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This submission covers issues pertaining to the overall mission and specific research funded or carried out by the NZAGRC, but also areas where I have personal expertise through my own research activities and involvement with the Intergovernmental Panel on Climate Change. As a result of the broader approach I have taken, the views expressed in this submission are my own and do not necessarily reflect the views of the NZAGRC partner organisations or other NZAGRC staff.

Q1 and general comments:

My overall sense is that the discussion paper is dominated by a short-term perspective in how it approaches its questions and considers possible solutions. For a paper that is charged with considering a transition to a low-emissions economy, longer term perspectives are necessary that orient themselves around a low-emissions economy as an end point rather than the status quo as the point of departure.

This would introduce a shift towards a cost-effectiveness framework for evaluating the costs and benefits of steps that can lead towards a low-emissions economy - which seems to be missing from the set of approaches proposed as relevant in the discussion paper (see Q31).

Consistent with this, the Commission should more actively consider changes that can, will and must occur over longer time frames (rather than as next step). This includes technological change, land-use change, and societal transformations including in social norms. At present, these perspectives are not strongly present and seem to be put aside in favour of considering what the immediate next steps towards a low-emissions economy could be.

A clearer sense of the longer term trajectory is important. This would allow a complementary perspective of reconstructing immediate next steps based on whether they are broadly consistent with the longer term goal. There is ample literature on social transformations (technological and land-use change could be seen as a subset of social transformations for the purpose of this discussion) and the Commission should ensure it actively draws on this literature to foster better understanding of the dimensions, drivers and necessary steps to achieve a low-emissions economy.

I note there is almost no discussion in the current discussion paper on the discount rate, despite the large body of international literature that has considered approaches to discounting for multi-generational issues. As the discount rate fundamentally affects cost-benefit analysis (as well as, even if sometimes less explicitly, almost any other decision-making framework that deals with long time frames), a proactive analysis and discussion of a way for New Zealand to decide on discount rates to be used in climate change analysis is essential in my view.

Page 6: The updated IPCC figure of the amount of warming caused by the emission of one tonne of CH₄ is 34. The figure of 28 uses the older approach to calculating GWPs, which did not consider climate-carbon cycle feedbacks because this information was not available when the GWP was first established. There is no reason in my view to exclude climate-carbon cycle feedbacks if the purpose is to account for the actual warming effect of the emission of a tonne of CH₄ relative to the emission of a tonne of CO₂. Also note that a recent important paper suggests that the radiative forcing of CH₄ may be underestimated, following a more detailed analysis of its absorption bands and overlaps with absorptions by other gases (Etiman et al 2016). This will be assessed in the next IPCC report.

Page 13: It would be instructive, from a productivity perspective, to compare the trend in GHG/GDP, CO₂/GDP, CO₂ (rather than all GHG) per capita, and emissions in individual sectors for New Zealand with the respective trends in other OECD and selected non-OECD countries. This would give a better sense of whether abatement costs in New Zealand are indeed high (as often stated) because New Zealand is already demonstrably highly efficient, or whether there may be some other engrained or even growing inefficiencies and hence policy opportunities.

Q2:

Demand-side approaches are the obvious and necessary complement to supply-side analyses. These need to be coupled with a long-term perspective to enable a pathway towards a low-emissions economy to open up. In the short-term, demand management is often associated with foregone consumption (and hence can be frowned upon as

interfering in personal freedoms), but not necessarily in the longer term if coupled with a successful societal transformation that reduces the demand itself.

Q3/Q4:

Modelling does indeed suggest that further improvements to productivity and efficiency of farms are possible (as noted) and would reduce emissions and increase profitability, but this begs the question why farmers are not doing it already. The Commission should engage substantively with this question since it is likely to also reveal useful insights into mechanisms to support adoption of any mitigation option in the agriculture sector. Leaving this question un- or under-addressed also invites opinion and strategic positioning to dominate evidence-based policy discussions. Any mitigation option in the pastoral sector, unless enforced through strict regulation, will rely on some incentives or benefits to farmers combined with freedom to adopt or not adopt specific mitigation options. If we do not understand why farmers act the way they do today, we have little reason to believe we understand how they will react when presented with, say, a methane inhibitor and a carbon price that nominally makes use of the inhibitor cost-effective.

The discussion of agricultural emissions and mitigation options gives too little recognition to the fact that emissions and production of this sector have been rising and are projected to continue to rise. Setting aside whether this is a bad thing or can be justified, it is noteworthy that tools to make robust projections of future growth are surprisingly limited and non-transparent. Growth projections made during periods of high milk prices and a bullish market outlook are often revised downwards during periods of lower milk prices and more depressed market outlooks. This does not in itself suggest that reducing growth is a desirable mitigation strategy for New Zealand, but it points to the fact that better understanding of long-term sectoral growth (or contraction), within the range of both international and domestic drivers, is critical to enable a coherent discussion of mitigation options encompassing total production, productivity, and new technologies and practices. A focus on technological interventions only misses a very substantive part of the equation driving future emissions in agriculture.

I agree that a methane vaccine would be extremely desirable (as stated) but it is technologically extremely challenging, but progress has been more substantive and promising with regard to developing an anti-methanogen inhibitor. This should be recognised as a potentially significant and more realistic mitigation option even if it may not be applicable to all livestock systems. More broadly, the Commission needs to develop a framework for thinking about and quantifying the benefits of developing such technologies, to better inform the quantum of research investment that can be justified. Even though research into new ways of reducing agricultural greenhouse gases has been on an unusually long-term funding basis, there is currently no real objective bases for deciding how much longer fundamental research could or should go on for if it doesn't yield proof of concept (for the vaccine) or if commercialisation efforts (e.g. of an inhibitor) run into hurdles that may challenge continued private-sector investment.

The discussion of historical investment in agricultural GHG emissions research should recognise the Pastoral Greenhouse Gas Research Consortium (PGGRC), which as an industry-led, 50/50 industry/government funded joint venture represents a particular approach to research funding that the NZAGRC complements. The Commission should develop a view on how to take research in this space forward, given that the funding for both bodies comes to an end in 2019 and there is therefore a very timely need to consider effective mechanisms to take the body of knowledge and capability that has been created forward, given that addressing agricultural GHG emissions is essential if New Zealand wishes to have a significant domestic component to meeting its long-term emissions targets.

Q5:

Land-use change is of fundamental importance if the land sector is to be part of New Zealand moving towards a low-emissions economy. On paper, horticultural enterprises appear to have higher profitability than dairying in parts of New Zealand, but horticulturalists are not buying out dairy farms in large numbers. This is likely to be influenced by hidden costs, skills barriers, infrastructure, investment costs, risks, along with more systemic influences in terms of attitudes of banks, international markets, export and training mechanisms. The Commission should seek to develop a better understanding of the true potential and barriers to land-use change to reduce emissions while sustaining not only economic but also social and environmental well-being by considering these factors.

Regional growth scenarios and strategies could be useful to explore the potential for and implications of land-use

change in detail. However, without a clearer long-term horizon point, the status quo with its aligned institutions and support mechanisms will be difficult to change. A targeted and objective analysis is necessary to better understand whether the status quo simply reflects the most economically viable form of land-use in most of New Zealand, or whether it largely reflects social and institutional lock-in that prevents genuine opportunities from being realised.

Any analysis would also need to draw on, if not develop, necessary skills to embed New Zealand regional growth scenarios with a quantitative understanding of global socio-economic development scenarios, given that the New Zealand economy would likely continue to depend on the export of land-based products. The framework developed in the international literature around “shared socio-economic pathways” offers potential in this regard, but coupling New Zealand scenarios to this international literature is only in its infancy. This limits a full consideration of alternative futures for New Zealand.

Q19:

I disagree with the unqualified statement in Table 4-1 that direct regulation doesn't (i.e. not ever) achieve emission reductions at overall least cost to the economy. That statement would only be true if there were no market failures, no information limitations or asymmetries, and no preferences in specific interest groups that go beyond economics. It is no doubt true that in some, possibly many situations, regulation will result in higher costs than market mechanisms, but the case remains to be made in each individual context. If any of the above situations apply, then this statement is no longer necessarily true. It is also important to consider whether least-cost is the dominant criterion for policy choices, or whether risk, equity, social inclusion etc are not equally or more important in some cases.

Q22:

Given the long-term nature and mixed public and private benefits from mitigation R&D, a key challenge is how to ensure social benefits are included when decisions are made about the volume and duration of R&D, choices within R&D strategies, and decisions and path dependencies around technology adoption and adaptation to New Zealand contexts. The IPCC noted in its AR5 that there are distinct market failures associated with research, technology development, and technology diffusion (see IPCC AR5 WGIII, chapters 3.11 and 15.6). I will not attempt to summarise the detailed discussion there but suggest that the Commission attempt to assimilate the findings from this assessment for the New Zealand context.

This would need to include consideration of the fact that, and reasons why, private R&D investment in New Zealand is significantly lower than the OECD average, and the long-term, high-risk nature of R&D investment especially where New Zealand is playing an internationally leading role e.g. in agricultural GHG mitigation.

Private sector engagement in R&D often requires the future benefits of successful R&D outcomes to be monetized, which is challenging without long-term policy and price signals or horizon points for emissions. Government has a role in this through provision of long-term policy perspectives and goals, as R&D funder, and as regulator of emissions or technology-related practices to create a technology pull. All of those approaches are potentially relevant in New Zealand but their applicability will differ for different sectors and be contingent on assumptions about other policy choices. A pure market based approach without a significant long-term horizon point is unlikely to deliver sufficient certainty for the private sector to continue investing significantly in high-risk technologies, and this could result in an early lock-in to already proven technologies, restricting future options.

Commercialisation of successful technology prototypes is generally thought to be best done by the private sector, but consideration needs to be given to government support programmes to assist with technology pull, both in New Zealand and internationally, to create a more stable and broad value proposition to private sector investors in this commercialisation. This includes long-term target setting, policy certainty (even if this implies a gradual and timed approach), and could also include active support for branding low-emissions products in international markets. An approach that leaves future mitigation targets e.g. for agriculture entirely contingent on the creation of new mitigation technologies risks creating a moral hazard for the private sector that has a stake in both the emissions-generating activities and the generation of mitigation technologies.

This suggests that technology policy needs to be strongly integrated in overall policy design and evaluated in this context. What type of support for innovation and technology best serves New Zealand's transition to a low-emis-

sions economy cannot be answered in isolation from other policy decisions.

Q31:

Significant gaps in the evidence base exist in future baseline production and emissions of the land-sector under different domestic and international scenarios (influenced by both climate and non-climate settings), and there are few transparent and widely accessible tools to develop and test such scenarios. Better and more consistent modelling of alternative futures of land-based sectors, including the potential and implications of land-use change, are critical to better inform options for low-emissions futures.

The Commission should also explore in a much more robust way than has been done in the past the multiple linkages between changes in New Zealand's international revenue streams and payments (affected by climate or non-climate decisions at the global scale), and costs and benefits of domestic climate policy. Most analysis to date has focused on the global carbon price as key linkage, but existing studies give ample evidence that other global policy decisions affecting commodity prices could have a bigger influence on New Zealand's net economic benefits than the carbon price alone. Developing a robust framework with the goal that this be used more routinely in the evaluation of policies would be an important goal resulting from this inquiry. For example, when the Ministry of Transport in 2009 evaluated the costs and benefits of any fuel efficiency standards, the analysis considered only the GHG costs but appears not to have assessed the broader economic and societal implications of New Zealand significantly reducing its fossil fuel imports (which impact on New Zealand's terms of trade, which could swamp the direct economic value of avoided emissions and would affect a far broader range of sectors). Conducting and demonstrating the value and use of such more integrated assessments, which should consider economic as well as broader societal and/or environmental implications and should consider alternative scenarios rather than a single 'best-guess' future, would be critical for a more robust assessment of the risks and benefits of alternative climate policy options.

Q33:

The Commission should develop and apply a framework for considering (including where appropriate, monetising) co-benefits of a low-emissions economy, and support such a framework to become the mainstream approach to evaluating the costs and benefits of climate policy. The co-benefit connections are numerous, including linkages between urban design, buildings, transport/mobility, and public health; reduced land-use intensity reducing GHG emissions and impacts on water quality; resilience to natural hazards and global economic shocks, economic diversification, and land-use change; reduced transport emissions and reduced reliance on fossil fuel imports. These are examples only, not an exhaustive list and not necessarily in order of importance.

The Commission should also consider possible institutions that can support recognition of co-benefits in policy design, implementation, and economic assessment. Generally, co-benefits are considered by agencies developing the core policy, and those institutions are not necessarily best equipped to assess co-benefits nor to consider implementation options that maximise realisation of co-benefits (not least because those agencies are not the primary beneficiaries of the co-benefits). It may be worthwhile to consider institutional designs that more effectively lead to a consistent consideration and where appropriate, quantification of co-benefits.

Q37:

I support a two-basket approach including for the scientific reasons given. However, some nuances should be applied to the discussion offered in the discussion paper:

- N₂O is a long-lived gas. As a result, an exclusive focus on CO₂ would not be appropriate from a physical science perspective, but should include all long-lived GHGs. A sole focus on CO₂ could only be justified by other policy considerations resulting in (permanently) different treatment of agriculture as a sector (responsible for the bulk of New Zealand's non-CO₂ emissions in the form of long-lived N₂O and short-lived CH₄).
- The trajectory of warming is not irrelevant, and controlling emissions of short-lived gases can reduce the rate of change in the near term. This should not be ignored.
- Even though emissions of CH₄ do not need to go to zero to be consistent with long-term climate goals, there is a clear and quantifiable benefit from reducing CH₄ emissions as much as possible. This is because a lower (sustained) flow of CH₄ emissions allows a (slightly) greater carbon budget to reach the same peak warming level.

As a result, lower CH₄ emissions would allow slightly later peaking of long-lived GHG emissions and slightly later point at which long-lived emissions have to reach net zero. This would allow deferral of some of the considerable costs associated with a rapid reduction of CO₂ emissions (or to make the actual achievement of temperature goals more likely). It would be helpful for the Commission to attempt to quantify this benefit of reduced CH₄ emissions (both by providing global context and focusing on implications for New Zealand using newly developed approaches and frameworks to consider short- and long-lived gases). It is true that CH₄ is less important than CO₂ overall, and that CH₄ does not have to be reduced to zero and can be reduced later - but choices around how to treat CH₄ are not cost-free across the economy as a whole. These costs can and should be quantified to inform a better discussion of the role of CH₄ emissions as part of a low-carbon economy.

An important corollary of adopting a two-basket approach would be to recognise that net emissions of long-lived GHGs have to reach zero (in the second half of the 21st century, and as noted in the discussion document, for a developed country like New Zealand this means for a whole number of reasons as close as possible to 2050). A two-basket approach would thus support a less ambiguous long-term signal for the trajectory of long-lived GHGs, which so far has been lacking for New Zealand. A switch to a two-basket approach in my view can only be justified if it is coupled with a clear vision for New Zealand to achieve net zero long-lived GHG emissions by a certain date. A two basket approach thus presents an important opportunity to provide clearer long-term signals.

As noted above, the question at what level emissions of CH₄ should be stabilised (noting that this level can and will be greater than zero) is not independent of the pathway for long-lived GHGs, but given the relatively short lifetime of CH₄, there is justification of updating goals and expectations for CH₄ as mitigation options for CH₄ in New Zealand and become better understood and new technologies are developed and become commercially available, and as the international response in the agriculture sector, both from a producer and consumer perspective, changes over time.