National Energy Research Institute

8 June 2018

Submission on: *Low-emissions economy: Draft report*

Index

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Recommendations

That the Commission in its final report:

General

- Build on the importance given to innovation in the Draft and explore it in greater depth;
- Directly address the level of funding for innovation in the energy sector, with particular reference to:
  - the current gaps in research into energy conversion and demand, and
  - the need for longer-term directed research to reduce the uncertainty and increase options for a lower-cost less disruptive transition;
- Identify where it considers the priorities areas lie in this funding, taking into account the work that NERI is progressing in this area;
- Ensure that fuel substitution, demand management, addressing longer-term more difficult issues today, and all of the energy sector, not just domestic use, are all given due weight in its recommendations;

Chapter 3 Mitigation pathways

- Move the current emphasis on macro scenario modelling on to consideration of the specific subsector opportunities and risks and potential priorities for action at this level;
  - In doing this give greater prominence to adaptive techniques rather than scenarios and deterministic pathways;
- Ensure that equal consideration is given to acting where the risks in so doing are judged low, and acting to reduce uncertainty, lower risks and expand options when they are not;

Chapter 4 Emissions pricing

- Ensure that any consideration of ceilings and floors in reform of the ETS takes into account of the downsides of having the Government involved in this way;

Chapter 5 Innovation

- Consider adopting a framework for analysing priorities for innovation that separates out where:
  - there is something unique to NZ about the problem that means we need to get it done here;
  - we are internationally strong in that area;
  - we need to import the innovation (the dominant group) but we need local capability to support this and address adaption and barriers to adoption.
- Note that innovation scanning will be part of what is required in all these areas, and that NERI is proposing to include this kind of service in its work on strengthen NZ's research capability;

Chapter 6 Investment

- Identify where the specific priorities for emission reductions lie and have those reflected in the Government's investment instruments (mirroring innovation investments) (Q6.1);

Chapter 7 Laws and institutions

- Recommend any proposed body has the external economy in scope and has some formal structure to ensure the importance of subsectors is not lost sight of;

Chapter 9 Policies for an inclusive transition

- Goes further into this area taking account of the comments in this submission, and recognises the need for research to address the various issues raised;

Chapter 10 Land use

- Broaden the consideration of the trade-offs in land use to include future demands for bioenergy and biochemicals;
  - The relative value of land use when producing these needs to be evaluated against its use for sequestration;
- Consider the need for a more fundamental look at agri-foods as NERI is proposing to do;

Chapter 11 Transport

- Includes fuels supplied in NZ for international transport in its analysis along with what that means for the ability to manage domestic emissions;
- Not pursue a ban on fossil fuels vehicles for the reasons in our submission (Q11.1);
- To achieve technology neutrality in a feebate include a subsidy for other renewable fuels used in transport at its implied level (Q11.2);
- Acknowledge that transport issues beyond EVs are significant (and beyond that currently shown in the Draft), in many cases uncertain and need to start to be addressed;
  - That will include issues on both the supply and demand for transport fuels;
  - It will need to include all modes;
- Review the priority research question that arise to help inform NERI's work on energy use, emissions and transport supply and demand (Q11.2);

Chapter 12 Electricity

- Widens the discussion of distributed energy resources (DER) in the Draft to include other forms of energy apart from electricity;
- Review the potential for biomass and low grade geothermal DER to level seasonal loads and biomass generation for dry year support;
- Identify any research questions that could help NERI's work on a 100% renewable electricity and the impact of storage;

Chapter 13 Heat and industrial processes

- Acknowledge the importance of biomass already in this sector, and its increasing potential to displace fossil fuels in new builds using well established technology.

Submission

Introduction

The National Energy Research Institute (NERI) is a Charitable Trust incorporated in New Zealand. Its primary purpose is to enhance New Zealand's sustainability and to benefit the New Zealand community by stimulating, promoting, coordinating and supporting high-quality energy research and education within New Zealand.

Its research members are Victoria University of Wellington, Auckland University of Technology, Scion, University of Canterbury and the University of Otago, and its industry association members are the Bioenergy Association, BusinessNZ Energy Council, and the Energy Management Association of New Zealand. This submission has been developed in conjunction with the membership, but does not necessarily represent their individual views.

NERI's focus is on the energy sector and unless explicitly stated otherwise these comments relate to reducing emissions from that sector.

In October 2017 we provided an initial submission to this inquiry and we are pleased to see a number of the issues we raised being addressed in the *Low-emissions economy Draft report* (hereafter *the Draft*), particularly the focus on the key sectors of the energy sector where fossil fuels are used (Transport, Industrial Processing and Electricity Generation). In what follows we comment in more detail, predominantly focussing on these sectors and on innovation.

In November 2017 we published the *Energy Research Strategy for New Zealand: The Key Issues* (*the Strategy*) [1]. Its scope is wider than the sector's GHG emissions, but reducing these is a significant consideration. Among other things *the Strategy* directly considers the support the science and innovation system could give in achieving a low emissions economy, particularly when it comes to medium-term public good science. We are in the process of developing a research programme to addresses the priority issues (Appendix 2).

In what follows we first makes some general comments directed at the role and funding of innovation that in our view needs to be more explicitly stated, and draw attention to three general issues with the way *the Draft* frames its recommendation; and then we move to a section by section discussion of its content, Questions, Findings and Recommendations where relevant to energy, referring back to the general comments where appropriate.

General Comments

Need to fund energy sector innovation

As *the Draft* attests reducing emissions in the energy sector is an extremely complex and difficult task simply because the sector itself is a large complex system that has an international dimensions and interacts with all parts of our economy and society.

Even without the need to reduce emissions the sector's future is uncertain given potentially significant political, social, technology, behavioural and environmental uncertainties changes impacting upon it.

All this plus the sector's heavy dependence on low cost fossil fuels constrain our ability to rapidly achieve emissions reductions without significant risk, cost and disruption.

The Report identifies "Innovation" as being a key way to help reduce this complexity and uncertainty, and thereby to help to enable a less disruptive, lower cost, less risky transition to our emissions targets.

However as it further notes "the current suite of government programmes lacks the strong strategic focus on low-emissions innovation needed for New Zealand to transition to a low-emissions economy with the greatest net benefit."

NERI strongly supports this view.

We would add that this will involve addressing the institutional, technological, behavioural and environmental issues as they interact and impact on NZ's energy emissions, and it will require significant effort on the longer-term more intractable ones.

Despite this need there are limited energy research investments being made in NZ apart from sustainable energy resources (wind, wave, solar, geothermal and forests).

This needs to be addressed because significantly increasing this funding and building energy research capability is the only way of removing unknowns about how to reduce energy sector GHG emissions and from that developing cost effective solutions to them.

We consider the Commission should directly address funding levels in this area, as *the Draft* does in agriculture. In *the Strategy* we identify key areas for investment and expand on these in this submission.

We would welcome further input from the Commission into this.

Framing of the Draft's recommendations

There are three issues about the way in which *the Draft* selects matters to be the subject of its recommendations. Each means options for actions (and complexities) are missed.

1. Improving the efficiency of fossil fuel use tends to be given disproportion weight in the recommendations compared with the alternatives of cleaner fuel substitution and demand management.
2. Similarly, "a long-term focus", as required by the Terms of Reference, gets less emphasis in the recommendations than the short-term more tractable issues.
3. Management of domestic energy emissions requires consideration of NZ's total energy production, not just the component servicing domestic loads. This is particularly true of transport, the largest source of energy emission where around 20% of our fossil fuel use is just assumed to be out of scope.

In the case of the first two *the Draft's* narrative and findings often discuss the issues, but this is not translated through to the recommendations. Our general concern is that as a consequence *the Draft* is silent on a range of important options to reduce

NZ's exposure to GHG emissions and is light on what should be being done today to start the process of addressing the longer-term more difficult issues.

The final report would be significantly enhanced if, when forming its recommendations, it more systematically addressed: opportunities in fuel substitution and demand management, perhaps even more so than fuel efficiency; longer-term issues and how to start addressing them thus broadening the scope of recommended short-term actions; and take into account the context of the complete NZ fossil fuels sector when considering options for reducing domestic emissions.

Appendix 1 gives more detail on the basis for these comments.

Chapter 3 Mitigation pathways

While the Terms of Reference calls for consideration of the "different pathways along which the NZ economy could grow and develop" *the Draft* rightly warns against the view that any transition is predictable (e.g. Finding F3.2). Notwithstanding most of Chapter 3 discusses the output of the Commission's scenario modelling.

Scenario modelling has been a commonly used in looking at NZ's energy/GHG emissions futures [2] [3] [4] [5] particularly in attempting to model national impacts from various assumptions. However once the general potential of achieving desired outcomes has been established there are diminishing returns from this type of modelling when it comes to determining what to do.

Instead what will be required is an adaptive approach, i.e. starting with our current situation and selecting what look like the best options for action towards the 2050 goal in light of the current state of knowledge and the uncertainty. As more information flows in the process is adapted in light of this. This requires not only an understanding of potential benefits but also a high level of awareness of the potential for lock-in to undesirable long-term outcomes, especially as infrastructure investments may have lifetimes of 50-80 years.

Any mitigation pathways will evolve from this process.

A consequence is that the optimum policy responses at any time (e.g. institutional change, pricing, regulation, investment etc.) will be state dependent. This implies subsector by subsector analysis of the optimum policy stances, not national analysis. For this reason the work on the energy subsectors in the Appendix to the background paper to the scenario modelling [6] is more useful to this end than the scenarios themselves.

However it must also be recognised that traditional sector boundaries may become increasingly blurred (e.g. between the electricity sector and the transport sector in relation to electrified transport and battery storage, or between the agricultural sector and the energy sector in relation to biofuels) and this will create new challenges for modelling and analysis.

We assume this is the approach proposed in the second phase of modelling underway with a view to exploring "Resilient Strategies", and we would endorse this.

We would add that within an adaptive framework it is useful to distinguish two broad types of action that might be taken based on the circumstances:

1. Where the impacts and interventions are relatively well understood: direct intervention (as necessary);
2. Where they aren't and there are potentially significant risks or high returns: further work with a view to reducing the risks or realising the returns. Because the future value of acting is uncertain the emphasis will be on high gain/low cost activities that reduce uncertainty and clarify pathways (see e.g. [7]). Directed research investments are one example[1], institutional arrangements that encourage adaption and innovations are another.

Hopefully the final report will work more explicitly within this framework for mitigation pathways, rather than scenarios. This will help identify the full range of policy responses, and give greater weight to the areas of uncertainty and what should be being done now to address them than currently occurs in *the Draft*. This would also go some way towards resolving debates about what to do now and when to wait.

Chapter 4 Emissions pricing

In terms of reform of the NZ ETS (F4.15) to include ceilings and floors we draw attention to one risk of Government intervention that isn't mentioned. The problem is that market participants are likely to have better information than the Government on where prices are heading. As *the Draft* notes in section 4.9 "Emissions pricing also decentralises decisions to invest, innovate and consume across the economy to people who have the best information about opportunities to lower emissions given their circumstances."

The option of encouraging a futures market isn't discussed as a solution to volatility nor are alternative policies to mitigate the problems e.g. the dis-incentives to invest in low emissions technologies in the face of uncertainty could be more directly addressed.

The commentary about technology roadmaps vs. national modelling on the prices required to achieving switching to low emissions technologies is weak in having a preference for the latter. The models by and large derive their cost structure for technologies from microeconomic analysis, just as good technology roadmaps will. Where the national models do add value is in giving a measure of aggregate response within the economy, but their usefulness is only as good as the underpinning analysis, approximations and assumptions and that often will be at a higher level and therefore less accurate than specific subsector consideration.

To summarise our view is that NZ needs to do more at the specific technologies/microeconomic level in areas of high risk or return to thereby "increasing the potential for deploying innovative technologies to reduce emissions" (F4.16).

[1] These may sometimes appear expensive but may well be low cost relative to the potential gains.

Chapter 5 Innovation

We support the findings and recommendations of this Chapter.

Supporting innovation in reducing emissions across the NZ economy in general will have value relative to the cost. In the energy sector at least NZ faces some relatively unique issues that go beyond business-as-usual that we are not currently addressing. Starting to selectively increase our understanding of these relatively longer-term more difficult issues now is central to improving our ability to adaptively plan.

The specific priority issues have been identified in *the Strategy* [1] and this inquiry is broadly confirming these. As noted earlier, based on *the Strategy* NERI is in the process of developing a SSIF Programme to addresses the priority issues (Appendix 2). We would encourage the final report to explicitly identify where it considers the research priorities to lie, particular the more difficult risks and opportunities in energy conversion and demand[2].

We assume that there will be similar areas outside energy that also would warrant specific mention and that are not currently addressed in *the Draft*.

Turning to some comments on the detail of this Chapter:

- Example 1, Box 5.1 shows the historic price reductions in PV panels but what is important is the outlook. This is likely to slow (Figure ES-1 [8]);
- Example 2 is somewhat dismissive of the outlook for hybrid electric aircraft having an impact because of weight challenges, perhaps overlooking the NZ researchers working on precisely this issue with Boeing and NASA [9] funded through the Endeavour Fund [10]. The NASA/Boeing roadmap has regional aircraft entering market in the 2030s potentially reducing fuels use to 60%. Airbus is also developing a hybrid electric demonstrator [11].
- Table 5.1 lists the various government funded research support schemes. It mentions the SSIF, but not that it includes CRI funding for work on renewable energy resources (geothermal, forestry, wind and hydro).

The conclusions about where NZ might invest in innovation to reduce emissions lack structure. Our view is that this can usefully be thought of in three groups:

- Some of the innovation we have to do is where there is something unique to NZ about the problem that means we need to get it done here. As mentioned earlier the areas should be able to be identified (see Appendix 2), but we should also allow bottom-up input into how best to tackle the problem areas. At the enterprise end specific targeted grants may be appropriate. At the beyond business-as-usual research end this will suit applied directed research funding instruments like the SSIF.
- There is other innovation that we should do because we are internationally strong in that area. The simplest way to encourage this is introduce a general across-the-board priority for emissions reductions as a criterion in all

[2] Research on renewable energy resources is already funded relatively well through CRIs and the Endeavour Fund [1].

innovation support programmes. Alternatively a more targeted approach could be adopted so the high risk/high payoff areas for NZ are specifically encouraged (see comments on Chapter 6).

- There is innovation that we need to import, and this will be by far the dominant category. It is also the one that many of the actors in economy are already motivated to pursue. However NZ will need to invest in innovation capability to support this process, including adaption to NZ conditions and NZ-specific research on social and technical barriers to adoption.

Innovation scanning is a particular case of the last and enhancing company's skills to do this and due diligence might be a place to start (see also F5.12). Effective due diligence is the key when working out how useful early stage technologies will ultimately be and this requires both a breadth and depth of technical expertise[3] often beyond that which firms have. Where research is being funded in areas of particular concern to NZ this will lie with those undertaking that research and scanning should be part of their brief (and has been included as Theme 5 in Appendix 2).

Chapter 6 Investment

The case for Government intervention in the capital markets depends upon the public benefits from emissions reductions. This means that across-the-board interventions will be less efficient than concentrating on areas where NZ has particular problems.

Unfortunately if anything NZ's current interventions in the energy sector target quite low pay-off subsectors and, as we note in our general comments, are preoccupied with low pay-off energy efficiency interventions. Much more limited attention is being paid to the higher return search for alternative fuels (EVs aside) and demand side initiatives [12] [13].

Just as we have argued that there are priorities for where NZ should undertake and fund research so the same logic applies to the Government's intervention in the investment market.

This should be made explicit in R6.4 including the indicative areas where the returns are seen as potentially high. This goes some way to solving the problem raised in Box 6.4.

In the case of Q6.1 if low emissions investments are to be given a priority then there also need to be priorities within that. In this case and at this level the Government wants to "pick winners".

[3] E.g. *the Draft* cites an article about a new "air breathing" battery from MIT [8]. At issue is whether this is better than the many other chemical storage technology developments that are being researched and whether it will make it to market? This is never a foregone conclusion; as the main body of this paper concludes "With <u>further development</u>, a new ultralow-cost electrochemical storage <u>option</u> <u>may</u> become available to support the growth of intermittent renewable generation and decarbonization of the world's energy systems" [emphasis added].

Chapter 7 Laws and institutions

We have two high level comments on the issues to be addressed in any legal or institutional proposals[4]:

1. Any laws and institutions needs to have the external economy in scope and not just be limited to the Paris Agreement. Without this the responses will sub-optimise in the energy sector at least (e.g. leakage), and we will have to separately address future Treaty obligations that are coming through from the International Marine and Civil Aviation Organisations [14] [15].
2. As we have argued the major issues in energy are subsector related. There is a risk that an umbrella body might lose sight of this. This dimension should be included in any legal framework e.g. a requirement to have specialist groups with some status in each of the major areas would be indicated.

Chapter 9 Policies for an inclusive transition

The transitions issue are potentially significant, particularly for domestic energy cost for renters and low-income households and the cost of transport as *the Draft* identifies. Five points not mentioned that are relevant to the former are:

1. Domestic thermal insulation and other forms of domestic thermal load shifting will have a disproportion payoff in terms of reducing fossil fuel use for electricity generation, at least in the short-term;
2. Ceiling and underfloor insulation and curtains are relatively easily retrofitted. Walls are more difficult. This is partially a technological issue, a particular problem for renters and low-income households and somewhat particular to NZ's building stock.
3. Current assistance for low income electricity users is poorly designed as *the Draft* notes in Chapters 11 and 12. It is based on volume of electricity used and doesn't necessarily target those in need[5]. Also it may reduce the effectiveness of any price signals that might be used to reduce emissions. The new winter electricity grant is also not necessarily well targeted.
4. Adoption of new technologies such as PV, batteries and EVs will usually decrease the operational costs of electricity supply and transport for those households. However it depends on having the wherewithal to make the initial investment. A concern is that low-income households will be disadvantaged by (a) bearing relatively higher portion of the costs of electricity generation and distribution infrastructure and (b) paying higher costs for mobility.
5. Assistance by way of part-charge has some advantages by providing support while maintaining incentives. This could be an option, and to the extent costs are relatively fixed (e.g. grid connections) could be covered by existing instruments like the accommodation supplement.

[4] The just released consultative documents on the Zero Carbon Bill [44] also do not address these issues.

[5] The Electricity Authority's consideration of the low fixed charge regime, reference in Box 12.7, acknowledges it didn't consider the effectiveness of the charge in achieving its social policy objectives.

NERI has identified existing building stock and equity, access and affordability as issues for further work (Appendix 2, Programme 5 and Theme 2).

Chapter 10 Land use

Expansion of renewable energy in NZ will require land. At the scales being considered in this Chapter the likely land use for additional wind and utility solar through to 2050 is minor, but energy crops are potentially much more significant [16]. We will discuss biofuels in relation to Chapter 11 Transport, but note that this section should discuss the trade-offs between sequestration and use for bioenergy, and include them when discussing the potential distortions that arise (F10.7, F10.14-16, R10.2-3). We would note that a similar comment applies to biomass feedstocks for solid fuels and biochemicals to replace petrochemicals.

An example of trade-off challenges is the widespread land use change across New Zealand that will result from (a) planting of forests for carbon capture and (b) forests and other crops for biofuels. For the latter there are likely to be location-specific requirements (e.g. close to major industry looking to replace coal with woody biomass) and hence new forms of competition for land which need to be anticipated and planned for. Another issue may well be one of social licence – how will New Zealanders respond to their known landscapes disappearing under forests, and is this likely to bring about a backlash if not carefully considered?

As raised in our general comments the findings and recommendations in this chapter are examples of *the Draft* focusing on improved efficiencies within agriculture (e.g. R10.8) much more so than the matters touched on in Box 10.11. NZ faces risks around the future of the food we produce. These are not just from better plant producing countries displacing our produce with alternative proteins. They could also arise from market sentiment moving against us because of the current high levels of emissions in our food production and distribution [17].

There are strong incentives on the existing industry to reduce its emissions and even to move their existing product base up-market in response to competition. There is, as *the Draft* documents, significant research support for these issues relative to other emissions related activities (even if this is still felt inadequate).

There is food innovation support (e.g. [18]) but this is largely limited to existing production processes and lacks a specific focus on the impact of GHG emissions from energy use. However as we allude in Appendix 1, considering the whole value chain from our resource endowments through to final product is likely to achieve better results when considering emissions reductions, particularly on longer time scales. But the barriers to significantly changing existing industries are high.

For these reasons NERI is proposing “Clean energy agri-foods – markets, products, production, processing” as a research programme to at least help manage the risks from the energy use perspective (Appendix 2, Programme 3).

Chapter 11 Transport

The Draft identifies EVs for the light vehicle fleet as “the most significant opportunity to reduce transport emissions in New Zealand”. The recommendations predominantly target increasing the proportion of low emission light vehicles entering

the fleet (R11.1-4), but also seek to “level the playing field” within the land transport sector (R11.4.5-6).

The findings also largely relate to these issues, but there is mention of alternative fuels (hydrogen, biofuels) for the heavy fleet and some options for mode shifting. These are put aside as not being significant.

We agree that EVs in NZ are a low risk option to reduce emissions in the light vehicle fleet and therefore policies in support should be pursued. We support the recommendations generally but make the following comments on the detail:

- Figure 11.2 ignores off road vehicles and the impact of fossil fuels supplied in NZ for international transport. Scion in their submission suggests that including them has light vehicles using under half the transport sectors fossil fuel energy use. Other solutions as well as EVs need to be considered.
- For completeness[6] F11.1 should mention the impact of the ETS on the competitiveness of alternative fuels.
- It is always risky to target a means (fossil fuel use) rather than the ends (low emissions), and doubly so when it comes to absolute prohibitions (Q11.1). As a starker example than hybrids the same fleet that uses fossil fuel could use drop-in renewable replacements. Putting that aside at this stage it appears that once externalities are taken into account EVs are (or soon will be) the lowest cost option for the low duty cycle fleet and options for the high duty cycle fleet are unclear and will crucially depend upon international technologies. A prospective ban (even if targeting emissions levels rather than particular fuels) therefore has limited value; unintended consequences; and could be revisited if circumstances change.
- The class of vehicles that can economically be electrified long-term (Box 11.3) is an issue we’ll discuss further below, but while the light/heavy vehicle split is a rough approximation the actual decision made will depend upon a range of considerations – the availability of alternatives; cost, both operating and capital; range; refuel time and infrastructure; gravimetric and volumetric density; life etc. Better understanding of these issues in the NZ context, now and in the future, is required.
- F11.8 notes a “lack of cost-reflective pricing for electricity” as the basis for “transitional price support to incentivise EV uptake”. Some discussion of electricity pricing is warranted particularly in relations to the findings and recommendations of Chapter 12 that do not currently address this issue directly.
- F11.9 again faces the problem that it is the fuel used rather than the conversion technology that determines the emissions, and this may change over the life of a vehicle. To achieve true technology neutrality other renewable fuels would need to be subsidized at the implied level of the feebate. Such an addition need not be unduly complicated, would be less distortionary and would help encourage transition in parts of the fleet not suitable for electricity (Q11.2).

[6] The conclusion that a low level ETS has limited impact in aggregate may remain (e.g. [42]) but it may encourage experimentation at the margin (e.g. [43]).

- Charging (F11.11 R11.3) is a critical issue for the limits of EV technology. While we will be largely a technology taker here, NZ is world leading in two aspects of this: inductive power transfer to allow dynamic charging [19] and fast, high energy flywheel discharge systems to allow rapid charging of large capacity batteries [20].

Turning to issues beyond EVs and referring back to our general comments we consider:

- Despite the uncertainty over options beyond EVs the final report needs to consider what we can do today to start managing that uncertainty. If the best option is to do nothing we should explicitly make that decision. We will identify some of the issues we consider we should be addressing now.
- There are risks on the demand-side in the transport sector that may be significantly disruptive of energy use, some on timescales shorter than significant penetration of EVs and other clean fuels into the market. One obvious example is the impact of immersive technologies;
- Similarly the supply-side for transport fuels is facing change, often in response to the demand-side changes. For example in NZ our fossil fuel supply chain will be facing pressure from low sulphur standards for marine fuels and progressive switching to EVs. This will have an impact on fossil fuel prices.

The Draft acknowledges in 11.2 that "transport patterns could look markedly different in a few decades time" quoting the Ministry of Transport: "Transport could be at the forefront of a 'fourth industrial revolution' – a fusion of the physical and digital worlds that is transforming how people live and work."

As an example *the Draft* looks at autonomous vehicles[7], drawing the conclusion that in the face of the uncertainty in technological developments the emphasis today should simply be on regulating emissions including pricing negative externalities.

There is another way to view this. By way of example, in the case of autonomous vehicles *the Draft* cites a MRCagney report [21] on their potential impact in NZ, arguing they will have limited impact over the next 20 years largely because of barriers to adoption. While the importance of autonomous vehicles to emissions reductions is unclear[8], if they are desirable in terms of public good the question for NZ to address is: "Does reducing those barriers warrant public investment?"

On that basis we have identified some examples of opportunities and risks on the transport fuels demand and supply sides that could have a significant impact over the next decade where NZ should be evaluating intervention beyond just relying on GHG pricing.

[7] It also mentions biofuels and electric motors for aviation and hydrogen fuelled vehicles. We've mentioned that NZ has researchers who will have a world class understanding of the status of hybrid electric aeroplanes, and will discuss how to address the other two examples later in this section

[8] It is potentially of some significance because the IEA suggests around 10% emissions reduction in the trucking fleet is possible [41].

Demand for transport fuels

- Augmented and virtual reality and telepresence. This is occurring now with 5G wireless providing the platform for even more sophisticated immersive technologies [22]. The hardware and software required is being developed with the home entertainment industry rolling out product. At low cost this platform will support virtual interactions substituting for the need for some forms of travel (e.g. shopping, business meeting etc.). We have some of the expertise [23] [24] and the motivation (geography and location) to be a world leader.
- Improved logistics. This is the subject of extensive study and activity internationally often in conjunction with looking at efficiency gains and fuel options e.g. [25] [26] [27]. Greening [28] identifies logistics measures for reducing fuel consumption and CO_2 in the 5-10% best case impact range, many with low to medium barriers to mainstream adoption.
- More flexible passenger transport. The use of ICT particularly to enable sharing and transport as a service will reduce vehicle kilometres driven and thereby emissions (F11.16). It will also help mitigate a particular NZ barrier to innovation - slow turnover in the fleet and a high proportion of second hand imports.

Supply of transport fuels

- The impacts of changes to transport fuel markets warrant consideration for their impact on the domestic supply and pricing of fossil fuels. The revised MARPOL Annex VI [29] lowers the global cap on sulphur in marine fuels. The local refinery cannot currently supply. None of the alternatives are particularly attractive [30], likely leaving the refinery with low value high sulphur fuel oils with a limited international market. This coupled with EV sales reducing demand will mean the costs of the balance of their slate will rise, at least in the immediate future. These likely adjustments over the next decade will increase the attractiveness of EVs (by increasing fossil fuel prices) and alternative marine fuels.
- While only indirectly impacting on domestic emissions our high exposure to consumer markets in Food (discussed above) and Tourism creates extra pressure on NZ to be able to supply cleaner international marine and air fuels to meet international specifications. Due to the global nature of these activities and NZ's small size, solutions for international shipping and aviation will have to fit in with global development.
- The supply of clean industrial chemicals will also influence options for clean transport fuels.

In response to these particular pressures and the more general pressure to reduce emissions, we can expect to see the NZ market fragment and sometimes become more decentralised. The significant low emissions transport fuels markets with potential fuel types (based on the recent literature) can be segmented into:

- Aviation: aviation biofuels, hybrid electric. Short haul (e.g. drones) electric, hydrogen;

- Marine: biofuels, clean hydrogen & ammonia [31] [32] [33] with a wider range including electricity for short haul shipping;
- Long-haul land and off-road: various clean gaseous (NG, LPG, hydrogen, ammonia, DME) or clean liquid (alcohols, biofuels) fuels. Possibly electric.
- Short-haul land: predominantly EVs.

To this we need to add in consideration of the supply of clean industrial chemicals.

NERI considers that modest investments accelerating desirable trends and reducing uncertainties on both the demand and supply sides are likely to be in the public interest. A sample of the kinds of questions NERI has identified that NZ needs to be addressing today are:

- In NZ what factors influence the dividing line between short haul (electric) and long haul (other fuels) land transport, what are the technology outlooks, can we increase the uptake of electricity, and, in particular, the role of domestic capabilities in doing this (e.g. dynamic and faster charging)? Can electricity meet other modes e.g. hybrid aircraft, short-haul shipping?
- What are the opportunities to improve logistics in NZ, particularly solutions that we should be looking to accelerate? Given that a number of advances require industry coordination what can/should the Government do to facilitate? Similar questions arise in considering increasing the efficiency of passenger transport.
- To what extent might immersive technologies displace mobility within and to and from NZ, and what are the barriers to adoption? What can we do to accelerate and in particular the role of domestic capabilities and Government leadership?
- How will consumer markets fare for products and services that have high emissions profiles (particularly food and tourism)? What are the options, and what can we do to de-risk them and facilitate their adoption – e.g. what is the willingness to pay for clean alternatives? What might the impact on fuel demand in NZ be?
- In looking at alternatives to electricity as a fuel there is much that can be done now specific to the NZ context despite the uncertainty:
    - Can we narrow down the scope of the likely types of biofuels (and clean industrial chemicals) that NZ will need to produce?
    - Within that scope what are the key constraints on meeting the NZ demand, particularly feedstocks and key resources like land?
    - What can we be doing now to start tackling these constraints (recognising that feedstocks like biomass will have potentially long lead times)?
    - Biomass feedstocks in NZ have largely been optimised for food, structural or pulp and paper applications, what can/has to be done to optimise for biochemical production?
    - Apart from biomass what other options to source the fuels are there (e.g. direct use of solar)?
    - Are there early opportunities to demonstrate supply chains and production systems for specific applications (e.g. marine fuels) and/or are there reasonably common precursor chemicals (e.g. clean lower

cost hydrogen) that will be required regardless that could be started to be developed?

- etc.

To this end NERI is developing research programmes to address these questions, particularly those that go beyond business-as-usual (Appendix 2, Programmes 1 & 2). A view from the Commission on these issues, any others and their priority will help shape this work.

Chapter 12 Electricity

Electricity systems are complex and undergoing significant disruption in the coming decades, and NZ is no exception. It also has a number of unique characteristics, for example apart from the high level of renewable generation the strength of the distribution system simplifies the use of electricity as an alternative fuel. It also has a relatively small number of large participants with incentives to think about longer-term developments, but those that are doing so are suggesting significant technological and systemic changes ahead (e.g. most recently [34]).

However there are some issues (e.g. F12.2, F12.4) that require ongoing research (not least the impact of storage) and NERI is proposing to address these (Appendix 2, *100% renewable electricity and storage*).

Beyond that there is one weakness in the Draft that should be addressed in the final report. This relates to a narrow demand-side analysis (another example of our general comments at the beginning of this submission).

In considering distributed energy resources (DER) the Draft assumes that it is electricity that DER is required to produce. Wider consumer options for energy are not considered, and if this is done it is possible that intervention beyond simply pricing emissions may be appropriate (R12.1-2).[9]

The Report notes "thermal generation mostly serves to meet demand at daily and seasonal peaks and during dry years", and by-in-large that demand will be thermal.

If direct thermal renewable DER were adopted in significant measure it could replace at least some of the fossil fuel electricity generation. This could offer a solution to a situation that is not otherwise easily addressed, particularly seasonal differences. Even though daily peaks are likely to be increasingly able to be managed through smart EV charging, smart hot water heating and embedded storage, thermal DER would still assist.

This then opens up the potential for DER biomass and low grade geothermal for residential, institutional, commercial and industrial space heating to compete with large NG generators. Both are well understood applications, but it is not clear what the relative economics are with rising emissions prices, or if there are any distortions in this market, or justification for intervention e.g. to accelerate innovation. These are matters we will address and we also recommend the Commission addresses them.

[9] This will increase the need to ensure that consumers of DER do accurately see the cost of the grid electricity they are replacing.

A further argument to investigate this area comes from a comment by Stevenson [35] on which this section of *the Draft* is based: "We believe there is much more work to do to understand the impact of efficiency on future electricity demand projections in the residential sector the commercial sector and the industrial sector." This will require an understanding of both the social and technical aspects of the drivers of demand and adoption of new technologies.

We also note that the competitive advantage of gas in managing the inter-seasonal differences and dry years is its ability to buffer energy in a high density form other than electricity and convert it as required with low capital cost generation plant. Biomass has some of those characteristics, particularly if it is being produced in an appropriate form to service other loads (e.g. marine fuels).

These are issues that should be addressed in the final report, and will be included as part of NERI's activities.

Chapter 13 Heat and industrial processes

Limiting our comments to energy use, the main barrier to the use of low emissions fuels are sunk costs and difficulties in servicing high temperature heat loads.

In this area NERI has taken the view that, as *the Draft* notes, the bulk of emissions come from a limited number of large fossil fuel users, particularly in the food sector. In the main these are low to medium temperature heat loads and the relevant producers are actively addressing their fossil fuel uses.

NERI understands that biomass and heat pumps are competitive with coal[10] for new builds at current ETS levels and co-firing is a possibility for existing plants. As the CO_2-e price increases so it will accelerate replacement of existing plants.

Further, wood provides ~75% of the Pulp, Paper and Publishing sector's energy needs [1]. This is about the level of electricity used by the residential sector [36].

So F13.4 is significantly at odds with what appears to be current practice and should be reviewed.

If the barriers to its use can be addressed it is a viable alternative for wider application. The Bioenergy Association will be making a submission on the closer-to-market issues with specific recommendations on overcoming the barriers.

Finally there are longer-term public good opportunities in exploring low fossil fuel alternative throughout the whole food value chain and this is a matter we propose to address (see comments on Chapter 10 and Appendix 2 "Clean energy agri-foods – markets, products, production, processing").

In the end *the Draft* simply ends recommending changes to EECA and moves to support CCS, neither of which will have significant impact. EECA will be limited to areas of minor impact (F13.2) and while providing for CCS in a neutral way (R13.3-4) makes sense, its prospect for NZ's emitters who are small on a global scale remains more difficult and further off than *the Draft* suggests [37].

[10] Natural gas is not likely to be a viable alternative.

Appendix 1: Further background on General Issues raised

1. Demand management

Fossil fuel use can be managed down in three broad ways: it can be used more efficiently; cleaner fuels can be substituted; or demand can be reduced.

A review of the changes in fossil fuel use over the last decade (2005 – 2015) shows the two big absolute shifts in fossil fuel use were in electricity generation due to fuel substitution (mainly away from coal to renewables while demand remained relatively flat) and in industrial demand due to growth (primarily Fonterra drying milk and Methanex). Domestic transport's fuel use has had a low rate of increase (reflecting some efficiency gains but dominated by kms travelled being flat despite economic and population growth) and international transport's has grown with GDP (reflecting demand growth with again some relatively limited efficiency gains) [36] [38].

So efficiency gains have been of secondary importance in determining fossil fuel use, and there is little reason to suggest that will change. However EVs aside the alternatives are still not a preoccupation of public policy, e.g. [12] [13].

The Draft's recommendations also underplay the alternatives:

On domestic transport the recommendations seek to increase the relative attractiveness of low emissions vehicles and increase demand for them, and to make emissions reductions a strategic focus for Government's investments within the transport sector. This will encourage a shift to low emissions vehicles at the margin, but *the Draft* is silent on both the more difficult case where low emissions vehicles are unlikely to be cost-effective, and on opportunities to accelerate reductions in the overall demand for vehicle use.

On electricity the recommendations focus on ensuring a level playing field over time for investments in renewables, and within the electricity sector on ensuring distributed resources and demand response isn't inhibited. Both are important (particularly in the situation we find ourselves in right now) but they don't address the issues of what is driving fossil fuel use in the sector, how to manage that demand now and in the future, and what the potential substitutes are.

On industrial demand the recommendations are institutional – refocusing EECA on emissions reductions and small businesses – and carbon capture and storage. Neither is likely to have a material impact on fossil fuel use even in the medium-term, particularly when compared with investments to explore ways to shift our industrial base to lower emissions alternatives.

2. The longer-term issues

Already touched on above, there is an emphasis in the energy related recommendations on short-term issues, where solutions are reasonably obvious. By and large EVs for transport, DG/DER for electricity and minor industrial process

efficiencies are happening (and CCS's impact is moot[11] and just one of a number of equally uncertain potential approaches to tackling emissions).

There is limited discussion at the subsector level of what the longer-term options are in the NZ context and what needs to be being done now to both help reduce the uncertainty surrounding these and to open up potential opportunities.

3. Total energy production

While there are some exports of energy that are discretionary there are others where the demand for the fuel can only be avoided at significant cost, and servicing a shift to low emissions fuels will require a significant shift in our domestic production.

The preeminent example is producing cleaner fuels for our international transport. This is largely ignored in *the Draft*.

The move to cleaner fuels is underway [14] [15]; NZ will be a technology taker - we will need to supply what is approved for aviation fuels [39] and what is adopted for long-haul shipping (vis. [40] [32]); and the demand is sufficiently large to have an impact on domestic alternatives to fossil fuel. Fuel supplied to international transport amounts to a quarter of that supplied for domestic transport (PJ) [1].

The fuels developed for international transport would also supply domestic shipping and aviation, and the availability of alternative low emissions fuels could also impact on other domestic uses e.g. perhaps bio aviation fuels for peaking electricity generation, renewable ammonia for trucking or as an industrial chemical.

Therefore fuels for international transport should be in scope, even if the emissions aren't.

[11] Managing CO_2 emissions from geothermal is however a strategically important issue for NZ, relatively unique, and one that appears easier to manage than industrial CCS (as *the Draft* reports).

Appendix 2: Working framework for SSIF Concept Business Plan

Programmes

Programme 1: Demand-side solutions for low- emissions, efficient heavy transport

Programme 2: Supply-side-side solutions for low- emissions, efficient heavy transport

Programme 3: Clean energy agri-foods – markets, products, production, processing

Programme 4: 100% renewable electricity (note this includes storage)

Programme 5: Energy performance of existing building stock

Programme 6: Improved geothermal extraction and conversion

Cross-cutting themes

Theme 1: Systemic change (includes system modelling)

Theme 2: Equity, access and affordability

Theme 3: Policy, markets, governance (institutional framework)

Theme 4: Impact

Theme 5: International technology scanning

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