomes more important globally our export markets focus more on GHGs emitted in getting NZ goods to their markets and tourists on the GHGs emitted bringing them to the country (Ministry of Business Innovation and Employment, 2017b).

p. 283: Greater consideration needs to be given to how to reduce fossil fuel use in sectors other than the light vehicle fleet.

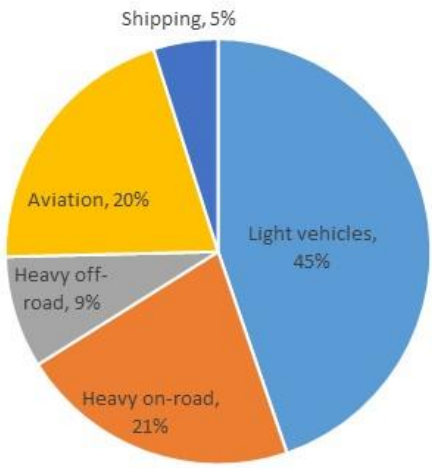

Fig 1. Fossil fuel draw-off in New Zealand in 2017 by sector in PJ. Source: MBIE (Ministry of Business Innovation and Employment, 2017a), assuming all petrol is used in light vehicles and diesel is responsible for 23.2% of total light vehicle fleet kms driven (Ministry of Transport, 2016).

- We support the conclusion that EVs are a good option for decarbonisation of much of the light vehicle fleet – and should be supported. However, if we use fossil fuel draw-off in New Zealand as a proxy for their GHG emissions, and include fossil fuel used both in international travel and off-road use (e.g. in the agricultural, forestry, fishing, infrastructure construction and mining sectors), then GHG emissions from light vehicles makes up less than half of the emissions from combustion of fossil fuels (Fig. 1).

p. 293: Is a high level of electrification of the light vehicle fleet really the best/most cost-effective option for decarbonisation the light vehicle fleet in New Zealand?

- While EVs certainly make sense in most urban situations, it might be more cost-effective (vs costs to roll out a comprehensive charging infrastructure) to offer a biofuel replacement for petrol for use in more remote rural locations. This biofuel could also replace fossil fuels use in PHEVs, which currently make up 40% of global EV sales [7]. Greater consideration needs to be given to which mix of solutions is the most cost-effective option.

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 date?

P. 293: Should NZ aim to phase out fossil fuel vehicle imports?

- We do not believe it is yet appropriate to set a target to ban fossil-fuelled heavy vehicles due to the lack of alternatives. The transition away from ICEs may occur but forcing it could result in unintended consequences. These unintended consequences are likely to be substantial, it could be considered social engineering as it will force lifestyle change (possibly at considerable expense).
- While recognising the power that such symbolic goals can have in catalysing change, such a major step would need to be very carefully thought through to ensure alternatives exist and avoid unintended consequences.
- One of the big plusses for biofuels, particularly drop-in biofuels, is that they can reduce emissions but be used in engines designed for fossil fuels and distributed via existing fossil fuel distribution infrastructure. As identified in the report, banning fossil fuel-powered vehicles could rule out future options for using low-emission fuels like biofuels – which might be the best decarbonisation option for light vehicles in certain situations (e.g. remote locations).

11.5 Increasing the uptake of low-emission vehicles

p. 294, p. 304: There is a need for a more balanced and comprehensive evaluation of the different decarbonisation options, particularly for the heavy duty transport where there are not yet technically-proven solutions.

- As this report will help to inform decision-making and direction-setting, potentially having consequences for many years to come, a more comprehensive and balanced analysis of the different decarbonisation options is required. The report, as captured by key point (middle of p. 281) or findings 11.12 and 11.13, needs to provide a more balanced assessment of the options. This assessment needs to take account of both the technical risks and whole new value chains which would be needed to allow large-scale deployment of the different decarbonisation options.

- Any such assessment needs to: (i) be done at a transport sector/ sub-sectoral level; (ii) take into account the technical risk associated with the different options; (iii) consider the risks and impacts on other parts of the economy associated with each option and (iv) consider public acceptance. We would be very happy to contribute to such an assessment.
- A recent International Energy Agency (IEA) report (IEA-RETD, 2015) provides a useful high-level analysis of the barriers to deployment of biofuels, hydrogen and EVs as renewable options for transport in urban areas (see summary below), and goes on to discuss with international example, appropriate polices needed to facilitate the different options.

Table 3 Barriers to renewable energy in transport

Barrier	Dimension	Energy carrier		
		Battery-electric	Hydrogen	Biofuel
Financial barriers* –	Energy carrier	Low	Low	High
	Energy infrastructure	Medium	High	Low-medium**
	Vehicle	High	High	Low
Technical barriers vehicle technology & compatibility	Vehicle	Medium-High	Medium-high	Low-medium**
	Energy carrier	Low	Low	Low-medium**
Low acceptance by transport users	All	Medium-High	High	Low-medium**
Lack of sufficient energy infrastructure	Energy infrastructure	Medium	High	Low-medium*
Vested interests	All	High	High	Medium
Competition for the use of available renewable energy sources	Energy carrier	Low	Low	Medium
Investment risks*	All	High	High	High

* Financial barriers are from a demand/consumer perspective; investment risks rather from the supply/industry perspective.

** Medium mainly applies to high blends. These barriers are low for low blends, as these can be used with existing infrastructure and vehicles.

- Of particular concern is that the high technical risk associated with hydrogen fuel cell vehicles is not adequately acknowledged in the report. We note that while some countries believe hydrogen is a potential transport fuel, and there is a lot of global research on its production and application in fuel cells, the technical risk remains very high, to the extent that significant deployment even by 2050 is questionable. For example, an IEA Technology Roadmap for Hydrogen and hydrogen fuel cell vehicle says (International Energy Agency, 2015):

  "Although the GHG mitigation potential of hydrogen technologies is promising, important obstacles for widespread deployment of hydrogen and fuel cell technologies need to be overcome. These barriers are mainly related to current costs of fuel cells and electrolysers, the development of a hydrogen T&D [transport and distribution] and retail network, as well as the cost efficient generation of hydrogen with a low-carbon footprint. Most hydrogen and fuel cell technologies are still in the early stages of commercialisation and currently struggle to compete with alternative technologies, including other low-carbon options, due to high costs. Additional attention will be required before their potential can be fully realised."

> "While the potential environmental and energy security benefits of hydrogen and fuel cells in end-use applications are promising, the development of hydrogen generation, T&D and retail infrastructure is challenging. For example, the risks associated with market uptake of FCEVs have been a significant barrier to infrastructure investment."

p. 294, p. 304: While implicit in much of the thinking presented, it would be valuable to include a more explicit discussion around current costs for the various options and the economy in general, and around technology learning and its implications on future costs.

- In this situation where we are comparing immature low-carbon technologies and value chains against those based around fossil fuel use, which have had more than 70 years of optimisation to drive down costs – it is not surprising that costs for all the new options are currently higher. Figure 2, taken from our roadmap report (Suckling Ian et al., 2018), illustrates the extent of cost reduction with time for bioethanol production in Brazil – but there are lots of other examples of such technology learning, including drops in the cost of solar electricity and batteries for EVs.

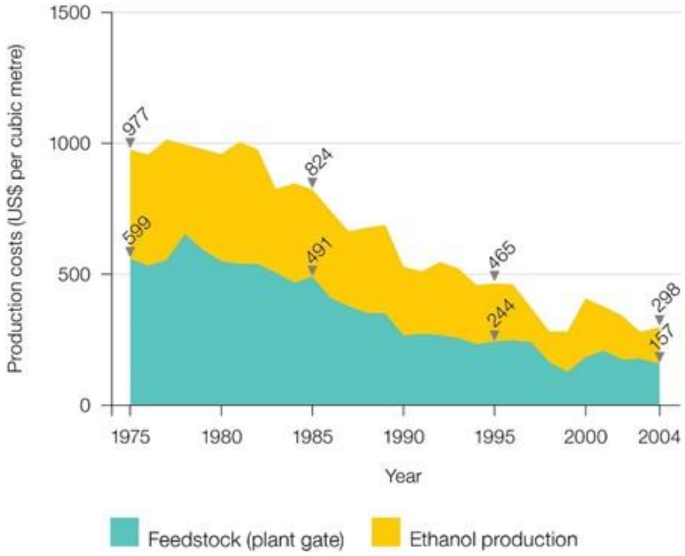

Fig 2. Decrease in production costs of Brazilian ethanol as the technology matures. Redrawn from (Suckling Ian et al., 2018)

- Biofuels are critiqued for being currently non-commercially viable (p. 306). This could also currently be said of EVs (in the absence of current government support), or hydrogen and fuel cells vehicles (not commercially proven or available in New Zealand).

p. 295: Due to their technical immaturity, the best options for decarbonising heavy duty transport are currently not clear, so the main policy interventions for decarbonisation should be focused around decarbonisation targets rather than facilitating specific solutions or options.

- As pointed out (p. 286, middle) technical developments are difficult to predict over the timeframes considered – and the rate of developments is even more challenging, so policy interventions such as an effective ETS or low-carbon fuel standards which allow a technology-neutral approach to decarbonisation (favouring those which offer the deepest decarbonisation at the lowest cost) will minimise the risk of locking in what turn out to be sub-optimal technology solutions (International Energy Agency, 2017). This parallels Finding F12.2, which refers to the risks of governments favouring particular technologies to generate low-emissions electricity.

p. 297: The current lack of flexibility of BEVs is likely to push many New Zealanders to PHEVs, particularly in one-car households.

- While many cars do make a great many short journeys with one passenger in urban centres, the same vehicle is also often used with a full load of passengers or to tow a boat / caravan / trailer or travel with skis / surfboards / mountain bikes etc. on the roof. Current BEVs simply cannot do this effectively, making them an unattractive proposition for many consumers, particularly in households with one vehicle or for single people running only one car. This lack of flexibility is likely to favour vehicles with ICEs or PHEVs, suggesting that a biofuel replacement for petrol might be a useful complementary measure to EVs for deep decarbonisation of the light vehicle fleet.

p. 302:

- The design of any feebate scheme, particularly if applied to the heavy vehicle fleet, should not dis-incentivise the use biofuels as a way of lowering carbon emissions. One of the big plusses for biofuels, particularly drop-in biofuels, is that they can be used in engines designed for fossil fuels and distributed via existing fossil fuel distribution infrastructure. The feebate should incentivise lower-emitting vehicles in a technology-neutral way.

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?

- As the best options for decarbonising heavy duty transport are currently not clear, and the status of biofuels (above), it is difficult to see a feebate scheme being a useful policy tool at this stage.
- It is also important to recognise that the goal of reducing emissions during heavy duty transport is to reduce the emissions per tonne of goods transported, so a feebate scheme should not dis-incentivise large trucks vs smaller trucks if fewer larger trucks give the lowest overall emissions.
- At least in the short term, where biofuels are essentially the only option for reducing emissions from heavy duty transport removing/reducing the price differential between biofuel and fossil fuels would be a much more effective intervention. There are a number of brand leaders interested in biofuels as a way of improving the sustainability of their business, but tell us the cost of fuel to their businesses limits uptake of higher priced biofuels.

11.6 Using biofuels to reduce transport emissions

p. 306: Future drop-in biofuels plants are likely to produce a mixture of drop-in petrol, drop-in jet, and drop-in diesel, meaning that if biofuels are used to decarbonise aviation, drop-in replacements for petrol and diesel will also be available to replace fossil fuels in other sectors.

- Drop-in biofuels are hydrocarbon fuels produced from biomass that are chemically identical to their fossil fuel equivalent and can be used in existing engines and fuel distribution infrastructure without significant modification. Due to the inherent technical nature of the processes, it is highly likely that drop-in biofuels will also be produced as a mixes containing various proportions of bio-derived replacements for petrol, jet and diesel (ratios may change for different processes and future developments). Biofuels offer the only significant medium-term decarbonisation option (on top of efficiency improvements), so if biofuels are used to decarbonise aviation, drop-in replacements for petrol and diesel will also be available to replace fossil fuels in other sectors, e.g. heavy transport, light vehicles, including PHEVs.
- The specifications for marine fuel are much less demanding than for jet or diesel fuels, so this fuel could be an attractive target for the development of a first step on the route to renewable low carbon liquid biofuels.

p. 307: Government policy interventions have been used overseas to drive the implementation of biofuels.

- Our Biofuels Roadmap study was undertaken to inform and stimulate debate on the large-scale production and use of liquid biofuels in New Zealand and specifically did not include any analysis of policy, as the relevant policy ministries MBIE, MfE and MoT were project stakeholders. With biofuels making up 4% of the transport fuels and high levels of biofuel uptake in countries such as Brazil, Sweden and the United States (particularly California), there is plenty of international experience to draw on. Leading sources of information here include refs (IEA-RETD, 2015; International Energy Agency, 2017; International Energy Agency, OECD, & FAO, 2017).

Page 306: 2nd para: The sentence starting “Total suitable feedstocks…” is far incorrect.

- The 8% figure refers to the level of biofuels that could theoretically be produced if all “wastes” (tallow, wood waste, municipal solid waste and forest residues) could be recovered and used as feedstocks (p. 45 from the cited Scion reference). Taking as an example the scenario of substituting 30% of liquid fuels with biofuels referred to in the next paragraph in the draft report – and only using the lower-value fibre logs and forest residues, this would require 523,000 ha of new and existing forests. This translates to ~30% of New Zealand’s existing plantation forest estate, or 40% of the possible harvest from the Governments 1 billion trees target if this was established in plantation forests.

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12. Electricity

Scion’s role

Scion has an active bioenergy R&D programme. Within this we have a Wood Energy Industrial Symbiosis project, which looks for opportunities for wood and other primary processing industries to beneficially co-operate in their use of energy.

Summary

While the widespread use of biomass to generate electricity generally is not a low-cost option in New Zealand, there are two specific situations where biomass could be a good feedstock to produce electricity:

- Biomass could be used to generate electricity in dry years, to keep the use of fossil fuels low. This could be undertaken in existing plants such as Huntly or in new purpose-built plants.
- Biomass can be used in combined heat and power (CHP) production at a distributed level. There are a wide range of industries in New Zealand (dairy, meat, wood, fruit / vegetable), and institutions such as hospitals which have both heat and power demands. This CHP technology exists at a wide range of scales (250kW to 100MW).

Scion’s comments

12.4 Future low-emissions electricity supply pathways

p. 333. Box 12.4.

- Forest biomass could be used to produce electricity in dry years, keeping the use of fossil fuels low. This biomass can be mobilised sufficiently quickly at scale to be a viable energy source for dry year generation. This could be combusted in existing plants such as Huntly, reconfigured to take a proportion of its fuel as biomass, or in new purpose-built plants. Torrefaction of biomass has been extensively researched globally, is nearing commercial viability, and looks to provide an attractive low-carbon feedstock for use in existing coal-fired power generation plant.
- Biomass could also converted into bio-synthetic natural gas which can either be fed into the natural gas pipeline network, or directly to a power plant or existing gas fuelled heat plant. This technology has been successfully demonstrated in Sweden (GoBiGas 2018).

12.5 Demand-side options

p. 337.

- In energy conversion terms the most efficient use (85 to 90% conversion) of biomass is direct combustion to produce heat. Combined heat and power is next most efficient (~70%), while simply making electricity without the capture of heat is the least efficient use of the biomass resource (this also applies to fossil fuels).
- Biomass can be used in combined heat and power (CHP) plants at a distributed level. There are a wide range of industries in New Zealand (e.g. dairy, meat, wood, fruit / vegetable) which have both heat and power demands. It is possible to have combined heat and power units at these sites which, depending on the demands on site, could have

the capacity to not only meet the heat and power demands of the specific industrial site, but also be able to export electricity to the grid. For example, this would also support the use of anaerobic digestion of wastes from a meat processing plant alongside a CHP unit running on the bio-gas. Current costs structures do not incentivise this approach; a possible solution would be for a feed-in tariff for bioelectricity.

- This CHP technology exists at a wide range of scales (250 kW to 100 MW) and government could lead the deployment of this technology with bio-CHPs in facilities such as hospitals and other facilities with substantial year round heat and power demands. Co-generation of heat and power is already used in the wood processing industry at pulp mills and large sawmills.
- There is sufficient biomass resource in many regions to consider CHP at small to medium scale (Hall 2017). Our recent work has shown some regions (e.g. Gisborne / East Coast) have an identified opportunity for biomass-fuelled combined heat and power.
- Landfill gas is another potential distributed source for electricity generation. Landfill gases currently contribute significantly to New Zealand's GHG emissions, so using this to produce electricity will also reduce waste emissions. Technologies to do this exist, and are in use in some cases, but the costs are currently higher than the mainstay renewable electricity sources such as hydro, geothermal and wind.

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13. Heat and industrial processes

Scion's role

Scion has an active research programme on solid biofuels, spanning biomass resources, processing technologies and techno-economic analysis, as well as a project focussing on wood energy industrial symbiosis, which has a goal of identifying opportunities to co-locate primary wood processing to optimise bioenergy use.

Summary

This section does not fully recognise the potential for woody biomass and other lignocellulosic residues (straws) to contribute to the national industrial heat demand.

- There is at least 10 PJ (and maybe as much as 15 PJ) of coal demand that could be substituted by these residues. The GHG reductions from this substitution would be between 1.3 M tonnes and 1.7 M tonnes of CO_2-e per year.
- A significant amount of biomass is already used for industrial heat in New Zealand, particularly by the wood processing sector.
- Technology to use biomass to produce process heat exists now, off the shelf and is already in use in New Zealand.
- A modest increase in the price of carbon would see industries with heat demand met by fossil fuels (especially coal) move to wood.
- Biomass residues from New Zealand's plantation forests are a low carbon fuel.

Scion's comments

Key Points

Page 347. Bullet point 4

"*biomass has been referred to as a possible lower-emission alternative to coal and other high-emissions heat sources. But significant technological and logistical improvements, as well as a much higher emission price, will be needed before biomass becomes a cost-competitive alternative for industrial process heat*" is substantially incorrect.

Specifically:

- The technology to both transport and burn biomass for process heat exists now and many wood processors already use wood as a source of process heat (see Fig 1 below and (MBIE 2017)). Fonterra has recently announced it will use co-firing of biomass at its Brightwater dairy plant and a number of companies and schools have converted to wood as part of the Wood Energy South initiative.
- Only a modest increase in the price of carbon, well within the range of increases in prices considered within this report, would see industries with heat demand met by fossil fuels, especially coal, move to wood. While actual costs are site-specific, the cost of biomass as a delivered fuel would be in the order of $10 per GJ at many heat-using sites. Gas already costs this depending on the size of the demand. Coal is cheaper at some sites, but transport is a factor that varies. For many the cost of coal would be in the order of $6 to 7 per GJ, more if transport distances are in excess of

100 km. The cost of coal will rise around $1 per GJ for every $10 increase in the carbon price. If industrial fossil fuel users were paying the full price for their carbon emissions and the cost of carbon gets to around $50, then biomass as a heat fuel will be able to compete. This is broadly consistent with the conclusion from Concept Consulting quoted on p. 353 of the draft report.

- There is a significant amount of unused biomass in most regions of New Zealand that could be used for process heat (Hall 2017). The bulk of this would come from existing plantation forests, its extraction and use would provide a low carbon heat source and help solve the post-harvest management issues that sometimes occur on steep sites.

13.2 Process heat

Page 348. Figure 13.1 requires revision. Figure 1, shown below, is reproduced directly from the quoted source of Figure 13.1 (Royal Society of New Zealand, 2016). This shows a much higher use of geothermal and biomass for process heat than does Fig. 13.1. It is also consistent (given the date changes) with information given in MBIE's Energy in NZ 2017 publication for industrial energy use (Ministry of Business Innovation and Employment, 2017). For what follows, we believe it is important that Fig 13.1 be updated to recognise that renewables are already being used in significant quantities for industrial heat generation. Perhaps the current Fig. 13.1 is actually emissions from process heat use in NZ?

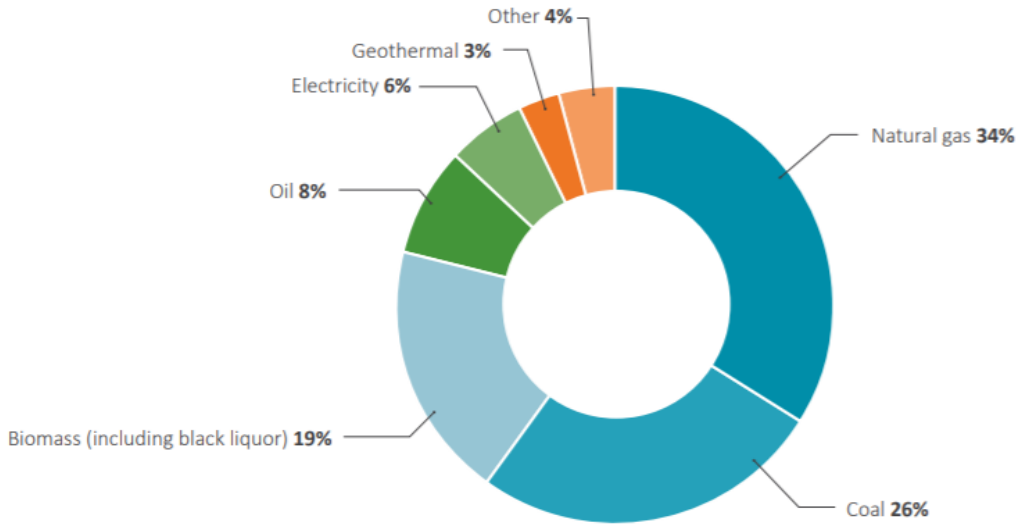

Fig 1. Figure reproduced directly from the RSNZ report showing the shares of fuels used to meet industrial heat demand in New Zealand.

13.3 Opportunities to reduce emissions from process heat

Page 349. The finding that “high temperature heat users have no viable short-term economic abatement opportunities” should be thoroughly tested.
Wood can and is used as a source of high temperature heat (e.g. in the pulp and paper and cement industries) and carbon generated from biomass can potentially be used in steel-making or aluminium production. As an example of the latter, CarbonScape, a Marlborough-based company, entered into a 9,000 tonnes per annum green coke supply agreement in 2013 with New Zealand Steel and Bluescope Steel of Australia (CarbonScape 2018).

We accept that moving to such lower-carbon biomass energy sources may incur significant capital and operating cost increases, and that these manufacturing sectors need to compete with firms that do not face emissions prices, but if they are major emitters and New Zealand has tough emission reduction commitments to meet, for how long can we ignore such emissions when other parts of the economy are bearing increased costs?

The nature of the process used for the production of quicklime (CaO) during cement manufacture is well suited to the combustion of organic wastes. Waste tyres are already mentioned in the document, but Golden Bay Cement in Whangarei also uses wood fuel sourced from construction and demolition waste as a source of process energy – in 2012 around a third of the fuel burned was renewable wood energy, reducing their CO_2 emissions by 58,000 tonnes per year (EECA 2012).

Page 350 (Table 13.1). NZ gas supplies are declining. Without new discoveries, New Zealand gas supplies are projected to decline significantly with little immediate prospect of improvement (MBIE 2017). As a result, the cost of gas is likely to rise from 2020. (Steve Bielby, NZ Gas Company, Radio NZ interview, March 2017). This will make large existing users of coal-fired boilers reluctant to shift from coal to gas when the gas supply / price is uncertain and they would also face the capital cost of installing a new gas-fired boiler.

Page 352. The statement that you need 7 - 10 truckloads of woody biomass to get the equivalent output to 1 truckload of coal is incorrect. It is closer to 3. Assuming a truck has a maximum payload of 29 tonnes (44 tonne GVM) carrying coal with a NCV of 21 GJ per tonne (optimistic) it will deliver 609 GJ per load. A typical chip truck (with a high volume configuration, not requiring any special permits) can deliver 29 tonnes of wood chip at 6.9 GJ per tonne, or 203 GJ per load. While volume can limit loads for some types of bulky biomass (e.g. wheat straw), the limiting factor for the trucks transporting wood chips is weight not volume.

Page 352. The statement that “woody biomass cannot be seen as a low carbon fuel in a lifecycle analysis” is incorrect, at least for biomass from New Zealand’s current plantation forests. IEA Bioenergy has recently published a report specifically to address in detail the concerns raised (including those raised in this report) around the environmental credentials of biomass (IEA Bioenergy 2018). The issues raised are situation-specific. If the forests which produce the biomass are sustainably managed (and New Zealand’s plantation forests are, over 70% FSC certified), and the forests sequester carbon relatively rapidly (as New Zealand’s do), and the biomass is used efficiently (e.g. for process heat or CHP) then the emissions are very low.

The Ministry for the Environment's figures used for its calculations of energy emissions give wood as emitting 0.0143 kg CO_2-e per kg of fuel versus sub-bituminous coal at 2 kg CO_2-e / kg (MfE 2015). On a per unit of energy basis the emissions by fuel are given in Table 1.

Table 1. GHG emissions per unit of energy by fuel (MfE 2015).

Fuel type	*kg CO_2-e per GJ*
Coal	~100*
Gas	53.89
Fuel oil	91
Electricity	29.5
Wood	2.1

*varies with coal type

Policies to reduce emissions from process heat

Page 353. Whilst we agree that raising the price of carbon will definitely drive change in industrial heat processes, the question of to what has to be considered. As indicated above, gas supplies are going to be substantially constrained over the next 30 years (MBIE 2017), without new discoveries / developments.

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14. Waste

Scion's role

Scion has a substantial history in working with waste. We have over 30 years' experience working with solid and liquid waste processing in the pulp and paper sector. This includes detailed work on biological wastewater treatment systems at full scale, new technology development for low nutrient wastewaters. Conversion of forest sector residual biomass (sawdust, bark) has been a strong focus of the Clean Technologies team – from strategic, logistical, and technical (torrefaction, pyrolysis) perspectives. A recent focus of the team has been into areas of municipal solid waste processing (wastewater sludges and garbage), sanitation engineering innovation, food waste anaerobic digestion, and gas phase biotechnology.

Summary

Overall, the chapter provides a good coverage of the issues of waste, with respect to a lower emissions economy. We generally agree with the commentary within this chapter, with some recommendations provided, either for correction of errors, or where we believe some missing information or clarification is required. In particular:

- Wherever possible, address NZ ETS issues at a national level. Local councils should not be made to shoulder undue burden, as many will be poorly equipped to provide effective outcomes.
- The collection and maintenance of high quality data is critical to achieving effective outcomes, and should be addressed with high priority.
- Addressing all sources of waste disposal (not just landfills e.g. composting) is recommended.
- Anaerobic digestion (AD) is presented as a significant tool in the box of solutions for reducing GHG emissions from waste. Currently we believe there is very low incentive to increase uptake of AD in New Zealand and recommend increased consideration of this in the report.
- We would recommend an increased emphasis on innovation potential to minimise and potentially reverse (via carbon capture) net GHG emissions in NZ via the waste sector.

Emphasis is put in our commentary on addressing the question as to whether the NZ ETS should be extended to cover wastewater treatment plants. Here we answer in the affirmative. We have provided a number of considerations which should be addressed, around NZ ETS implementation to wastewater.

Scion's comments

Overarching comments

- Minimisation of methane and N_2O emissions from waste appear to be the main considerations of the report. There is potential for the waste industry to participate in net carbon capture, using the energy contained within waste to drive reactions for CO2 capture (e.g. Lu et al., 2015). The setup of the NZ ETS and associated legislation should be flexible enough to allow for such innovations.

- In the report, anaerobic digestion (AD, either in-vessel or landfill gas capture and utilisation) is presented as a key component in the waste sector addressing GHG emissions. However, in New Zealand the business case for AD is very poor, due to the significant costs associated with gas clean-up for use in electrical generation, low electricity prices, and the complexity of the energy market with respect to small suppliers of electricity supplying to the electricity grid. Thus, methane that is generated which is surplus to on-site energy requirements (electrical and heat) will often be flared, a completely wasteful activity that generates CO_2 with no commensurate value extraction. In order to facilitate and incentivise widespread uptake of the technology and full value extraction from methane generation, this will need to be addressed at the policy and regulatory levels.
- The opportunity for refuse derived fuels is not mentioned. This is an area of recent technology development that requires some analysis to see where it would fit into New Zealand waste management / energy recovery. Note – this is not mass burning of bio-MSW, although this is also a possibility, as new combustion / emissions technologies make this a more attractive proposition than it was historically. The Productivity Commission report quotes a 10-year old reference on particulates being an issue with MSW. Whilst that is broadly correct, there are technologies that have been developed to deal with this. It is also worth noting the recent banning by China around export of waste plastics etc. to China for recycling; this may well change the landscape around those wastes substantially.

Specific comments

Comments on recommendations

R14.1

- Strongly agree. The collection of high quality data is essential for effective administration of the NZ ETS.

R14.2

- Strongly agree. The application of the levy to all known consented waste disposal facilities would close loopholes and provide incentive for change to our waste disposal practices.

R14.3

- Strongly agree. The current levy cost does not provide a strong incentive for change of practice.

R14.4

- Strongly agree. The GHG issue for NZ is one that should be addressed in a comprehensive manner, with national level resources. Requiring local councils to shoulder the burden will lead to inconsistent outcomes, and should be avoided.

R14.5

- Agree. Unnecessary overlap of levy and NZ ETS should be avoided. Further, it is not just NZ ETS and Waste Levy which need to work in concert. Waste disposal is associated with nutrient and organic loadings to the receiving environment (waterways and land),

and this should be included in a comprehensive approach to waste disposal in New Zealand that incorporates GHG emission potential. Anything else runs the risk of ending up with conflicting outcomes arising from following different legislation.

Key points

Bullet point 4:

- Agree and strongly support the increased use of landfill gas and anaerobic digest with CHP to reduce emissions from landfills and wastes.

Bullet point 6:

- Strongly agree with this. Need much better data, and rectifying this should be given a high priority. In particular, we emphasise the quality of the data for:
  - Unmanaged solid fill sites, including those associated with large wood processors.
  - Emissions from wastewater treatment, using the mix of treatment processes that are relevant to NZ.

14.1 Waste emissions in New Zealand

- On pate 365, the report states that: "*Methane (CH_4) comprises the majority of waste emissions (97%), followed by nitrous oxide (N_2O) at 3% (solely from wastewater treatment) and carbon dioxide (CO_2) at 0.03% (solely from incineration) (MfE, 2017g).*"

  This statement should be preceded by a statement about why CO_2 from solid and liquid waste is not considered for GHG inventory purposes. Otherwise, the statement is misleading as to the type of major gases emitted from waste.

- The attribution of GHG emissions arising from all disposal methods for wastewater treatment sludges (e.g. composting and land application) are not described in this report. This should be clarified, to provide a full picture of wastewater treatment impacts for NZs GHG inventory.

- On page 367, para 2, the report states: *"Wastewater emissions rose 11% between 1990 and 2015 due to an increased volume of wastewater handled during this period. The majority of emissions are CH_4, but N_2O emissions occur both directly at wastewater treatment plants (WWTPs) and indirectly after effluent disposal into waterways or the ocean.[145]"*

  The data appears to be from NZ GHG inventory report (MfE, 2017). This report has used, for example, a methane correction factor (MCF) of 0.25 kg methane/kg COD, which is the default value for overloaded aerobic treatment plants (Doorn et al., p 6.21). The reference cited in footnote 145 (Coster, n.d., section 4.3.2) provides a country specific (Australasia value) MCF of 5% (0.05 kg methane/kg degradable COD) for facultative lagoons (WSAA, 2007). The inventory estimation is a five-fold higher value and may be an overestimation, assuming most plants are not overloaded. Note that the MCF for well-managed aerobic plants are taken as zero by the IPCC.

Waste types and facilities

- Figure 14.2, note 3 states: "Clean fills are sites disposing of largely inert waste (e.g., concrete or sand) that does not decompose and therefore cause emissions".

We suggest this should be "…. cause no emissions."

- On page 367, the report states: "*The meat, and pulp and paper industries comprise the two main sources of industrial wastewater in New Zealand (MfE, 2017g). However, these industrial wastewaters are nitrogen-rich, which is the reason for the relatively high level of industrial N_2O emissions from wastewater in New Zealand."*

  This is factually incorrect. Pulp and paper wastewaters are nitrogen-poor, and frequently external nitrogen is added to the wastewater for effective treatment. However, N2O emission is still possible from pulp mill effluents and quantities can be large given the large volumes processed.

- The following comment from NZ GHG inventory report (MfE, 2018, p. 330) is relevant:

Nitrous oxide emissions

Direct emissions of N_2O from domestic wastewater plants are typically minor and only occur in advanced centralised treatment plants. Good practice guidelines (IPCC, 2006a) advise that the estimation of direct N_2O emissions is only necessary where advanced centralised treatment plants account for a major proportion of wastewater treatment. This is not the case in New Zealand, so no direct emissions of N_2O are reported.
However, indirect emissions of N_2O may occur after disposal of effluent into waterways, lakes or the ocean. New Zealand reports indirect emissions of N_2O from domestic wastewater.
The IPCC Guidelines (2006a) indicate that, compared with domestic wastewater, the N_2O emissions from industrial wastewater are believed to be insignificant. However, these emissions are not insignificant in New Zealand, because the meat and dairy processing industries produce nitrogen-rich wastewaters.

New Zealand compares unfavourably on waste emissions internationally

- In 2016, New Zealand had 4.693 million inhabitants but also had 3.5 million arrivals of which 1.8 million were holiday makers. This effectively increases the New Zealand population by up to 25% depending on the length of the stay. When travelling, waste minimisation is less about behavioural change and more about the "reduce, reuse and recycle" infrastructure provided because tourists have limited opportunity to seek out waste minimisation options even if they normally would do so.
- To achieve waste minimisation, encouragement of behavioural change through incentives like ease-of-use (for example, kerbside food waste collection coupled with council operated AD plant) or economic returns (NZ ETS, or direct financial gain) may be more effective than punitive measures like the Waste Levy.

Emissions reductions do not require the development of new technology

- While methane capture and use as a fuel is widely practised and no new technological developments are needed, the fact that most emissions are not captured is due to low economic gain from using methane as a fuel. Waste to energy is at the lower end of the waste management hierarchy. Thus research and technological developments are needed to find out higher end uses for methane and other potent GHGs. One such opportunity is the use of gas phase biotechnology to convert methane to products (e.g.

bioplastics), in-line with circular economy principles. Further, putting more emphasis into strategies that minimise waste production in the first place would be even more effective.

14.5 Opportunities to reduce emissions from waste

Reducing emissions from known, consented facilities

- The document seems to make assumptions regarding ownership of the landfills as being, in the main, local councils. The major landfills in New Zealand have significant private ownership, particularly when considered by volumetric input (e.g. Hampden Downs Landfill, one of the major landfills for the North Island). Has the report considered the perspective of these private owners? Their commercial imperative may align or it may conflict with that of the Waste Levy, in reducing volumes to landfill. We recommend consideration of this in the final report.

Question Q14.1: Should the New Zealand Emissions Trading Scheme be extended to cover wastewater treatment plants?

- In our view, the NZ ETS should be extended to cover wastewater treatment plants. This is fair, and will provide incentive for the sector to reduce emissions, along with other parts of our economy. Whilst the sector arguably makes a small contribution to NZs GHG emissions, each area needs to take responsibility for its particular contribution. There appears to be ample mechanisms within the NZ ETS to protect the sector from undue cost (free allocation of units, for example). Bringing wastewater treatment plants under ETS will lead to more reliable data, better managed treatment systems, and eventually lower reportable GHG emissions from this source.
- We note a number of factors that require consideration:
- Good data is critical, to adequately describe the emissions from the sector. Strong priority should be given to this as a first step.
- Decisions on the scope of emissions and methodology will be essential for the wastewater treatment industry to make significant GHG emission reductions. The current NZ GHG Inventory includes "indirect emissions of N_2O from… effluent into waterways, lakes or the ocean". It is unlikely that an operator can realistically influence these emissions arising and therefore their ownership and accounting of these emissions should be questioned under an ETS. Likewise, "*Direct emissions of N_2O from domestic wastewater plants are typically minor… so no direct emissions of N_2O are reported*". This omission could seriously underestimate the extent of this emission source for certain WwTPs. Direct N_2O emissions are a source which can be influenced by operational practice, and therefore they should be included in an ETS.
- Options to mitigate GHG emissions are required if the inclusion of wastewater treatment is to be successful. The use of anaerobic digestion, currently installed at eight plants in New Zealand (p336, MfE, 2018), is a viable method to reduce CH_4 emissions and can be easily accounted for. At smaller sites it may be uneconomical to install anaerobic digestion, therefore viable options may be limited.
- Innovation within the sector will be driven by incentive to reduce emissions. Remaining outside the NZ ETS gives little reason to make change to current practice. This innovation may take the form of faster adoption of currently available technology, through to radical changes to the way treatment is completed. Indeed, there is an argument that current conventional approaches to biological treatment (activated sludge processing)

are grossly wasteful, and that the climate challenge requires a complete rethink of how we treat wastewater. We see no reason that New Zealand should not participate in this rethink. Indeed, it is as an opportunity to be embraced, rather than avoided.

- Verification that fugitive emissions from processes (e.g. holding tanks) are not occurring would, we believe, be necessary to trade these emission reductions.
- There are limited examples of digested sludge being recycled to land. Consideration of the methane emissions of land-applied sludges (either digested or undigested) will need to be captured within the ETS accounting.
- If digested sludge is sent to landfill, further CH_4 and N_2O emissions are possible and would be captured under the ETS. Given that the methane potential has been drastically reduced through digestion, the emission factor should be lower than raw sludge.
- The methodological approach used must incentivise the reduction of N_2O emissions. The method used in the NZ GHG Inventory (p336, MfE, 2018) is incapable of achieving this, since it is based on per capita protein consumption. A method of direct measurement of N_2O from secondary wastewater treatment is therefore necessary. Operators would then have a choice as to how to better operate plants to reduce N_2O emissions.
- For the water industry, focussing on CH_4 and N_2O to the exclusion of energy use, does not best incentivise GHG emissions reduction. For example, wastewater treatment plants can consume 0.25 – 10% of the national energy usage (Gu et.al. 2017). This is primarily due to the aeration required in conventional activated sludge processes. A GHG reduction scheme which includes direct energy use in wastewater treatment would have the scope to achieve more meaningful emission reductions.

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15. The built environment

Scion’s role

Scion conducts built environment research on wood design & construction technologies, the environmental benefits of using timber in future urban developments, and the social and cultural implications of using wood in the design and construction sector. Our work evaluates the contribution that timber construction technologies make to balancing urban carbon emissions. Using timber and other wood-based building materials that store long term carbon previously sequestered will help reduce greenhouse gas (GHG) emissions and address climate change. This will contribute to maintaining a balance between people and the natural environment contributing to achieving the United Nations Sustainable Development Goals (SDGs).

In addition to bio based materials and value chains within a bio based economy framework, Scion Built Environment researchers are also investigating building design and construction optimisation strategies to improve human health and well-being, and relieving fuel poverty through building highly energy efficiency strategies for New Zealand homes and public buildings.

Both nationally and internationally, Scion provides expert advice pertaining to maximising the use of timber building technologies and engineered wood products in relation to environmental sustainability, building multi-performance, human health, and well-being.

Summary

The major focus of this Chapter is on indirect rather than direct sources of emissions from the built environment (BE). It is our recommendation that a major review is conducted that focuses on direct BE emission sources and direct emission reduction strategies, including pathways toward their implementation, incentives and solutions for barrier mitigation, policy making, and regulations.

BE consists of complex systems that enable activities resulting in emissions of greenhouse gases (GHGs). The BE includes human-made and human-impacted land, land use and activities, hard infrastructure (roads, buildings, power lines, water systems, landfills, etc.) supported by technologies, and soft socio-institutional infrastructure (economic, political, demographic, and sociological factors) that shapes the hard infrastructure and are supported by governance policies and regulations (Chester M.V. et al., 2014).

This Chapter has a strong focus on indirect BE sources of emission (e.g. transport emission, embodied energy in building materials). However, those source of emission are within the domain of, and can be addressed more efficiently and directly within other sectors such as the Transport sector and the Manufacturing sector (which is a key producer of products for the construction industry (MBIE, 2018)). Furthermore, more direct built environment related emissions, for example from building operation, are deemed as a minor priority due to the (current) renewable energy proportion provided by the NZ Electricity sector, or are not considered within this Chapter (e.g. urban lighting, land use, water infrastructure, urban forests - as a beneficial negative source).

Acknowledging mutual influences and identifying joint opportunities between the BE and other sectors is fundamental, and achieving the emissions mitigation potential of the building sector is essential to meeting the Paris Agreement commitments. It is internationally accepted that this path requires both reducing global energy and manufacturing emissions

(Otto M., 2016; UN-Energy, 2009), and that for the building sector this also require avoiding energy consumption through mainstreaming of highly energy-efficient, zero-energy or energy-positive new buildings, and renovating the existing stock of buildings by 2030 (Otto M., 2016).

While it is relevant to compare benefits with trade-offs for each potential emission minimisation strategy, it is also necessary to avoid precluding any strategy on the basis of potential free-market decision-making and consumers expectations.

Therefore, we recommend to review the text with the aim of encouraging all the opportunities for achieving emission reduction through the transition towards high-quality, mixed-use, higher-density urban environments, and strategies for overcoming barriers. The barriers highlighted within this Chapter, (e.g. market driven costs of policies that seek to encourage higher-density development; New Zealanders' preferences and lifestyle expectations; and long-term implementation and benefit return; and emission offsets deriving from expected low-emissions transport uptake), should be analysed with the aim of suggesting potential solutions for their mitigation.

We recommend considering all potential BE direct emission saving strategies and their implementation pathways in the New Zealand context (including mitigation to barriers, and policy options) as the main objective and goal of this Chapter. We also recommend increasing focus on investigating international best practice in relation to BE emission mitigation, including examples of successful implementation of policies and solutions for the mitigation and removal of barriers and their adaptation to the New Zealand context. All the available reduction strategies, at all scales of the BE, should be considered using a holistic and integrated approach, including considering both short-, medium- and long-term benefits. As suggested by Martina Otto (UN Environment), available technical and financial resources, the many effective technologies, materials and design concepts, and proven policy measures have to be fully mobilised (Otto M., 2016).

Scion's comments

Key points

Bullet point 2: Establishing an effective price on emissions is the most efficient mitigation strategy for most of the emissions generated from the built environment

This statement is justifying a strategy using generic assumptions. To avoid the statement being perceived as a claim there is the need to:

- Define and reference what level is considered "effective" for the price on emissions.
- Explain how that effective price will directly contribute towards mitigating the different sources/causes of emission from different components of BE (e.g. building lifecycle, urban form, and infrastructure).
- Explain how the defined "effective price on emissions" will be more efficient compared to other strategies mentioned in the report, and referenced in this review, that are recommended and adopted internationally
- Suggest how to mitigate the risks identified by New Zealand Steel within their submission to the Productivity Commission, for example that higher NZ ETS emission prices will favour the import of materials produced under more favourable ETS pricing regimes (Nowlan J., 2017).

Bullet point 3: The emissions embodied in buildings can vary significantly depending on the materials used and the construction technique

- Substitute the word “beams” with “structural elements”. Alternatively substitute the phrase “laminated timber beams” with “structural engineered wood products”.
- There is no mention of Wood Encouragement policies that are implemented by Local Authorities internationally (British Columbia and Ontario in Canada, France, Japan, Australia, Finland, the Netherlands) and in New Zealand (e.g. Rotorua Lakes Council Wood First Policy, Gisborne City Council Wood First Policy currently under discussion) (makeitwood, 2018; Forest Enterprises, 2018).

Bullet point 4: Establishing limits on the emissions embodied in buildings is impractical

- We propose inserting “and supports”, “and buildings”: *“…the Code enables* and supports *the adoption of low-emissions construction* and buildings*.”* Please see further comments and also consider international approaches towards policy making that supports efficient transitioning towards low-emissions construction and buildings, including operational energy.

Bullet point 5: Commercial and residential buildings account for more than half of New Zealand’s electricity consumption

- *“…buildings account for more than half of New Zealand’s electricity consumption”:* Please clarify whether this refers to operational electricity only and therefore embodied energy in materials is not included, or otherwise.
- *“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, within the New Zealand context, improving the energy efficiency for new and existing buildings is of high importance to take account of future risks, and in relation to the considerations below. Therefore it is recommended to reconsider this statement and approach the need for regulating (including rigorously accounting and incentivising) buildings’ operational energy efficiency in New Zealand:

  1. As noted within this Chapter buildings still “*account for more than half of New Zealand’s electricity consumption and electricity generation”* and still *“use coal and gas-fired stations to meet peak demand, much of which is generated by domestic electricity use on winter mornings and evenings”.*
  2. New Zealand energy demand could grow due to e.g. net migration and building stock increases, changes in heating/cooling demands in relation to climate change, and demand from electric vehicles.
  3. As confirmed by the New Zealand Ministry of Social Development within the publication by Lloyd B., (2006), the low values for New Zealand residential energy use reflect low levels of space heating. Houses in New Zealand are “energy efficient” in the respect that they use little energy, but are poorly heated.
  4. Low-income homes in New Zealand were found to be colder than WHO guidelines: 16–17°C in living areas and 14°C in bedrooms on average (EHINZ, 2018a, Braubach M, et al., 2006) which suggest minimal space heating compared to other developed

countries. In addition to this EHINZ (2018b) suggest that in 2013, 44,800 households did not have a source of home heating, which is 3.0 percent of households, an increasing percentage compared to 2006. Furthermore BRANZ 5th House Condition Survey highlighted that 46% of New Zealand households do not heat bedrooms in winter and that without any heat input in winter, it is unlikely the homes indoor temperature would always achieve the World Health Organisation (WHO) minimum recommended level (BRANZ, 2018).

This is in relation to different causes including lack of regulation, users' behaviours, fuel poverty in relation to both financial condition and building envelope and/or building system energy efficiency. Due to the high social costs of living below WHO levels, space heating behaviour should be expected to change in a foreseeable future. This would affect the energy demand from the New Zealand housing stock. This potential trend is confirmed by the registered increase in building electricity use per capita in New Zealand for the period 2000-2012. In 2012 the per capita building electricity use was 120% higher compared to 2000, the highest rate among the 2014 G20 members (OECD/IEA and ipeec 2015).

5. New Zealand is a signatory of the Paris Agreement on Climate Change. For the building sector this means avoiding at least 50% of projected growth in energy consumption through mainstreaming of highly energy-efficient, near or net-zero energy or energy-plus new buildings, and a renovation of the existing stock of buildings by 2030 (Otto M., 2016). Furthermore the World Green Building Council of which the NZGBC is member developed a Coordinated Action towards meeting the Paris Agreement commitments urged the need for all new buildings to operate at net zero carbon from 2030 and 100% of buildings to operate at net zero carbon by 2050. Suggesting that net zero carbon buildings must become standard business practice as soon as possible, avoid the need for future major retrofits; and prevent the lock-in of carbon emitting systems for decades to come (WorldGBC, 2017).
6. According to UNICEF New Zealand (2018) "The poor standard of New Zealand housing exists largely because of a lack of regulation around acceptable housing standards. The cost to the New Zealand healthcare system, as a result of kids living in unhealthy homes, is immense. Over 40,000 New Zealand children are admitted to hospital every year due to income poverty and inadequate housing, and the cost of this hospitalisation to the tax system is around $1,500 per patient, per day. When these children go back home to the same cold houses, they get sick over and over again, the cycle repeats itself." (UNICEF New Zealand, 2018).
7. The International Energy Agency suggest that Energy efficiency measures (including for buildings) are among the most cost-effective actions to reduce emissions and that Energy efficiency policies and technologies will play a key role in reducing emissions (OECD/IEA, 2017).
8. Building design and construction for energy consumption minimisation are already available in New Zealand. For example, the Passive House Standard is a rigorous, systems-based approach to closing the gap between the anticipated and actual performance of buildings (BRANZ Level, 2018). The first certified Passive House home in New Zealand was completed in Auckland in 2012. Many more have followed since. Certified Passive Houses have been built in all climate zones, from very cold to very hot. With New Zealand's overwhelmingly temperate climate, the targets are far easier to meet than in countries with more extreme climates (BRANZ Level, 2018).

Bullet point 6: Electricity emissions still account for around 5% of New Zealand's emissions…

- *"A range of policy measures are already in place to improve the energy efficiency of buildings."*

  However, the existing New Zealand policy measures presented have not been assessed on the basis of their real potential for of contributing to achieving Paris Agreement targets.

  For example, among those measured there is no regulation on mandatory building energy rating and robust verification of performance, a best practice example of which is the European Energy Performance of Buildings Directive (European Commission, 2018; EU Parliament and Council, 2010).

- *"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."*

  This assumption requires further explanation and referencing. The assumption that higher emission prices reflected on energy charges to consumers would drive customers' decisions towards upgrading and implementing energy efficiency strategies (as seemingly suggested further in the text) is questionable. There is a need to consider the implication and impact on customers' financial capacity and on the capacity of the government to further implement existing and additional incentive schemes for customer support. It is fundamental to address the risk that rising utility costs would impact most on housing life-time affordability, with greater repercussions on tenants, low-income and fuel-poor citizens who would potentially reduce or avoid space heating thereby impacting their health and wellbeing, instead of investing in energy efficiency for buildings and appliances.

Bullet point 7: 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."*

  However, arguably "living preferences of many New Zealanders", as defined later in the text, the New Zealand housing market is becoming increasingly unaffordable and for this reason there is the potential for many New Zealanders to change their lifestyle in the future despite the living preferences of today.

- *"By then, reductions in vehicle emissions may have already been achieved through advances in low-emissions transport."*

  This is an assumption. Whilst it seems likely that there will be an increase of electric car market uptake, the timeframe and success for full establishment of low-emission transport is yet unsure. Urban planning that allows for efficient transport options is one of the many options and, despite not being a short-term solution, urban planning regulation should at least attempt to minimise the barriers for higher density new developments and urban regeneration.

15.1 Introduction

- There is no reference to New Zealand being a signatory of the Paris Agreement (MFE, 2016) or to how specific international built environment emission mitigation approaches, strategies, policies and incentives towards barriers mitigation were used to inform this report and could be transferred, adapted and be applied in the New Zealand context. It is therefore recommended that this be addressed.

- *"For example, the way some cities have developed has made residents less reliant on private vehicle travel, producing lower transport emissions."* This Chapter has a strong focus on transport emissions, however it is believed that transport emissions are only one among the many (and to some extent an indirect component) sources of emissions. More direct sources of emissions are, for example building operational and urban lighting emissions, and urban forests intended as a beneficial negative source of emissions due to carbon sequestration as an influence on urban micro climate.
- Page 385 – Introduction, second bullet point: *"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."* The sentence seems to suggest that BE is not a target sector for minimising emissions in the short-term. However, due to the gradual nature of change in the BE, this sector should be targeted with urgency as suggested by international policies and literature. Rephrasing the sentence is recommended, for example: "changes in the built environment are usually very gradual, and therefore the material contribution to emission reduction targets will be incremental in the long term."

15.2 Emissions through the life-cycle of a building

Figure 15.1 Emission sources in the life-cycle of a building (p. 385)

- It is recommended to rename the emission sources according to the rationale suggested by Cabeza L.F. et al., (2014) Fig. 2. as follows:
  - Change "Construction for "*Manufacturing Phase*"; and
  - Add Phase to "*Use*" and "*End of Life*"

  This because the term *"Construction"* does not appropriately reflect the complex multi-industry value chain and the stakeholders included within*: Extraction of raw or recycled materials; Transportation; Manufacture of components and products; Transport to site; Construction process.*

Emissions embodied in construction (pp. 386-388)

Strain's 2017 White Paper citation (p. 386)

- Strain's White Paper seems imprecise in relation to the time of occurrence of embodied emissions: *"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."*
- Embodied emissions happen during the Manufacturing Phase[5] which is before, and separated from, the "first 15–20 years of a building's life". A more robust expression of that concept is: "the GHG emissions related to the embodied energy of materials and construction are equal to the GHG emissions of the first 15–20 years of a building's

[5] (see previous comment Figure 15.1 Emission sources in the life-cycle of a building (pp. 385))

operational life". This suggests that talking about GHG emissions during the Manufacturing Phase* providing short term benefits should not support the interpretation (and Strain's argument) that operational life emissions (Use Phase*) are less relevant to address, but otherwise that "operating emissions happen over time and are cumulative" therefore the benefit of minimising emission is cumulative over time. It is therefore recommended that this report should foster a holistic approach aimed to tackling GHG emission in all building's life cycle phases as a way to minimise emission both in the short-term and long-term. This entails both: specifying and using low-embodied energy building materials as suggested in this section of the report; and adopting nearly-zero, net-zero and positive energy design strategies for new builds and retrofits, which the report does not seem to recommend. The proposed holistic approach including operational emission strategies is aligned with the recommendations of the Paris Agreement on Climate Change and the approach of international initiatives such as the WorldGBC Collaborative Action and international policies such as for example the Directive 2010/31/EU on the Energy Performance of Buildings (EPBD) of the European Parliament and of The Council of the European Union (WorldGBC, 2017, Otto M., 2016; EU Parliament and Council, 2010). As noted by the European Commission in July 2014 a key element of the EPBD for achieving the longer term objectives of the EU's 2020 Targets and the climate strategy objectives set by the Low Carbon Economy Roadmap 2050, is the requirements regarding nearly zero-energy buildings (Groezinger J. et al., 2014).

- In addition to this, it is relevant to note that using a building life-cycle approach energy-positive buildings can contribute offsetting embodied emission in building materials by feeding the extra energy produced from renewable sources to the grid, thus contributing displacing fossil fuels (Cole R. J. and Kashkooli A. M. S., 2013).

  *(see previous comment Figure 15.1 Emission sources in the life-cycle of a building (pp. 385))

The International Energy Agency (p. 386)

- It is believed that this information can support the introduction of Wood Encouragement policies such as Rotorua Lakes Council Wood First Policy nationwide. However, there is no mention in the current report of Wood Encouragement policies that are implemented by Local Authorities internationally (British Columbia and Ontario in Canada, France, Japan, Australia, Finland, the Netherlands) and in New Zealand (e.g. Rotorua Lakes Council Wood First Policy, Gisborne City Council Wood First Policy currently under discussion) (makeitwood, 2018; Forest Enterprises, 2018).

Monahan and Powell (2011) example (Table 15.1, p. 386)

- This table relevant to show the beneficial impact of building with wood. However, providing the figures of "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)." is not relevant and potentially misleading as noted by the author "Clearly, emissions reductions of this nature are not feasible as much of New Zealand's residential building already uses timber cladding and framing".

- Therefore it is suggested to consider the New Zealand based literature. This includes the studies cited by Stocchero, Seadon, Falshaw and Edwards (2017) within their Auckland-based case study which analysed the carbon sequestration, carbon storage, and emission minimisation benefits deriving from maximising the use of timber in future urban developments. Exemplar New Zealand studies are: Buchanan et al. (2012), Buchanan and Levine (1999), John et al. (2009), Burgess et al. (2013).

Waikato Regional Council and Scion citations (p. 387)

- New Zealand studies such as Buchanan et al. (2012), Buchanan and Levine (1999), John et al. (2009), Burgess et al. (2013), Stocchero et al. (2017) can provide figures. For example John et al. (2009), when comparing four building design options for the construction of a University of Canterbury laboratory building in Christchurch, calculated that the extensive use of timber stored more carbon over the building's life-cycle than that was emitted during the manufacturing of all the other building materials (assuming 100% of the carbon was permanently stored in timber and EWP).
- For this reason, from a building material perspective, it is recommended to use a holistic approach that considers sequestration optimisation, storage maximisation and emission minimisation as suggested by Stocchero et al. (2017).

Changes to the Building Code (p. 387)

- Sentence: *"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."* However, it is recommended to also analyse the option of introducing Wood Encouragement policies such as Rotorua Lakes Council Wood First Policy nationwide (please see previous suggestions with references).

Second bullet point (p. 387)

- *"For some building types, low-emissions materials may not be cost effective."* Cost effectiveness needs to be defined in relation to the performance that materials are required to provide and how the delivered performance is measured and certified. In the current market/policy framework the costs are related mostly to the expected structural, durability, health and safety performance. However, as noted by Groezinger J. et al., 2014 while cost optimality is the current framework regarding the ambition level for both renovation of existing buildings and new buildings, the principle of nearly zero-energy buildings, for example, will be guiding the design of new buildings as from 2021 (and for new public buildings as from 2019) onwards and therefore a smooth and consistent transition of policies and markets from cost optimality to nearly zero-energy buildings is needed (Groezinger J. et al., 2014). In the same way, with respect to the goal of minimising carbon emissions from building materials, a smooth and consistent transition of policies and markets from cost optimality low embodied-energy buildings is also required.

- Rosen and Guenther (2015) suggest that, given the actual physical climate change crisis, policymakers should not base climate change mitigation policy on estimated net economics, but rather mitigation policies must be forcefully implemented in spite of the many uncertainties involved in trying to predict the net economics of doing so. The OECD adds that financial turmoil is not a reason to delay since the consequences of inaction on global warming will continue to grow more and more costly over time. To achieve the emission reductions necessary to forestall a continuing cycle of global warming, a broad range of policy instruments will need to be deployed; and action by all countries will be required (OECD, 2008).

- This suggests, for example, considering the introduction of low-embodied energy policies such as for the wood-focused encouragement policies introduced in Rotorua New Zealand, and internationally (British Columbia and Ontario in Canada, France, Japan, Australia, Finland, the Netherlands) as a direct incentive in addition to the proposed indirect incentive such as raising the emission's price in New Zealand's Emissions Trading Scheme (ETS).
- Depending on the New Zealand's Emissions Trading Scheme (ETS) alone to influence emissions occurring within the BE should be carefully considered and evaluated, since it directly targets industrial energy efficiency which effectively occurs outside the virtual boundary of the built environment (manufacture industry). This approach is confirmed, for example, by the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) developed by the World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and Local Governments for Sustainability (ICLEI), which is accepted internationally and used in New Zealand (e.g. by Auckland Council) to identify, calculate and report on city greenhouse gases emissions does not include embodied emissions in fuels, water, food and construction materials since those emissions mostly occur outside the geographical boundaries of a city (Xie S., 2017).

Proposed raising of the emission's price in New Zealand's Emissions Trading Scheme (p.387)

- Despite this being discussed within Chapter 4 it would be beneficial to provide more information in this chapter regarding the foreseen time of implementation and time of delivery of impact (benefits), trade-offs and conditions for impact delivery in relation to emissions mitigation for this strategy. They should be compared and related to the other strategies specific for the built environment in order to compare the efficacy and benefit of the proposed strategies both in the short, medium and long term.
- As anticipated, it is recommended to consider a holistic approach considering multiple strategies and actions in relation to the built environment to provide greater outcomes in relation to carbon mitigation.

Following from previous: "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." (p. 388)

- This assumption requires references and further explanation, particularly explaining how this will incentivise the use of low embodied energy materials that may still not be cost effective from a market price point of view.

F15.1: Increasing the price of emissions in the New Zealand Emissions Trading Scheme is the most effective way... (p. 388)

- This assumption require references and further explanation in relation to the potential of introducing direct incentives to *"low-emissions materials (that) may not be cost effective."*
- First sentence after F15.1: Recommend to add "and foster": *"…building regulations must be sufficiently flexible to enable* and foster *the adoption of low-emission building materials and processes…"*

- In relation to cited commitment for MBIE and the Energy Efficiency and Conservation Authority (EECA):

  "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)."

  This is relevant to the following section "*Emissions generated from using buildings"* and it is therefore recommended moving it to that section.

  In addition to this, and in relation to the section "*Emissions generated from using buildings"* This commitment for MBIE and the Energy Efficiency and Conservation Authority (EECA) is aligned with the previous recommendation regarding operational emission minimisation through the requirement for new build and retrofit highly energy-efficient, near or net-zero energy or energy-plus new buildings. It is however fundamental for this report to suggest that energy rating tools and certification systems should be mandatorily implemented in NZ to robustly account for a building's primary energy demand and therefore for the operational carbon emission (depending on to the source of energy used). There are many existing tools that allow for the certification of buildings' the energy demand in relation to local environment conditions and building envelope and systems design. Some of those have been already used on a voluntary basis in i.e. HERS and the Passive House Standard. The European Union has been implementing mandatory building energy efficiency rating schemes. Under the EU Energy Performance of Buildings Directive energy performance certificates must be issued when a building is sold or rented, and they must also be included in all advertisements for the sale or rental of buildings. The European Union has also implemented different financing schemes and initiatives to accelerate energy efficiency investments (European Commission, 2018; EU Parliament and Council, 2010).

Emissions generated from using buildings (pp. 388-389)

- First Paragraph:

  "The commercial and residential sectors account for 2% of New Zealand's emissions (MfE, 2017g). … The New Zealand emissions inventory does not distinguish what these fossil fuels are actually used for, although space heating is a likely significant component."

  However, it is relevant to comment that this energy demand is in relation average New Zealand indoor temperatures that are often below the WHO recommendations of 18-22°C, (depending on room function) for safe indoor temperature ranges with recommended minimum temperatures of 18°C, for houses inhabited by non-risk categories, and 20°C for houses with young children, elderly people or ill people (Braubach et al., 2011; WHO, 2007) and with an increasing percentage number of houses with no heating (EHINZ 2018).

Electricity use in New Zealand buildings (p.389-391)

- *"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)".*

It is recommended to consider adopting the EU Directive Energy Performance of Buildings (EPBD) approach that recommends implementing strategies for achieving Nearly Zero Energy Buildings (NZEBs). NZEBs address the responsiveness towards the intermittent availability of renewables while still providing healthy and comfortable living conditions by minimising their energy demand through an efficient building envelopes and systems.

An example of the implementation of NZEBs in New Zealand derives from the Certified Passive Houses that have been certified under the international Passive House Standard. Certified Passive Houses are eligible for full point accreditation under different criteria of the New Zealand Green Building Council Homestar v.4 Certification, including the criteria Efficient Space Heating that awards dwellings which have a very low 'carbon dioxide emissions to space heating load' ratio (NZGBC, 2018). The Passive House Standard is singled out as one of the key climate change mitigation options for buildings in the Intergovernmental Panel on Climate Change's 5th assessment report and is already a mandatory requirement in international city councils (e.g. Dún Laoghaire-Rathdown County Council in Ireland, Bruxelles in Belgium, Luxemburg, Nuremberg in Germany) and fostered and supported by local authorities and financing groups worldwide (e.g. Austria, Belgium, Canada, Germany, Ireland, Italy, Norway, Spain, U.S.A.) (iPHA, 2018; PassiveHouse+, 2016; Lucon O. et al., 2014).

Paragraph about reviewing New Zealand's Building Code (p. 390)

The following text allows for confusion and misinterpretation:

- *"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."*

  There is already evidence that there are net benefits in raising energy efficiency standards both in New Zealand and internationally, this is demonstrated, for example, by the inclusion of the Efficient Space Heating criteria within the New Zealand Green Building Council's Homestar v.4 Certification and by the EU Directive Energy Performance of Buildings (EPBD) that both aim to reduce emissions through building envelope and systems energy efficiency improvements. Also, the sentence is implying, but should explicitly state, that the New Zealand context is currently benefitting from the favourable renewable energy balance combined with reduced heating habits from building occupiers.

- *"These benefits will need to be assessed against any costs, including higher building costs."*

  While it is important to keep construction affordable (building cost), it is also relevant to consider the life-time operational cost in relation to the recommended level of indoor conditions, market cost of energy, and social cost of carbon. The Intergovernmental Panel on Climate Change (IPCC) suggest that recent developments in technology and know-how enable construction and retrofit of very low- and zero-energy buildings. This can often be achieved at little to marginal investment cost, typically paying back well within a building's lifetime (robust evidence, high agreement). The IPCC therefore recommends approaching the cost assessment considering that there is the need to address barriers which include imperfect information, split incentives, lack of awareness, transaction costs, inadequate access to financing, and industry fragmentation (Lucon O. et al., 2014).

- *"Additionally, improvements in the efficiency of operations also need to consider emissions embodied in materials."*

  It is important to consider approaching emission mitigation strategies simultaneously in all the phases of a construction project including the manufacturing of materials and the construction of the building on site.

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 (p. 390)

- This should be reworded as the sentence suggests there might not be scope to materially reduce peak demand for electricity through the introduction of more stringent energy efficiency standards. However, there is evidence that NZEBs such as Certified Passive Houses are reducing peak demand by requiring limits for peak demand per square meter (10W per m^2) (Passive House institute, 2015). Furthermore, internationally, the history of energy efficiency programmes in buildings shows that 25–30% efficiency improvements have been available at costs substantially lower than marginal supply (Lucon O. et al., 2014).

  In addition to this, the sentence seems to be in contradiction to the sentence *"As noted above, improving energy efficiency of buildings has the greatest impact on electricity emissions to the extent that it reduces peak demand."* reported later in the same page.

  It is therefore also recommended considering the Building Code as an actuator tool to reduce the barriers for the uptake of NZEBs (and low-embodied building) and even better to suggest a robust best-practice pathway to be followed, rather than an exploratory tool to investigate the scale of benefits.

Improving energy efficiency in existing buildings (p. 390)

- *"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."*

  However, significant increase in new building volume is expected in the foreseeable future, for example the New Zealand Government's KiwiBuild programme alone is aiming to deliver 100,000 affordable, quality homes for first home buyers over the next decade (MBIE, 2018). StatsNZ (2017) reported that in the year ended June 2017 alone 30,453 new homes were consented across New Zealand, near levels last seen in early 2005. Despite this increase, there is an estimated potential shortfall of about 9,000 new homes consented compared to what was needed to meet increased demand from a larger population in the same period.

  As previously mentioned, New Zealand is a signatory of the Paris Agreement on Climate Change. For the building sector this means avoiding at least 50% of projected growth in energy consumption through mainstreaming of highly energy-efficient, near or net-zero energy or energy-plus new buildings, and renovation of the existing stock of buildings by

2030 (Otto M., 2016). Furthermore the World Green Building Council, of which the NZGBC is a member, developed a Coordinated Action towards meeting the Paris Agreement commitments. They identified the need for all new buildings to operate at net zero carbon from 2030 and 100% of buildings to operate at net zero carbon by 2050. This suggests that net zero carbon buildings must become standard business practice as soon as possible to avoid the need for future major retrofits; and prevent the lock-in of carbon emitting systems for decades to come (WorldGBC, 2017).

- Therefore it is suggested to reconsider this position*: "In addition, the standards that apply to new buildings have already been raised incrementally over time."* since, as noted previously in the same page *"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" (NZGBC sub. 82, pp. 1–2).*

- *"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."*

  Higher energy prices are not a direct incentive, rather they are a motivational economic incentive accessible only to those that are in the position to make a decision and in the economic condition to afford to invest. This mechanism is therefore effective when targeting building owners that can afford to make energy efficiency investments, however it is less effective for lower wealth populations, tenants and, *"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"*.

  Therefore, when proposing such a strategy, it is fundamental to implement other support strategies (such as direct economic incentives and subsidies) to mitigate the risk of increasing fuel poverty in New Zealand. The New Zealand Ministry of Social Development reports a publication by Lloyd B., (2006) which defines a household is in fuel poverty as one "that would need to spend more than 10% of the total household income on all household fuels to achieve a satisfactory indoor environment. A satisfactory indoor environment is defined as being at temperatures of at least 21°C in the living areas and 18°C in other parts of the house" which is aligned with the WHO recommendations. The finding from Lloyd B., (2006) study showed that "the total number of households likely to be in fuel poverty comes to between 10% and 14% of the total population of the four main centres, which includes just under half (47%) of the total population of New Zealand."

  For this reason it is strongly recommended to consider additional strategies which are also supported by incentive schemes in order to reduce barriers such as transaction costs for energy efficiency investments and inadequate access to financing. This has been suggested by the IPCC (Lucon O. et al., 2014) and implemented by the European Union with their support schemes and initiatives to accelerate energy efficiency investments (European Commission, 2018).

- *"Although improvements in efficiency would presumably make a building more marketable when seeking new tenants"*:

  A successful example of a mechanism to align market value to certified energy efficiency performances is the mandatory building energy efficiency rating scheme implemented by the European Union under the current Energy Performance of Buildings Directive where buildings' energy performance certificates must be issued when a building is sold or rented, and they must also be included in all advertisements for the sale or rental of buildings (European Commission, 2018; EU Parliament and Council, 2010). The regulated and mandatory nature of the methodology to account, prove and certify the energy efficiency performance and savings allows to mitigate the risk of claims and therefore support market confidence in establishing costs and benefits.

Table 15.3: Initiatives to encourage improvements in energy efficiency (p.391)

- *"Government should continue to implement energy efficiency initiatives provided that they are assessed based on their costs and benefits*."

  It is recommended that the Government defines/adapts/adopts, and implements at a national level, a methodology to robustly account for the achieved performances and the derived benefits. Only when the benefits are robustly accounted for can costs and incentives be robustly associated. The European Union mandatory building energy efficiency rating scheme implemented under the current (and previous iterations) of the Energy Performance of Buildings Directive provides a good example (European Commission, 2018; EU Parliament and Council, 2010) of associated incentives and subsidies in relation to building energy efficiency achievements for new builds and retrofits.

Emissions in the disposal of buildings (p. 392)

- It appears the end of life phase has been not considered with the necessary depth. The emission reduction benefits of suggested strategies have not been analysed.

  It is recommended to undertake analysis and use appropriate referencing to identify and propose strategies and implementation pathways. For example: requirements for design for disassembling, specification and quantification of re-used and/or recycled materials; mainstream manufacturers' requirements for production; and end-users' use of Environmental Product Declarations (EPDs). Turner et al (2015) recommends to quantify the GHG impacts of material recycling to better understand the GHG impacts of waste management activities and identify emissions reduction opportunities.

- *"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)"*

  It is recommended to analyse and identify potential strategies to be implemented to extend the lifespan of buildings such as, for example, changes in the building code and regulations to extend durability requirements, to foster and regulate building retrofit, design for future flexibility (Adaptability, Transformability, and Convertibility), and design for climate change resilience.

- *"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".*

It is recommended to analyse and using appropriate referencing to identify and propose strategies and implementation pathways. Turner et al (2015) recommends to quantify the GHG impacts of material recycling to better understand the GHG impacts of waste management activities and identify emission reduction opportunities.

For example, according to the Sustainable Steel Council in New Zealand, “Pacific Steel makes steel in New Zealand entirely by recycling while New Zealand Steel is the country's largest steel producer generating up to 650,000 tonnes a year using a sand-to-steel process.” Of the approximately 500,000 tonnes of scrap metal generated annually in New Zealand, Pacific Steel use an average 300,000 tonnes per year to produce wire rod, reinforcing bar and other products while the rest is exported. While energy savings are accounted to be as high 75% no specific New Zealand figure was disclosed on GHG emission savings achieved through steel recycling while North American figures were referenced instead. This suggests a potential knowledge gap to be addressed (Sustainable Steel Council, 2013a; Sustainable Steel Council, 2013b; Nowlan J., 2017). Along with steel, other main building materials such as timber, concrete, and insulating materials should be analysed in relation to their re-usability and potential end of life emission and (previously sequestered) carbon storage scenarios. For example, John et al. (2009) reported that, in the New Zealand context, landfilling waste timber would provide a net permanent storage of 44% of the original carbon while energy conversion would result in 35% avoided emissions from substituting fossil fuels for energy production. However, the primary importance of reliable data in order to plan, assess and implement any emission mitigation strategy needs to be acknowledged.

- *“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.”*

  As noted by the New Zealand Steel submission to the Productivity Commission there is a risk that higher NZ ETS emission prices will favour the import of materials produced under more favourable ETS pricing regimes (Nowlan J., 2017). It is recommended to consider a multi strategy approach across the whole building life-cycle including requirements and incentives, for example for low embodied energy materials substitution, design for flexibility, material disposal and recycling, use of locally made and recycled materials.

15.3 The relationship between urban form and emissions

How does urban form affect emissions? (p. 392)

- The current approach by the Productivity Commission within this section is focusses only on three main GHG emissions issues related to urban form: transport-related emissions; different types of building operation; and the building of different types of neighbourhoods. It also appears that the majority of effort focussed on analysing existing international literature in relation to benefits and trade-offs of higher density urban environments in relation with vehicle miles travelled (VMT) emission reduction, while the other two main focus issues have been analysed with less depth.
- It is relevant to note that urban form is to be considered an enabling factor in achieving GHG emission reductions through many different strategies. Given the complexity of the subject it is therefore recommended to analyse the contribution of urban form considering the enabling factor towards GHG mitigation through a plethora of related strategies. Examples of these include: building design efficiency strategies; land-use and

management; urban forests and green areas; urban micro-clima; infrastructure and transport (public and private) system design; and urban waste management.

For this reason, the benefit of urban form might prove more complex to analyse on the basis of emission figures from single parameters compared to more integrative per capita emission figures.

Dodman D. (2009) reported that analysis of single cities showed that urban residents generate a substantially smaller per capita volume of carbon emissions than residents elsewhere in the same country. For example, in London, per capita emissions in 2006 were just over half the British average (in 2004) despite the rise in population of 0.7 million people during the same time period. (Mayor of London, 2007; Dodman D., 2009).

The relationship between urban form and transport emissions (pp. 392-394)

- This title of this should be changed to reflect the stronger focus of this section on vehicle miles travelled emissions and avoid confusion with the overarching 15.3 section title.
- The section is confusing given the provision of a plethora of international and national reference in potential contradiction one to each other. It is suggested to reorganise the literature review in order to provide more concise information to reduce confusion.
- The conclusive statement "*Overall, there is not a strong case to use urban planning policies to reduce emissions*." is not supported by strong evidence. Rather, more analysis and evidence based research is required to support this assumption, which is in contradiction with many other international research and governance expert approaches. For example, work by Raparthi K. (2014) on the impact of urban planning policies on carbon-dioxide emissions supported the use of master plans as an effective tool in mitigating climate change and emphasised the application of urban planning as a policy tool for mitigating climate change. In 2015, Mark Watts, the C40 Executive Director, identified urban density as one of the three key elements to a sustainable low carbon city: "cities must pursue density, not sprawl as 60% of growth in energy consumption is due to sprawl. Rigorous planning policy is needed to deliver compact, dense cities, with plenty of green space and eco-system services." Interestingly Watts' second key element is related to urban transport: "A successful city is not where the poor drive cars, but where the rich choose to use the bus: Switching to electric vehicles is part of the solution, but the basic model of urban mobility has to be public transport, cycling & walking." The third key element suggested that: "We shouldn't be afraid of good regulation – it drives successful markets. Climate change is fundamentally a product of market failure, and if national governments can't intervene, local governments must." (C40 Cities, 2015).

  The Québec Ministère des Affaires municipales et des Régions (MAMR) in 2005 published the 'Reduction of Greenhouse Gas Emissions and Land Use Planning' best practice guide which includes the increase of density and diversification of use in urbanised zones among other GHG emission reduction strategies such as: consolidate and structure urbanization for the agglomeration; consolidate and revitalize city centres and neighbourhoods; design an integrated transportation infrastructure network; and reforest open space and protect green space (Québec MAMR, 2005).
- It is recommended the report has a stronger focus on investigating and proposing examples and solutions for the mitigation and removal of barriers' towards achieving the emission mitigation goals. The barriers highlighted within this section, such as "significant costs of policies that seek to encourage higher-density development", including market driven costs such as "land prices", and consumer's "preferences' and lifestyle expectations, speed for implementation and expected (but not guaranteed) emission

offsets deriving from technology “advances in low-emissions transport” have been presented in the text as barriers without suggesting potential solutions for their mitigation. By doing this the text is seemingly discouraging the opportunity of achieving emission reduction through the transition towards high-quality, mixed-use, higher-density urban environments rather than striving to overcome these barriers.

While we agree it is relevant to compare benefits with trade-offs for each potential emission minimisation strategy, it is also necessary to avoid precluding any strategy on the basis of potential free-market decision-making and consumer expectations. It is recommended to consider potential emission savings strategies and their implementation pathways in the New Zealand context (including barriers to mitigation and policy options) as the main objective and goal of this report.

Urban form and building operational efficiency (p. 395)

Major review recommended:

- The presented analysis on urban form and its effect on building operational efficiency is limited in scope. Urban form is considered only from its effect on a single building form, specifically high density and compact forms of buildings. However, urban form, and the form of the urban environment, will have an effect (positive or negative) on building operational energy also by the impact on other factors such as (but not limited to): the urban micro clima; enabling building’s sun orientation and exposure including shading from buildings and trees; and heat island effect mitigation through green-roof areas.

It is strongly recommended to investigate the extent to which urban form is either enabling or creating a barrier towards more carbon efficient buildings from a holistic point of view. This should include urban land use such as the role of urban forests in offsetting carbon emission through carbon sequestration, and reducing GHG emissions by conserving energy used for space heating and cooling (Mc Pherson G. E., 2008).

- It is also recommended to consider how urban planning can enable overcoming barriers towards more energy efficient building design and development, and how to effectively integrate energy targets within the physical planning of neighbourhoods.
- Conclusive sentence: “*While higher-density dwellings might 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*.”

While understanding that the large proportion of renewable energy available in NZ is a positive offset, we disagree with the implied message that improvements on buildings’ operational energy efficiency are not needed. Improving buildings operational energy efficiency (end emission) is needed as confirmed by the statement reported on page 389, section *‘Electricity use in New Zealand buildings’: “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)”.

In addition to this, New Zealand's commitment towards the Paris Agreement, is building the case to proactively consider all the opportunities to mitigate buildings' operational energy emissions. Finally, as previously noted, the future energy demand and pressure on the existing grid from building's operational energy is unsure due to the combination of factors contributing to predicting expected built volume growth, the need for reaching healthier air temperature levels in new and existing homes, and the potential impact of electric transport transition on the existing grid and power networks (Putrus G.A. et al., 2009).

Urban form and emissions embodied in construction (p. 395)

- *"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)."*

  This sentence appears to suggest that the proposed solutions within Chapters 4 and 13 will be sufficient to substitute potential strategies to incentives to use building materials and building forms with lower embodied emissions. Furthermore it is unclear how the increase of the NZ ETS price (Chapter 4) would incentivise "build forms with lower embodied energy", this requires further explanation and referencing.

Conclusion on urban form and emissions (p.396)

- It is recommended to review the section using the recommendations set out in the summary section of this response, strongly focusing on direct BE emission sources and direct emission reduction strategies, including pathways toward their implementation, incentives and solutions for barrier mitigation, policy making and regulations. All the available reduction strategies, at all scales of the BE, should be considered using a holistic and integrated approach, including considering both short, medium- and long-term benefits.

15.4 Construction of infrastructure (pp. 396-399)

- The scope of this section seems too narrow in relation to the contribution of BE infrastructure towards emissions and emission reduction opportunities. The current focus is on construction of infrastructure, however, it is recommended to review this section to investigate infrastructure contribution considering the broader BE complex systems that enable activities resulting in emissions of greenhouse gases (GHGs). In addition to construction of infrastructure, the recommended holistic approach should include human-made and human-impacted land, land use and activities, hard infrastructure (e.g. roads, power lines, urban lighting, water systems, waste systems, etc.), and should consider all the opportunities for emission mitigation deriving from enhanced technologies, efficient management systems and soft socio-institutional infrastructure (economic, political, demographic, and sociological factors) that shapes the hard infrastructure and that are supported by exemplar international governance policies and regulations (Chester M.V. et al., 2014).

15.5 Conclusion (pp. 399-400)

- *"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."*

This statement is in contradiction to the international position in relation to the contribution of BE to greenhouse gasses emissions previously referenced within this Chapter response. The current New Zealand Energy sector renewable energy balance and the current New Zealand total emissions profile should not be used to downplay the scale and impact of BE emissions. Instead, actions to mitigate emissions across, and at all scales, of the BE should be considered in order to future proof all New Zealand sectors and economy.

- *"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."*

  It is strongly recommended to reconsider this position on the basis of the evidence previously referenced within this response.

- *"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."*

  As previously noted within this review this statement is justifying a strategy using generic assumptions. To avoid the statement to be perceived as a claim there is the need to:

  1. Define and reference what level is considered "effective" for the price on emissions.
  2. Explain how that effective price will directly contribute mitigating the different sources/causes of emission from the different components of the built environment considered (building lifecycle, urban form, and infrastructure).
  3. Explain how the defined "effective price on emissions" will be more efficient compared to other strategies mentioned further in the report and referenced in this review that are recommended and adopted internationally
  4. Suggest how to mitigate the risks identified by New Zealand Steel within their submission to the Productivity Commission, for example that higher NZ ETS emission prices will favour the import of materials produced under more favourable ETS pricing regimes (Nowlan J., 2017)

Therefore, it is strongly recommended to reconsider this position on the basis of the evidence previously referenced within this response.

- *"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".*

This statement is in contradiction to the international position in relation to the contribution of BE to greenhouse gasses emissions previously referenced within this Chapter response. Furthermore there is a level of contradiction within the statement itself. The current New Zealand energy sector renewable energy balance and the current New Zealand total emissions profile should not be used to downplay the scale and impact of BE emissions. Instead, actions to mitigate emissions across, and at all scales, of the BE should be considered in order to future proof all New Zealand sectors and economy.

- *“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.”*

  As previously recommended within this response, the New Zealand housing market is becoming increasingly unaffordable and, for this reason, there is the potential for many New Zealanders to change their lifestyle and in the future despite the “living preferences” of today.

  Moreover, whilst it seems likely that there will be an increased electric car market uptake, the timeframe and success for full establishment of low-emission transport is undetermined. Urban planning allowing for efficient transport options is one of the many options and, despite not being a short-term solution, urban planning regulation should be considered as an option to minimise the barriers for higher density new development and urban regeneration.

- We reiterate the recommendation for a major review that focuses more strongly on direct BE emission sources and direct emission reduction strategies, including pathways toward their implementation, incentives and solutions for barrier mitigation, policy options and regulations. All available reduction strategies, at all scales of the BE, should be considered using a holistic and integrated approach, including considering both short, medium- and long-term benefits. As suggested by Martina Otto (UN Environment) available technical and financial resources, the many effective technologies, materials and design concepts, and proven policy measures need to be fully mobilised.

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