A Submission on the Draft Report of the New Zealand Productivity Commission "Low-emissions economy"

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1. About me

I am a specialist in the technical, policy, and social aspects of the environmental consequences of industrial and urban development. I have more than 40 years of environmental management experience in various capacities, both locally and internationally, and especially in air quality management and related fields.

I am a Chartered Chemical Engineer and a Chartered Scientist. I was closely involved in early advances in environmental science and management in New Zealand in the 1970s. That involvement continues in my current work areas, including peer reviews for various agencies and appointments as an independent Commissioner for Resource Management Act hearings.

After a successful career in a significant New Zealand Government statutory role, including during the 'think big' industrial development era, I entered the international arena as the Air Quality Management Specialist, World Health Organization, based in Kuala Lumpur, Malaysia. These duties included as an adviser to the Governments of the Asia-Pacific region on various aspects of environmental management. That work has periodically continued, most recently as a consultant to the World Bank, the Asian Development Bank, Swisscontact, etc.

From 1996 to 1998 I was the foundation General Manager (CEO) of Environmental Services Australia, the commercial arm of the EPA Victoria. I attended the COP-21 climate change meeting in Paris, and I was involved in setting up a climate change centre, CCA@AIT, at the Asian Institute of Technology, Bangkok. I have been to Antarctica twice, in 2007 down the Ross Sea and in 2017 from and to Argentina. Those trips were related to my work on climate change mitigation.

As an invited participant to the 2016 Symposium on Environmental Sustainability and Climate Change, I am a member of the Oxford Round Table.

My professional affiliations include:

- Chartered Chemical Engineer
- Registered Chemical Engineer, Australia
- Chartered Scientist
- Member, Institution of Chemical Engineers, United Kingdom
- Member, Consulting Engineers Advancement Society (CEAS)

- Member, Institute of Directors in New Zealand
- Member, ProGroupNZ (a group of independent international development consultants)
- Member, Resource Management Law Association of New Zealand
- Member, Oxford University Round Table
- Member, The New Zealand Petroleum Club
- Member, Engineers for Social Responsibility
- Member, Taranaki Chamber of Commerce

This submission is made in a personal capacity, and not in respect to any of those organisations.

More information about me is available on my web-site (link above) and my LinkedIn profile (in which is embedded my Executive and Governance Curricula Vitae), accessible by searching 'Kevin Rolfe New Zealand'.

2. Draft Report: Some Supportive Comments

At about 500 pages, the draft report is detailed, and much of the content is strongly supported. The three principal long-term drivers toward reducing emissions of greenhouse gases – afforestation (another 1.3 million to 2.8 million hectares in trees, most on land converted from marginally profitable beef and sheep farms), electrification (primarily of transport), and changes to the structure and methods of agricultural production - are appropriate. They reflect the current emission's profile of agriculture 48%, transport 41%, industrial processes and products 7%, and waste 5%. Forestry currently offsets 30% of those emissions.

The draft report predicts through modelling that a much higher carbon price will be required. It indicates a range of $75 per tonne of CO_2 equivalent to over $200 per tonne over the next few decades. This is the topic that has received the most publicity about the draft report. With the usual caveat that modelling is only as good as the quality of the input data, this prediction seems to be in line with those in other developed countries. It is substantially higher than the current market price of $21.

The draft report compares the use of Emissions Trading Scheme (ETS) with a Carbon Tax to drive behavioural change. It recommends retention of the ETS, but identifies some areas of reform to make it more effective. This is a pragmatic recommendation, but in my opinion a carbon tax is more easily understood mechanism. Singapore[1] recently joined 67 other countries, including China, the European Union, and Japan, by introducing a carbon tax, to take effect from 2020. It is initially set at a low rate, but it will rise over time.

[1] "Singapore Budget 2018: Carbon tax of $5 per tonne of greenhouse gas emissions to be levied", *The Straits Times*, 19 February 2018, https://www.straitstimes.com/singapore/singapore-budget-2018-carbon-tax-of-5-per-tonne-of-greenhouse-gas-emissions-to-be-levied

In line with reports[2,3] from Parliamentary Commissioners for the Environment and the Commission's original issues paper, the draft report recommends the formation of an independent Climate Change Commission, based on the UK model. The Labour-led government has now[4] adopted this approach, and it intends to implement that through the passage of a Zero Carbon Act later this year. A predecessor body – the Interim Climate Change Committee – was set up in April, with a particular mandate to address how the agriculture sector may be brought into the ETS. This is supported, although it is noted that a Citizen's Assembly in Ireland recently[5] called for carbon taxes on agriculture.

In line with the more recent Parliamentary Commissioner for the Environment's report[3], the Commission recommends separate targets for long-lived (CO_2 and N_2O) and short-lived (CH_4) greenhouse gases. Specifically, it recommends that the long-lived gases need to reduce to net zero "at a minimum", while short-lived gases need to be reduced to stabilise global warming. With greenhouse emissions from agriculture the largest source in New Zealand, and always some doubt about the true global warming potential of individual gases over time, this approach is strongly supported.

Also strongly supported is the recommendation that there be emission standards for all new vehicle imports, and a "feebate" scheme whereby high-emissions vehicles would incur a fee while low-emissions (such as electric) vehicles would receive a rebate.

3. Draft Report: Some Additional Comments

In August 2017, a Taranaki Regional Economic Development Strategy (called Tapuae Roa - Make Way for Taranaki)[6] was released. Subsequently an Action Plan was released. The Strategy looks at Four Futures: Energy Futures, Food Futures, Maori Economy Futures, and Visitor Sector Futures. Especially with the Government announcement on 12 April 2018 to ban future off-shore oil and gas exploration[7], the Energy Futures have taken on a particular focus.

The Action Plan has two proposed initiatives for Energy Futures:

- A Clean Energy Development Centre
- A Hydrogen Energy Ecosystem – "H_2 Taranaki"

As Taranaki is the main energy region in New Zealand, both initiatives are relevant to a low-emissions economy.

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[2] "Stepping stones to Paris and beyond: Climate change, progress and predictability", Parliamentary Commissioner for the Environment, July 2017

[3] "A Zero Carbon Act for New Zealand: Revisiting Stepping stones to Paris and beyond", Parliamentary Commissioner for the Environment, March 2018

[4] "The 100 Day Plan for Climate Change", Office of the Minister for Climate Change, 20 December 2017

[5] "Citizen's Assembly Call for Carbon Taxes on Agriculture, Irish Examiner, 19 April 2018, available at https://www.irishexaminer.com/ireland/citizens-assembly-calls-for-carbon-taxes-469618.html

[6] "Tapuae Roa: Make Way for Taranaki Strategy", August 2017, and "Action Plan: A Plan to Prosper Taranaki"

[7] "New Zealand bans future oil and gas exploration", *The Chemical Engineer*, May 2018, p.18

A Hydrogen-fuelled Vehicle

The emissions implications of hydrogen production depend on the process used to produce it. Steam methane reforming, the most commonly used method, has a waste stream of CO_2. Electrolysis of water, using renewable energy such as solar or wind, would produce no CO_2 emissions. The latter is a more expensive option currently, but costs are reducing.

This specific example raises topics that are generally applicable to a low-emissions economy. A report by the Grantham Institute at Imperial College London and Carbon Tracker on low-carbon technology[8] concludes that Business as Usual scenarios are no longer relevant.

The Commission's draft report, just like the Net Zero in New Zealand – Pure Advantage report for GLOBE-NZ[9], also largely written by Economists, is lacking in its coverage of low-carbon technology. To address that, and to comment on supplementary benefits of a low-emissions economy, the remainder of this submission looks at the following five topics:

- Carbon Capture and Utilisation
- Deep Well Geothermal
- Biomethane as a Transition Fuel
- Air Quality Co-benefits of a Low-Emissions Economy
- The Sustainable Development Goals

[8] "Expect the Unexpected: The Disruptive Power of Low-Carbon Technology", February 2017, available at https://www.carbontracker.org/reports/expect-the-unexpected-the-disruptive-power-of-low-carbon-technology
[9] "Net Zero in New Zealand – Pure Advantage", Summary Report, Prepared for GLOBE-NZ by Vivid Economics, March 2017, available at http://www.vivideconomics.com/publications/net-zero-in-new-zealand

4. Carbon Capture and Utilisation

Carbon Capture and Sequestration (CCS) is mentioned in the draft report, as it is in most reports of this type. Although CCS is an essential technology for meeting international climate change targets, and quicker deployment of CCS will achieve a cheaper transition to a low-carbon future, it does have practical difficulties. There are only 37 CCS projects worldwide, storing only 31m tonnes per year of CO_2. That is well short of the 10b tonnes per year needed by 2050 to limit temperatures from climbing by 2°C[10].

A case study is provided by the Boundary Dam CCS project in Canada, which in October 2014 became the first coal-fired power station to implement a full-scale, fully integrated, post-combustion CCS system[11]. One year after operations began, the plant was operating at just 40% capacity, caused by serious design issues. Although they were overcome and will be for future plants, the amine solution used to absorb the CO_2 is degrading 2-3 times faster than expected, placing a high operational cost on the plant. So, in summary, while Boundary Dam has proved that CCS can technically produce clean power from coal, the economic feasibility of the technology is less certain.

There are questions about the storage of the captured CO_2. To date most commercial CCS projects are reliant on the use of the captured CO_2 for enhanced oil recovery, which is perpetuating our reliance on fossil fuels. There are other storage options, such as the CarbFix process described later in this submission, but they also are not 100% reliable in that leakage of the captured CO_2 may occur.

In Europe, CCS projects have been delayed and even cancelled by public concerns – "not under our backyard" being the catchcry. Enter carbon capture and utilisation (CCU), a term which covers a range of technologies that capture and convert CO_2 into viable commercial products, such as construction materials, chemicals, and fuels. CCU is a relatively little known term, but it has an exciting future.

Small scale use of captured CO_2, from gas treatment plants like at Kapuni to reduce the carbon dioxide content of the natural gas[12], for such things as fire extinguishers and aerated drinks, has been used for decades. A major breakthrough came in 2016 when the German chemical company, Covestro, started to make polyols, a precursor in the production of polyurethane foams, with CO_2 replacing 20% of the oil-derived propylene oxide. This is a major shift forward in technology – where CO_2 is a feedstock for the chemical industry, that is, a useful product and not a waste. This requires a fundamental change of thinking about CO_2.

10 "IChemE unveils position paper for CCS", *The Chemical Engineer*, May 2018, pp. 12-13

11 "The Privilege of Being First", *The Chemical Engineer*, May 2018, pp.36-39

12 "Benfield Process: A process using potassium carbonate to reduce acid-gases, CO_2 and H_2S from petroleum and industrial gases, with a gas absorption step and a carbonate regeneration step", Oli Systems, 16 October 2014. **Available at** http://wiki.olisystems.com/wiki/Benfield_process

The current plant at Dormagen produces 4,000 t/y of polyurethane foam, branded as cardyon™, used in mattresses and car seats. Covestro[13] has plans to expand production to 100,000 t/y, and to licence the technology with others to hasten the uptake. As well as producing more of the product, Covestro plans to double the proportion of CO_2 in the polyols. The limit set by chemistry is 43% CO_2.

Covestro Plant to Utilise Captured CO_2 to Produce Polyols, Dormagen, Germany

There have been recent studies of the environmental benefits of the CO_2 – to – polymer technology, as part of plans to build the first commercial plant in the UK[14]. They are two-fold. First, there is the turning of this waste product from an environmental burden into a useful raw material. Second, for every tonne of CO_2 used in the manufacture of polyols the partial displacement of oil-based feedstock results in a reduction of CO_2 emissions by a further 2 tonnes.

What is also underway is an expansion to the range of chemicals that Covestro and others can make using CO_2 as a feedstock. An analysis has shown that about half of all the processes in the chemical industry can involve the use of CO_2. Likely near-term developments are to use CO_2 to produce rigid foams for use in insulation and construction products, and to use CO_2 and methane to produce rubbers.

[13] "Covestro to expand CO2-using processes", *The Chemical Engineer*, June 2017, 12-13
[14] "Friendly Foams", *The Chemical Engineer*, May 2018, PP. 40- 44

5. Deep Well Geothermal

New Zealand was an early leader in the development of geothermal energy, and should continue to be so in the future. Some of the most interesting developments, especially in the low-emissions economy area, have been taking place in Iceland.

First, to set the scene, some background information:

Geothermal fluids are not environmentally benign. They are made up of not only steam or hot water, but contain varying amounts of gases such as carbon dioxide, hydrogen sulphide, methane, and ammonia, and toxic elements such as mercury, arsenic, fluorides, and boron. Depending on the composition of the geothermal fluid, the sensitivity of the receiving environment, and the technology used, utilisation of geothermal fluids can produce environmental effects.

There are three types of geothermal plants. Dry steam plants (which are rare) use steam directly from the reservoir to drive turbines to generate electricity. Flash steam plants (such as most in New Zealand) convert hot water from the reservoir to steam in a flash tank, and the steam drives turbines to generate electricity. In both types, when the steam is cooled it condenses to water, and is re-injected (outside the geothermal reservoir) to produce recharge. The non-condensable gases, containing carbon dioxide and hydrogen sulphide, are usually, but not necessarily, discharged to atmosphere.

A third type of geothermal plant uses a binary cycle system, whereby the geothermal fluid heats a secondary fluid to produce the energy and the geothermal fluid is re-injected. With no separation of condensate and gases, no discharges to atmosphere should occur. Binary cycle plants are favoured for power generation when the temperature of the geothermal fluid is below about 130°C.

In addition to electricity generation, geothermal fluid can be used for district heating. It has long been used in Beijing, China, for that purpose. In Iceland it is used for both. The Hellisheidi geothermal power plant produces about 303 MWe of electricity and up to 400 MWt of thermal energy, used for district heating in Reykjavik some 26 kilometres away. This ranks Hellisheidi as the largest geothermal power station in the world in terms of installed capacity[15]. I visited Reykjavik and the Hellisheidi geothermal power station in May 2017.

The latest, and the most exciting, developments in Iceland are in deep well drilling and the technology to capture and store both carbon dioxide (CO_2) and hydrogen sulphide (H_2S), called CarbFix and SulFix respectively. A 4,650m (that is, 4.65km) drill hole was completed on the 25th of January 2017. It is at supercritical conditions (426°C and 340 bar), but it is a success.

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[15] **https://www.extremeiceland.is/en/information/about-iceland/hellisheidi-geothermal-power-station**

Hellisheidi Geothermal Power Station, Iceland

CarbFix and SulFix goes further than just storage. They involve gas capture and re-injecting a mixture of approximately 70% CO_2 and 30% H_2S, dissolved in water, into basalt formations. Over 95% of the CO_2 and H_2S was mineralized, to carbonate and sulphur respectively, in less than 2 years. These major technological advances in deep well drilling and environmental management in Iceland are generally applicable elsewhere, and should be considered in the future for New Zealand. Apparently New Zealand has only limited areas with underlying basalt formations, but much of the ocean floor is basalt.

6. Biomethane as a Transition Fuel

Although the climate change requirement is to phase out completely the use of fossil fuels, that will take time and transition fuels are required. One such option is biomethane, which is biogas with the carbon dioxide and trace gases (typically a total of about 30 to 50% of the biogas) removed. Another name for biomethane is upgraded biogas. It is a high-quality fuel, suitable for use in the power generation, industrial, domestic, and transport sectors.

Biogas is the product of anaerobic digestion of organic material, where micro-organisms break down the organic material in the absence of oxygen. Worldwide there are millions of biogas plants, of varying size, utilising refuse and other forms of organic waste. There are 27 million biogas digesters in China alone. Biogas upgrading to biomethane is a state of the art technology which is currently being practiced at more than 500 of those plants, about 90% of them in Europe.[16]

[16] Frank Hoffman and Clemens Findeisen. "The use of biomethane in the transport sector – a viable option?" SUTP News 1 February 2017. Available at **http://www.sutp.org/en/news-reader/the-use-of-biomethane-in-the-transport-sector-a-viable-option.htm**

An example from the Asia-Pacific region is a palm oil plant close to Kuala Lumpur, Malaysia. The palm oil industry is important in Indonesia, Malaysia, and Thailand. The effluent from a palm oil factory (commonly referred to as palm oil mill effluent or POME) is usually stored in open lagoons, emitting enormous amounts of methane into the atmosphere. The plant near Kuala Lumpur has a covered lagoon and the captured biogas is upgraded to biomethane. The biomethane is compressed and put into cylinders and sold as a fuel.

A Ferry fuelled by Biomethane (Konstanz, Germany)

There are several technologies available to upgrade biogas to biomethane. The most widely used technology for removal of the carbon dioxide and other trace gases is water scrubbing, followed by chemical absorption. Other options include pressure swing adsorption, physical adsorption, membrane separation, and cryogenic separation.

Biomethane has similar combustion characteristics to natural gas (which is typically about 95% methane) and its usual product compressed natural gas (CNG). For areas with a pipeline network for distribution of natural gas, much of the North Island, the biomethane can be added directly to the natural gas grid. This offers huge storage capacities, and electricity can be generated when it is needed (that is, when there is no generation by other renewable means, such as from solar or wind. Similarly, the distributed mixture of CNG and compressed biomethane can be used as a transport fuel.

In areas that do not have a pipeline network, such as the South Island, there are the options of long-distance transport in ships as LNG and short-distance, land transport of biomethane compressed in cylinders. In the future biomethane may be blended with LNG, hence extending the life of natural gas reserves. The critical factor is that the biogas must be upgraded to at least the quality of natural gas.

Biomethane is a fuel that can be produced almost anywhere. In cities, sources of the biogas include solid waste management facilities and wastewater treatment plants. It is an option with significant potential for adoption in New Zealand.

7. Air Quality Co-benefits of a Low-emissions Economy

A frequently occurring and important co-benefit of measures to address the climate change challenge is to improve local and regional ambient air quality. The mortality associated with poor air quality in New Zealand exceed those associated with vehicular accidents by a factor of at about two and a half.[17]

The statistics are:

- about 1,000 premature deaths per year
- about 500 extra hospital admissions for cardiovascular and respiratory diseases
- about 1.3 million restricted activity days (when morbidity is sufficient to prevent activities such as work or study)
- social costs per year of about $4 billion (or about $1,000 per person)

Domestic heating is the principal source (56%), followed by motor vehicles (22%), open burning (12%), and industry (10%).

A low-emissions economy will, by changes to cleaner fuel types, improved energy efficiencies, and other measures such as those indicated in this submission, will achieve marked reductions in discharges of air pollutants. If the recommendation in the draft report for a "feebate" is implemented it will have a significant impact of discharges of air pollutants from motor vehicles.

Internationally, on motor vehicles, there have been announcements in recent months by various countries (Norway, France, the United Kingdom, and China) to phase out fossil fuel vehicles as part of the Paris Agreement (see footnote reference in the next section of this submission). Norway has set a date of by 2030; France and the United Kingdom by 2040 (although Scotland's First Minister has announced a phase out date of by 2032). In China, the world's largest market for automobiles with over 28 million sold in 2016, there is a quota system, requiring at least 8% of vehicles sold in 2018 to be electric, rising to 10% in 2019, and 12% in 2020. Automakers are similarly joining the bans, some as soon as 2020 for new models.

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[17] Kuschel G, Metcalfe J, Wilton E, Guria J, Hales S, Rolfe K, et al. 2012. *Updated Health and Air Pollution in New Zealand Study. Volume 1: Summary report.* Prepared by Emission Impossible and others for the Health Research Council of New Zealand, Ministry of Transport, Ministry for the Environment, and New Zealand Transport Agency, available at http://www.hapinz.org.nz

Also in response to the Paris Agreement, as well as concerns about local air quality, phase outs and bans are being adopted by various countries with respect to the cessation of burning coal to generate electricity. France has set a date of by 2022; the United Kingdom by 2025; and Finland and Canada by 2030. In 2016 China banned new coal-fired power stations and new coal-based industry until at least 2018.

8. The Sustainable Development Goals

Another area of co-benefits of a low-emissions economy is achievement of the Sustainable Development Goals[18], adopted by the 194 countries of the UN General Assembly (including New Zealand) on 25 September 2015.

Sustainable Development Goal 3: Good Health and Well-being has the (unfortunately qualitative, rather than quantitative) target of: by 2030, substantially reduce the number of deaths and illnesses from air pollution[19]. Other Sustainable Development Goals (SDGs) relevant to ambient air quality improvement are Goal 7: Affordable and Clean Energy; Goal 9: Industry, Innovation and Infrastructure; Goal 11: Sustainable Cities and Communities; and Goal 13: Climate Action.

At the historic Conference in Paris in December 2015 (COP21) of Parties to the United Nations Framework Convention on Climate Change (UNFCC), 196 nations agreed to help mitigate climate change and keep the average global temperature "well below 2^{o}C" by the end of this century, the so-called Paris Agreement[20].

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[18] Officially known as "Transforming our world: the 2030 Agenda for Sustainable Development", adopted at the UN Sustainable Development Summit in New York, 25 September 2015. The Agenda has 92 paragraphs. Paragraph 51 outlines the 17 Sustainable Development Goals and the associated 169 targets.

[19] Part of Target 3.9 of Goal 3: Good Health and Well-being. Available at **http://www.who.int/mediacentre/events/meetings/2015/un-sustainable-development-summit/en**

[20] The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gas emissions mitigation, adaptation, and finance starting in the year 2020. The language of the agreement was negotiated by representatives of 196 parties at the 21st Conference of the

This target is widely recognised as ambitious, but it needs to be. If we continue producing emissions at the current rate, there could be a rise in global temperatures of 3-4^{o}C by 2100.

There are strong interlinkages between the Paris Agreement and the SDGs. Action on climate change to attain a low-emissions economy and action to meet the SDGs have mutually supporting goals, including the common goal of a sustainable, resilient, and secure way of life. Hence, actions to achieve a low-emissions economy will contribute to the success of all 17 SDGs.

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Parties of the UNFCCC in Paris and adopted by consensus on 12 December 2015. As of October 2017, 195 UNFCCC members have signed the agreement, 168 of which have ratified it. Under the Agreement, each country determines, plans and regularly reports its own contribution it should make in order to mitigate global warming. There is no mechanism to force a country to set a specific target by a specific date, but each target should go beyond previously set targets. In June 2017, US President Donald Trump announced his intention to withdraw the United States from the agreement, causing widespread condemnation in the European Union and many sectors in the United States. Under the agreement, the earliest effective date of withdrawal for the US is November 2020.