NEW ZEALAND
PRODUCTIVITY COMMISSION
Te Kōmihana Whai Hua o Aotearoa

Low-emissions economy

Issues paper
August 2017

The Productivity Commission aims to provide insightful, well-informed and accessible advice that leads to the best possible improvement in the wellbeing of New Zealanders. We want to gather ideas, opinions, evidence and information to ensure that this inquiry is well-informed and relevant. The Commission is seeking submissions on the questions contained in this paper by 2 October 2017.

Low-emissions economy

Issues paper - August 2017

The New Zealand Productivity Commission
Te Kōmihana Whai Hua o Aotearoa[1]

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The Commission – an independent Crown Entity – completes in-depth inquiry reports on topics selected by the Government, carries out productivity-related research, and promotes understanding of productivity issues. The Commission aims to provide insightful, well-informed and accessible advice that leads to the best possible improvement in the wellbeing of New Zealanders. The New Zealand Productivity Commission Act 2010 guides and binds the Commission.

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[1] The Commission that pursues abundance for New Zealand

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The issues paper

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

This paper contains specific questions to which responses are invited. These questions are not intended to limit comment. Participants should choose which (if any) questions are relevant to them. The Commission welcomes information and comment on all issues that participants consider relevant to the inquiry's terms of reference.

Key inquiry dates

Receipt of terms of reference:	26 April 2017
Due date for initial submissions:	2 October 2017
Release of draft report:	February 2018
Final report to Government:	30 June 2018

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Why you should make a submission

The Commission aims to provide insightful, well-informed and accessible advice that leads to the best possible improvement in the wellbeing of New Zealanders. Submissions help the Commission to gather ideas, opinions and information to ensure that inquiries are well-informed and relevant, and that its advice is relevant, credible and workable.

Submissions will help shape the nature and focus of this inquiry. Inquiry reports may cite or directly incorporate relevant information from submissions. There will be an opportunity to make further submissions in response to the draft report.

How to make a submission

Anyone can make a submission. It may be in written, electronic or audio format. A submission can range from a short letter on a single issue to a more substantial document covering many issues. Please provide supporting facts, figures, data, examples and documentation where possible. Every submission is welcome; however, identical submissions will not carry any more weight than the merits of the arguments presented. Submissions may incorporate relevant material provided to other reviews or inquiries.

Submissions may be lodged at www.productivity.govt.nz or emailed to info@productivity.govt.nz. Word or searchable PDF format is preferred. Submissions may also be posted. Please email an electronic copy as well, if possible.

Submissions should include the submitter's name and contact details, and the details of any organisation represented. The Commission will not accept submissions that, in its opinion, contain inappropriate or defamatory content.

What the Commission will do with submissions

The Commission seeks to have as much information as possible on the public record. Submissions will become publicly available documents on the Commission's website shortly after receipt unless accompanied by a request to delay release for a short period.

The Commission is subject to the Official Information Act 1982, and can accept material in confidence only under special circumstances. Please contact the Commission before submitting such material.

Other ways to participate

The Commission welcomes engagement on its inquiries. Please telephone or send an email, or get in touch to arrange a meeting with inquiry staff.

1 The inquiry

What we have been asked to do?

The Government has asked the Productivity Commission to undertake an inquiry into how New Zealand can maximise the opportunities and minimise the costs and risks of transitioning to a lower net-emissions economy. The purpose of the inquiry is to "identify options for how New Zealand could reduce its domestic greenhouse gas emissions through a transition towards a lower emissions future, while at the same time continuing to grow incomes and wellbeing" (Terms of Reference, p. 2).

The inquiry task is framed around two broad questions:

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

The Commission's approach

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

Policymakers will also have to make difficult and sometimes controversial choices in order to create a low-emissions economy where we will, overall, be better off. Given that delaying action will result in a more abrupt transition (World Bank, 2015), they will also need to find a path forward that protects vulnerable people, and supports firms and households to adjust in order to make the most of the opportunities that will be on offer.

The two broad questions above suggest a two-pronged, interconnected approach to finding a path to a low-emissions economy. One prong would look at opportunities for emissions reductions across different emitting sources, technologies, and processes in the economy (which are consistent with growth in incomes and wellbeing). This would also identify opportunities arising from a low-emissions transition, such as productivity or intellectual property gains arising from new technologies. The other prong would examine the economic institutions and policy tools that would best encourage and incentivise businesses, households, consumers and government agencies to use these opportunities to move to a low-emissions future.

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

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

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

The scope of the inquiry

This section draws on the Terms of Reference (TOR) to define the scope of the inquiry.

The veracity of climate change

The TOR specifically excludes a focus on the veracity of anthropogenic[2] climate change. New Zealand's international commitments reflect the acceptance by successive Governments of the need to join international efforts to reduce greenhouse gas (GHG) emissions.

New Zealand's commitments to emissions reductions

The TOR asks the Commission to identify opportunities for New Zealand to move to a low-emissions economy while growing incomes and wellbeing. This is in the context of New Zealand's domestic and international commitments "to address the impacts of climate change and to limit the rise in global temperatures" (TOR, p. 1). Under the Paris Agreement, New Zealand has committed to reduce its emissions by 30% below 2005 levels by 2030, and under the Climate Change Response Act 2002, has committed to reduce its emissions by 50% below 1990 levels by 2050 (see Chapter 2).

The TOR asks the Commission to look at the path to a lower *net* emissions economy. In this context "net" refers to total domestic GHG emissions less atmospheric carbon absorbed (primarily, in New Zealand, through growing forests). The Government has not, as yet, formulated a net emissions target for the period beyond 2050. Some commentators on New Zealand's low-emissions pathways envisage, at least in some scenarios, moving to zero net emissions (Generation Zero, 2017; Vivid Economics, 2017). The TOR envisages a further reduction in emissions beyond 2050.

The Commission will therefore adopt a working assumption that New Zealand governments will likely frame targets for beyond 2050 that require significant further GHG emissions reductions over existing commitments (see Chapter 5). However, the TOR exclude an exploration of the suitability of New Zealand's current, or any future emissions reduction target.

[2] Anthropogenic climate change is that caused by humans.

Māori interest and climate change mitigation

Māori collectively have a variety of interests in measures to reduce domestic GHG emissions (Chapter 2). Māori interests are also explicitly recognised in the Climate Change Response Act 2002. The TOR directs the Commission to consult with the Climate Change Iwi Leaders Group:

> The Climate Change Leadership Group …is a national grouping with its membership identified by the Iwi Chairs Forum … which is made up of the Chairs of Tribal iwi Authorities drawn from Iwi throughout New Zealand… (CCILG, 2016, p. 2).

International trading in carbon credits

For a period of time New Zealand was able to acquire specified emissions reduction credits generated in other countries in order to meet its international commitments. While New Zealand closed the New Zealand Emissions Trading Scheme to international emissions units in 2015, the Government currently holds a large stock of accumulated credits that it intends to use to meet its 2020 commitments under the United Nations Framework Convention on Climate Change (UNFCCC).

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

Adaptation to climate change

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

How can the Commission add the most value?

This inquiry will build on a substantial amount of work, both in New Zealand and internationally, that has focused on the issue of how to transition to a low-emissions economy. In New Zealand, key pieces of work or activity include:

- The Royal Society's report, *Transition to a low-carbon economy for New Zealand*. Released in 2016, this report took an in-depth look at sectoral mitigation options for New Zealand and discussed potential emission reduction pathways (RSNZ, 2016).
- *Net zero in New Zealand: Scenarios to achieve domestic emissions neutrality in the second half of the century*, a report by Vivid Economics (2017) that was commissioned by GLOBE-NZ, a cross-party group of parliamentarians. It used scenario analysis to model possible future states of the New Zealand economy that would achieve lower emissions.
- The BusinessNZ Energy Council's (2015) *New Zealand energy scenarios: Navigating energy futures to 2050* generated scenarios for possible energy outcomes under different economic and regulatory conditions.

- Motu's multi-disciplinary programme *Shaping New Zealand's low emissions future* which ran from 2013-2016 and was predominantly aimed at making the New Zealand Emissions Trading Scheme (NZ ETS) more effective.
- The review of the NZ ETS, currently being carried out by the Ministry for the Environment (MfE, 2017g).
- The *Climate Changes, Impacts & Implications for New Zealand* research project funded by the Ministry of Business, Innovation and Employment from 2012-2016.
- Various reports by the Parliamentary Commissioner for the Environment, including on New Zealand's policy framework for climate change (2017), agricultural GHG emissions (2016), biofuels (2010) and solar water heating (2012).
- The work of various Government-coordinated reference groups, such as the Climate Change Forestry Reference Group and the Biological Emissions Reference Group.

Internationally, a vast array of activity is occurring in this area. Particularly relevant reports that the Commission has drawn on for this issues paper include:

- *Decarbonizing development: Three steps to a zero-carbon future* by the World Bank (2015).
- *Investing in climate, investing in growth* by the Organisation for Economic Co-operation and Development (OECD) (2017b).
- *Report of the high-level commission on carbon prices*, led by Joseph Stiglitz and Nicholas Stern (Stiglitz & Stern, 2017).
- The extensive work of the Intergovernmental Panel on Climate Change (IPCC), such as their 2014 Fifth Assessment Report.

The Commission considers that it can add the most value in this inquiry in the following ways:

- providing an independent and robust analysis of whole-of-economy trade-offs based on sound economic analysis;
- developing ways to assess the benefits and costs of different pathways for New Zealand to transition to a low-emissions economy (rather than, for example, providing more or different scenarios of what the future might look like);
- taking a longer-term perspective in identifying policies and institutions that will be required to achieve a low emissions economy that enhances productivity and wellbeing;
- describing what a low emissions economy will mean for the many different businesses and households in New Zealand;
- developing conceptually sound but doable recommendations for change; and
- bringing its expertise and understanding of innovation, and the development, adoption and diffusion of new technologies, in the New Zealand economy to this task.

Q1 **How can the Commission add the most value in this inquiry?**

2 Mitigating emissions in the New Zealand context

The impact of greenhouse gas emissions on the climate

Greenhouse gas (GHG) emissions caused by human activity impact global temperatures (Box 1). The Intergovernmental Panel on Climate Change (IPCC) concludes:

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

These increases in global temperature are causing, and will continue to cause, widespread impacts on humans and natural systems. While the detail of these impacts is uncertain, New Zealand can expect rising sea levels, more frequent extreme weather events such as droughts and cyclones, as well as impacts on human health and wellbeing (Meduna, 2015; MfE, 2017b). Such impacts will have substantial long-term consequences for businesses, communities and the natural environment.

Box 1 **GHG emissions**

How GHG emissions cause temperatures to rise

GHGs trap heat in the earth's atmosphere - a process known as the greenhouse effect. There are several different types of GHGs including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). These gases form a blanket above the earth's surface and prevent the sun's infrared radiation from escaping into outer space. GHGs play an important role in keeping the temperature of the earth's surface sufficiently warm to support human life.

However, the rapid increase in the rate of human-induced GHG emissions is strengthening the greenhouse effect. Many different types of human activity result in GHG emissions, such as using fossil fuels for transport and energy, or deforestation, or farming. Over half of global GHG emissions are CO_2 emissions.

GHGs accumulate in the atmosphere over time. This means that temperature rise depends on the stock of cumulative emissions stored in the atmosphere rather than the flow of emissions at a certain point in time. Indeed, even if net global emissions suddenly dropped to zero, the planet would still feel the impact of historic emissions for centuries to come.

The role of carbon sinks in removing GHGs

While human activity increases the stock of CO_2 in the atmosphere, some natural processes remove carbon from the atmosphere. This process is known as carbon sequestration, and the reservoir where CO_2 is stored is called a carbon sink. Trees are excellent carbon sinks.

They sequester carbon as they grow and store it through the process of photosynthesis. However, once a tree ceases growing, it stops absorbing carbon.

Variation in the impacts of different GHGs

The length of time that GHGs spend in the atmosphere, and the warming impact of GHGs at different points in time, vary. Short-lived gases have a large warming effect immediately after they are released into the atmosphere, but they dissipate quickly. By comparison, long-lived gases, such as CO_2, have a relatively smaller influence on the climate in the short-term, but persist in the atmosphere over much longer timescales, and are the dominant driver of global temperature increase. The variation in the impacts of different GHGs makes adding up the cumulative impact of emissions difficult.

Measuring GHG emissions

A standard metric known as the 100-year Global Warming Potential (GWP_{100}) is used in international agreements to account for the relative contribution of GHG emissions to warming over 100 years. Emissions are typically measured in units of equivalent CO_2 (CO_2e). For example, one tonne of CH_4 will cause roughly 28 times as much as warming as one tonne of CO_2 over 100 years. Therefore, one tonne of CH_4 is equivalent to 28 tonnes of CO_2e. There is an active debate over whether separate metrics or an alternative metric should be used to compare long-lived and short-lived gases.

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

The global challenge of reducing GHG emissions

Substantial and sustained reductions in global GHG emissions are required to limit rises in global temperatures and the harmful impacts of climate change. To have a likely chance of limiting global temperature rise to 2˚C above pre-industrial levels, IPCC scenarios indicate that global anthropogenic GHG emissions need to reduce by 40-70% by 2050, and to close to zero by 2100 (IPCC, 2014).

While some amount of climate change is now unavoidable, allowing global temperature rise to exceed 2˚C risks much more serious and irreversible impacts (IPCC, 2014; Maslin, 2009). Such impacts include: a significant increase in heatwaves and extreme rainfalls; water scarcity; threats to food security; dangerous flooding caused by sea-level rise; and major extinction of species of flora and fauna. The magnitude of changes expected from only a few degrees of global temperature rise are substantial.

Reducing CO_2 emissions to net zero levels is an especially crucial part of stabilising global temperatures (Allen, 2015; World Bank, 2015). This is because CO_2 can stay in the atmosphere for hundreds of thousands of years, contributing to long-term warming. Given the long duration of CO_2 in the atmosphere, it is important to focus on addressing cumulative CO_2 emissions rather than the flow of CO_2 emissions at a certain point in time.

One helpful way of thinking about tackling climate change is the need to keep global cumulative CO_2 emissions within a fixed "carbon budget". A global carbon budget is the quantity of CO_2 that can be emitted before it becomes likely that temperature rise will exceed a certain threshold. The IPCC (2014) estimate that the global carbon budget, as of 2011 and for a 2˚C threshold, is about 1000 Gt of CO_2.[3] In other words, temperature rise will likely exceed 2˚C if cumulative global CO_2 emissions from 2011 onwards exceed 1000 Gt of CO_2. If reductions in global carbon intensity continue at business as usual levels, this budget will be used up by around 2036 (RSNZ, 2016).[4]

In 2015, 195 national governments, including the New Zealand Government, pledged to reduce their country's GHG emissions in a collective effort to keep temperature rise below 2˚C (Box 2).

Box 2 **The Paris Agreement**

At the 2015 United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in Paris, 195 national governments committed to reducing or controlling their national GHG emissions between 2020 and 2030. Collectively, these individual commitments aim to keep temperature increases well below 2˚C, with the goal of limiting temperature increase to 1.5˚C.

To encourage urgent and strong action, the agreement also aims to peak global emissions as soon as possible, as well as achieve net zero emissions – balancing the amount of GHGs emitted into the atmosphere with the amount of GHGs removed from the atmosphere by sinks (eg, forests) – in the second half of this century.

Under the agreement, each government must communicate their Nationally Determined Contribution (NDC) every five years, outlining its country's emission reduction target. These targets are voluntary. However, failing to comply with these targets puts a country at risk of being "named and shamed" by the international community, and suffering reputational damage.

Based on the IPCC's projections, the aggregate emission reductions pledged thus far by all 195 countries will not achieve the 2˚C target. For this reason, countries are expected to set progressively ambitious emission reduction targets beyond 2030. Article 4.1 of the Agreement expresses an expectation that all countries strive to achieve net zero emissions in the second half of this century.

Source: MfE (2016d); UNFCCC (2017)

The Paris Agreement highlights the urgent need for countries to transition their economies to a low-emissions pathway. The speed at which countries make this transition matters a great deal. Because the impacts of climate change depend on the stock of GHGs (in particular CO_2) that accumulate in the atmosphere, delaying action, and deferring mitigation to the future comes at the cost of greater long-term temperature rise, even when the future action is substantial.

[3] IPCC scenarios indicate that cumulative anthropogenic CO_2 emissions from 1880 onwards need to stay below 2900 Gt to limit temperature rise to 2 ˚C with a probability of greater than 66%, taking into account the predicted impact of non-CO_2 gases. By 2011, cumulative emissions totalled approximately 1890 Gt CO_2.

[4] Carbon intensity refers to the amount of CO_2 emitted for a given level of economic output. Business as usual levels correspond to the average carbon intensity reductions that occurred between 2000 and 2014 – 1.3% per year.

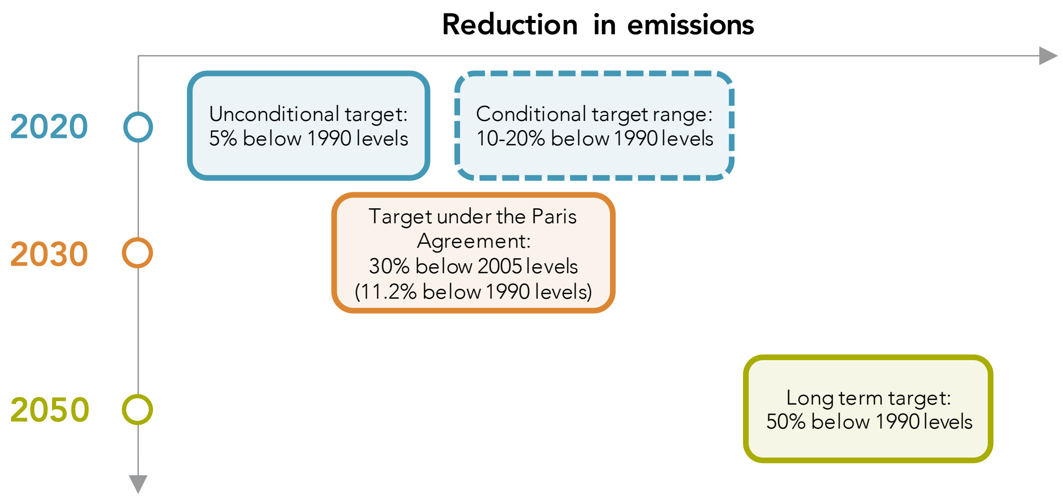
> A delayed mitigation pathway that continues with high annual CO_2 emissions for several years, followed by a rapid decline in the future to reach zero emissions, will contribute more warming than would an early mitigation pathway, with earlier peaking of emissions followed by a more gradual reduction over time, to reach zero emissions that same year (RSNZ, 2016, p. 35).

Delaying action also risks locking in costly long-term investments in high-emitting technologies (see Chapter 5). Moreover, it is likely to exacerbate the economic and social costs resulting from a low-emissions transition, since future emission reductions would need to be much more dramatic and abrupt to compensate for previous emissions (RSNZ, 2016; World Bank, 2015).

New Zealand's commitments to emission reductions

New Zealand has committed to reducing its GHG emissions. Recently, New Zealand submitted its first Nationally Determined Contribution (NDC) under the Paris Agreement to reduce its emissions to 30 percent below 2005 levels by 2030. New Zealand's most long-term target, set in 2011 under section 224 of the Climate Change Response Act 2002, aims to reduce emissions to 50% below 1990 levels by 2050. In total, New Zealand has four national emission reduction targets (Figure 1).

Figure 1 New Zealand's national emission reduction targets



Source: MfE (2017b)

Note: The 2020 conditional target range is subject to a "global agreement that sets the world on a pathway to limit global temperature rise to not more than 2°C, comparable efforts by developed countries, actions by advanced and major emitting developing countries fully commensurate with their respective capabilities, effective rules governing land use, land-use change and forestry (LULUCF)", and "a full recourse to a broad and efficient international carbon market" (Cabinet Office, 2009, p. 1).

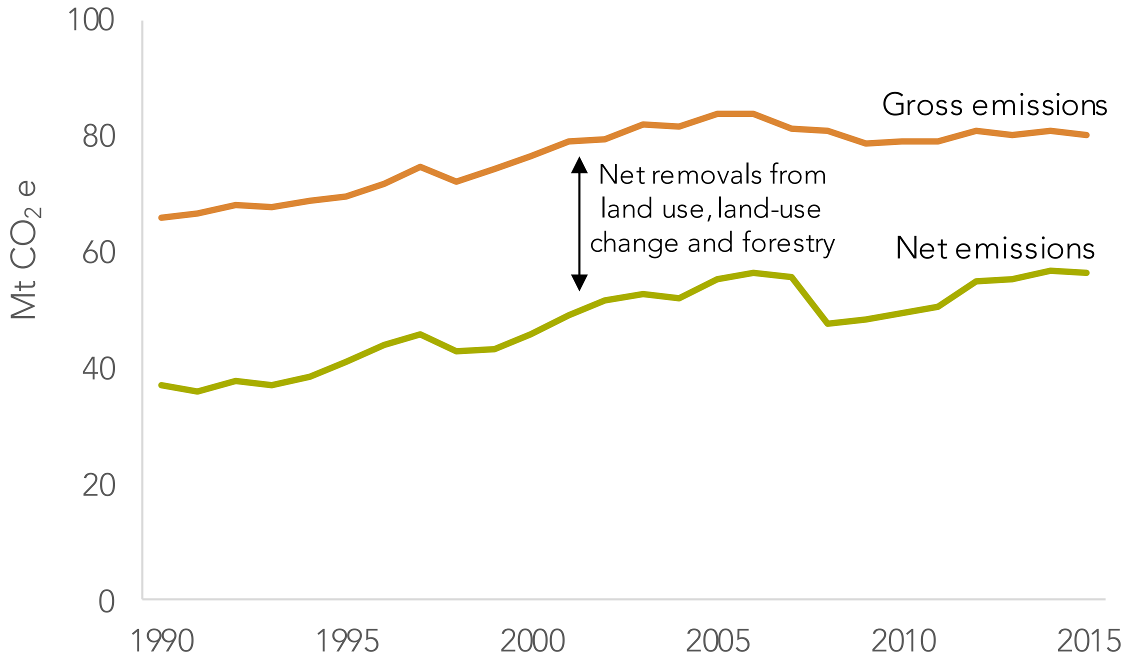
New Zealand's targets are expressed as commitments to reduce *net emissions* relative to *gross emissions* in a baseline year.[5] Under the UNFCCC, gross emissions exclude sources and removals

[5] This approach to emissions reductions is known as a gross-net approach.

relating to land use, land-use change and forestry, nearly all of which comes from deforestation and sequestration of carbon by growing forests.

Since 1990, both New Zealand's gross and net emissions have risen (Figure 2). New Zealand's gross emissions are greater than its net emissions because New Zealand's forests are a net carbon sink. This means that the amount of carbon that forests sequester from the atmosphere exceeds the amount of carbon emitted because of deforestation. Currently, forestry offsets about one third of New Zealand's gross emissions.

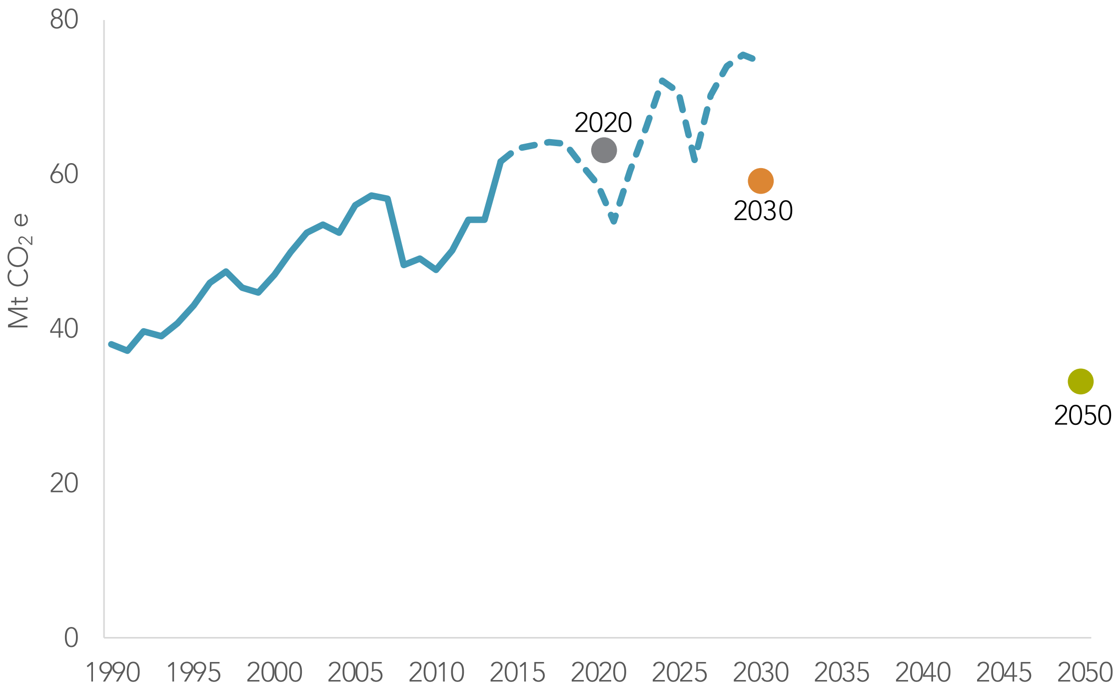
Figure 2 New Zealand's gross and net emissions, 1990-2015



Source: MfE (2017d)

Figure 3 indicates that New Zealand is on track to meet its 2020 target. But, after 2020, net emissions are projected to increase rapidly. One key driver of this increase is the many forests that will reach harvest maturity in the 2020s (Chapter 3). As Figure 3 illustrates, New Zealand will need to reduce its net emissions by roughly 50%, with respect to current emissions levels, to meet its long-term 2050 target.

Figure 3 New Zealand's net emissions from 1990 to 2013, future projections and current emission targets for 2020, 2030 and 2050



Source: MfE (2015a)

Notes:

1. Special accounting rules determine forestry's contribution to meeting New Zealand's targets.[6] These rules are more stringent than the ones used for New Zealand's emissions reporting under the UNFCCC (ie, the emissions shown in Figure 3). For instance, in 2015 New Zealand's GHG inventory reported net removals from forestry of about -24 Mt CO_2 e. Yet only -12 Mt CO_2 e could be counted towards its targets (MfE, 2017e). Consequently, Figure 3 underestimates New Zealand's net emissions, with respect to meeting its targets.
2. The 2020 conditional target range of 10-20% below 1990 emission levels is not shown.

None of New Zealand's targets relate specifically to domestic emissions. New Zealand can meet its commitments by any combination of reducing its domestic gross emissions, increasing its stock of forest sinks, or by acquiring credits from international carbon markets. For the first commitment period of the Kyoto Protocol, a subsidiary treaty of the UNFCCC, New Zealand pledged to reduce its emissions to 1990 levels. Throughout this period, New Zealand accumulated a large surplus of international carbon credits. New Zealand managed to comfortably achieve this target largely by using up some of these credits and by increasing its forestry stock.

Although the Government decided not to sign up for the Kyoto Protocol's second commitment period, New Zealand can use up the rest of the surplus supply of credits from the first commitment period to meet its 2020 target. Thus, New Zealand is projected to comfortably meet its 2020 target, without needing to reduce its domestic gross emissions (MfE, 2017d).

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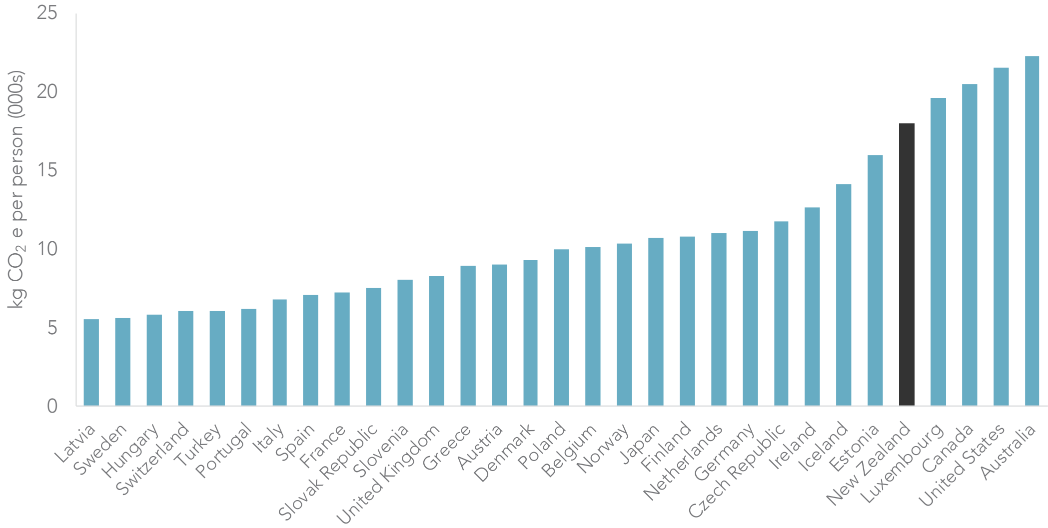
[6] Essentially, only removals of carbon from forestry that occur in forests planted after 1989, which are caused by humans (eg, afforestation), and which would not have occurred in a business-as-usual scenario can be counted towards meeting targets (MfE, 2017d).

New Zealand's emissions profile

New Zealand is a small country and its emissions make up only about 0.15% of the world's total emissions. However, New Zealand's GHG emissions per person are high (Figure 4).

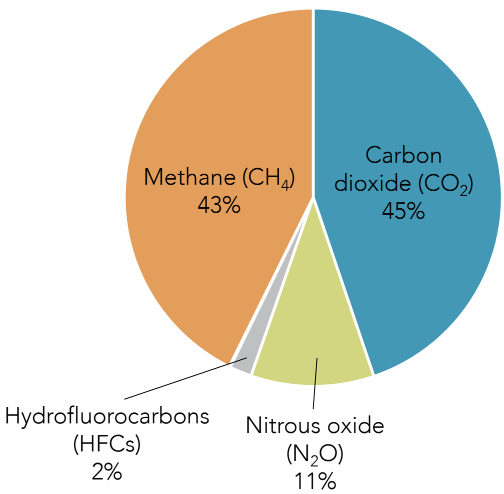
Figure 4 Gross GHG emissions per capita for OECD countries, 2014



Source: OECD (2017c)

The challenge New Zealand faces in mitigating its emissions differs from most other developed countries, due to its unusual emissions profile. For most developed countries, dealing with climate change means focusing on mitigating CO_2 emissions. Yet, over half of New Zealand's emissions are made up of non-CO_2 gases – CH_4 and N_2O – due to its large agricultural sector, and abundant sources of renewable energy for electricity (Figure 5). It is possible that emissions profiles of this character will become more prevalent in other developed countries in the future as energy and transport decarbonisation occurs.

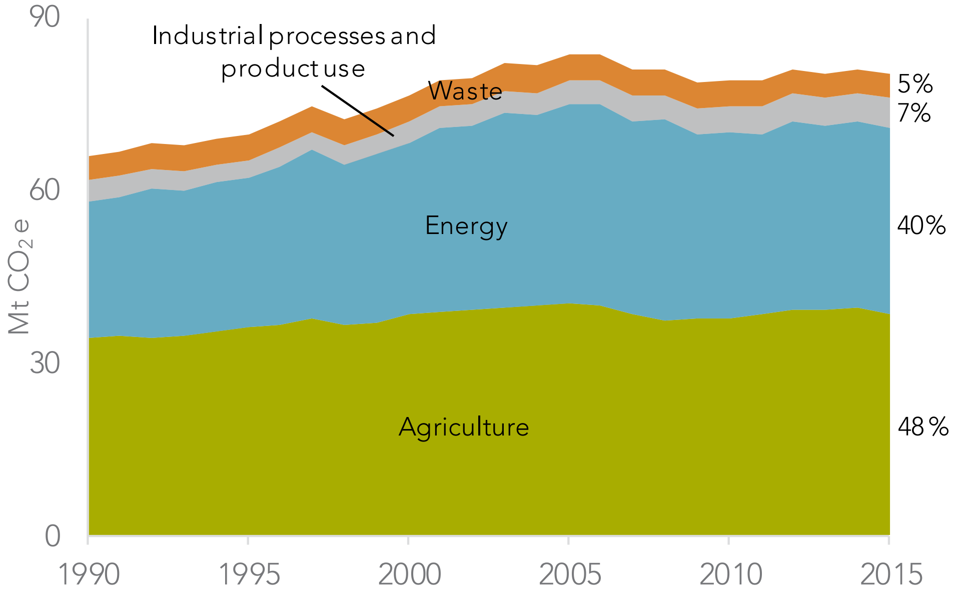
Figure 5 Types of GHG emissions in New Zealand, 2015



Source: MfE (2017d)

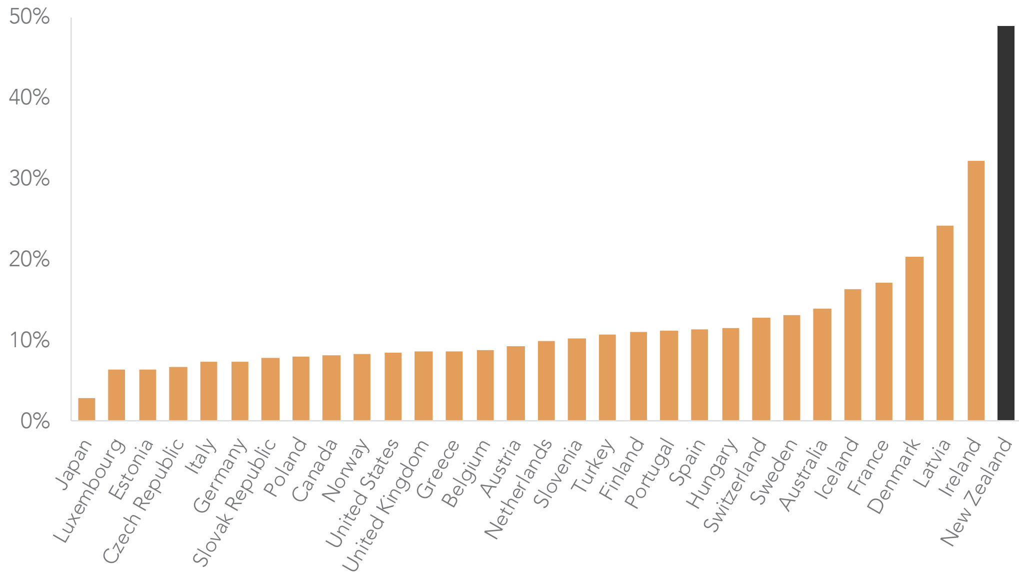
Note: Perfluorocarbons and sulfur hexafluoride together accounted for approximately 0.1% of emissions.

Figure 6 Sources of New Zealand's GHG emissions by sector, 1990-2015



Source: MfE (2017d)

Figure 7 Agricultural emissions as a percentage of gross emissions across OECD countries, 2014



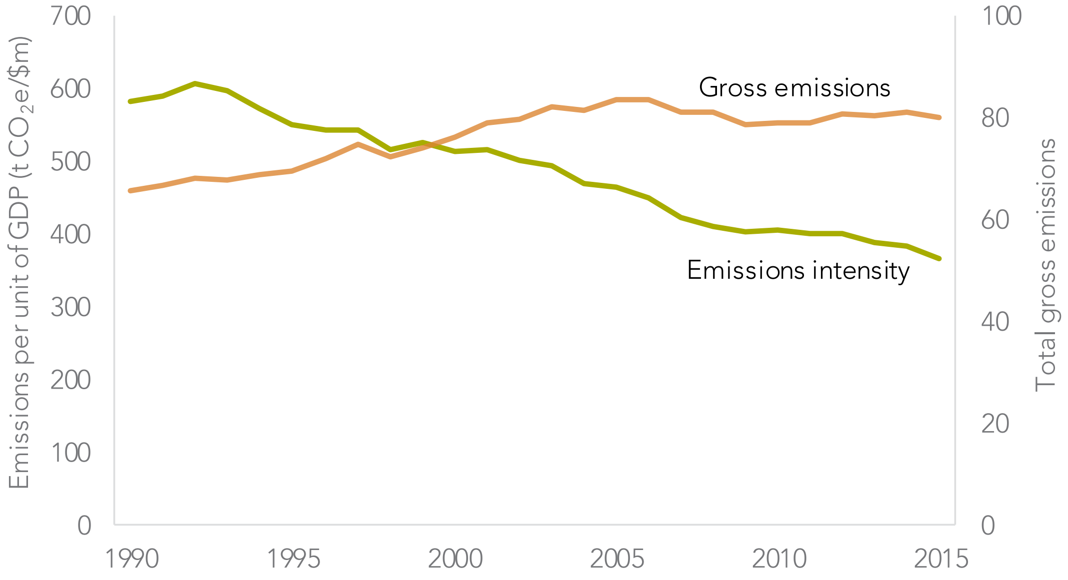
Source: OECD (2017c)

Nearly half of total emissions come from agriculture (Figure 6) – considerably more than any other developed country (Figure 7). About 76% of agricultural emissions are CH_4 gases, while around 21% are N_2O gases (MfE, 2017d). Sheep and cattle are responsible for nearly all these emissions (Chapter 3).

This is not to say that CO_2 is not important in the New Zealand context. Energy emissions (mostly CO_2) make up 40% of New Zealand's emissions. This mainly comprises emissions from transport, producing industrial heat, and generating electricity (Chapter 3). Between 1990 and 2015, energy emissions increased by over 36%. New Zealand's plentiful sources of renewable energy have however limited the increase in energy emissions. Around 85% of New Zealand's electricity is generated using renewable sources, particularly hydro and geothermal power. Overall, roughly 40% of New Zealand's energy is generated using renewable sources.

The story differs when thinking about emissions intensity – this refers to the emissions produced per unit of gross domestic product (GDP). Despite recent increases in overall emissions, New Zealand's emissions intensity fell by about 35% between 1990 and 2015. Technological advancements, particularly in energy efficiency and agricultural productivity, and greater use of renewable energy help to explain this fall. The fact that total emissions have risen in part reflects economic and population growth increasing the overall demand for fossil fuels.

Figure 8 New Zealand's gross emissions intensity and gross emissions, 1990-2015



Source: Productivity Commission analysis of Statistics New Zealand (2017b) and MfE (2017e) data

New Zealand's current approach to emission reductions

New Zealand's policy response to climate change strongly reflects its position as a small, trade-reliant country, with a unique emissions profile compared to other developed countries. As discussed above, New Zealand has relied heavily on international trading of carbon credits to deliver its emission reduction contributions. The Government has stated its intention to contribute its "fair share" to tackle climate change, to the extent that its relative costs of mitigating domestic emissions match other developed countries (New Zealand Government, 2015). The Ministry for the Environment points to New Zealand's high proportion of biological and transport emissions, and its limited scope for further decarbonisation of the electricity sector. It argues that:

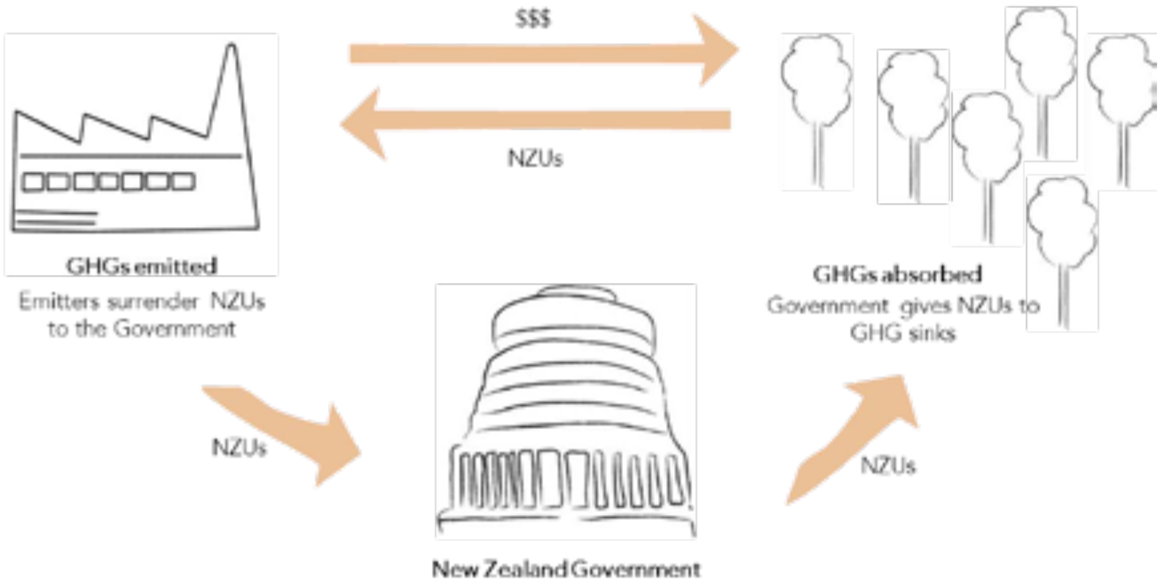
> [t]hese features of New Zealand's national circumstances mean that the cost of mitigation is likely to be higher for New Zealand than for most other developed countries. Remaining competitive with trade partners, while taking responsibility for emissions reductions targets will therefore present a challenge for New Zealand and has shaped New Zealand's approach to addressing its emissions (MfE, 2015a, p. 46).

The New Zealand Emissions Trading Scheme (NZ ETS)

The New Zealand Emissions Trading Scheme (NZ ETS) is the Government's principal response to climate change. Established under the framework of the 2002 Climate Change Response Act, the NZ ETS commenced in 2008. It currently requires the energy, fishing, forestry, industrial processes, liquid fossil fuels (ie, transport fuels), synthetic gases, and waste sectors to report on, purchase and surrender emissions units to the Government (MfE, 2015b).

Under the NZ ETS, New Zealand Units (NZUs) each represent one tonne of carbon dioxide equivalent (CO_2e). The scheme covers carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs). Participants must surrender one NZU for a certain amount of CO_2e emitted, eg, one NZU per tonne of CO_2e emitted. Participants can purchase NZUs from the Government at NZ$25 per NZU. The Government provides credits in the form of NZUs to eligible forestry activities that operate as carbon sinks (Figure 9).

Figure 9 The basic structure of the NZ ETS



Source: MfE (2015b)

Allocations of NZUs differ according to participant firms' activities and is determined under the Climate Change Response (Moderated Emissions Trading) Amendment Act 2009. Trade-exposed and emissions-intensive industries receive free allocations of between 60 to 90% of their requirements as determined by the Climate Change (Eligible Industrial Activities) Regulations 2010. This system is designed to maintain the international competitiveness of New Zealand production and to prevent emissions leakage (see also Chapter 5).[7]

[7] Emissions leakage, in essence, refers to the situation whereby the introduction of emissions restrictions in location A can provide the incentive for high emissions production to move to location B to avoid those restrictions.

The point of obligation – the point at which the scheme participant is required to monitor and surrender NZUs – differs for each participant sector but in general, is upstream (eg, fossil fuel producers or importers) rather than downstream (eg, consumer-level).[8] For example, in the industrial processes sector the point of obligation is at the point of production of the good in question (eg, aluminium), and in the waste sector it sits with landfill operators.

Māori and climate change mitigation

Māori collectively have a variety of interests in measures to reduce domestic emissions. First, like other New Zealanders, they face the potential harms caused by climate change. In particular, many Māori communities and marae are located on the coast and at risk from sea-level rise and storm surges – identified as the primary impact of climate change in New Zealand (Meduna, 2015). Many Māori support New Zealand joining with other countries to take measures to reduce emissions and mitigate the potential future effects of climate change (CCILG, 2016).

Second, Māori have Treaty of Waitangi interests in the protection of their ancestral lands and waterways, and more broadly the natural environment, expressed in the values of kaitiakitanga. Kaitiakitanga "denotes the obligations of stewardship and protection … [and] is most often applied to the obligation of whānau, hapū and iwi to protect the spiritual wellbeing of natural resources within their mana" (New Zealand Law Commission, 2001, p. 40). Measures to reduce GHG emissions aimed at mitigating the negative effects of climate change are likely also to have benefits in protecting the health (mauri or life-supporting properties) of New Zealand's lands, forests and waterways. The Paris Agreement specifically recognises the rights of indigenous peoples (CCILG, 2016). Māori interests in climate change mitigation are explicitly recognised in the Climate Change Response Act 2002.

Third, land, and forest land in particular, features in settlements of historic Treaty claims. Policies to reduce agriculture emissions and sequester carbon in forest could potentially affect the value of land and forests. Consistent with this, iwi had a particular interest in the design of the NZ ETS and its bearing on past and future Treaty settlements (Indigenous Corporate Solutions, 2008; Insley & Meade, 2008).

Fourth, irrespective of Treaty settlements, Māori own significant tracts of agricultural land and forests (relatively more of the latter) (Insley & Meade, 2008). Measures to reduce emissions that affect the use of agricultural land and forests are therefore of particular interest to iwi and Māori communities.

Fifth, Māori are over-represented among low income households, who may be more vulnerable and less resilient to potential increases in fuel and food prices arising from measures to reduce emissions (CCILG, 2016).

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

3 Emissions sources and mitigation opportunities

This chapter looks across the economy at the sources of emissions and the technologies and processes that appear to offer significant opportunities to reduce emissions. The analysis is preliminary mainly because, in many areas of the economy, the nature, cost and efficiency of technology that could lower emissions is changing rapidly. Moreover, currently unknown technology could quickly overtake options that look promising right now (Chapter 5). Fifty years ago, in 1967, no-one could have predicted the pervasive and disruptive technologies that have since emerged, or easily have taken the possibilities into account in their decisions.

New technologies will be a central part of a transition to a low-emissions economy. Yet New Zealand is relatively slow to adopt the best new technology from overseas and New Zealand firms are slow to adopt the technology used by the leading New Zealand firms in their industry (Conway, 2016). A key question is how to encourage businesses, households and consumers to create, find and utilise promising new technology, and to choose the most efficient means (over time and across the economy) of mitigating emissions (Chapter 4).

Emissions sources, technologies and processes

The *New Zealand Greenhouse Gas Inventory* (MfE, 2017d) defines sectors by sources of emissions.[9] The inventory provides detailed analysis that gives an in-depth picture of the technologies and processes that produce emissions (Figure 10). This information helps to identify the current and likely future availability of practical and cost-effective methods of significantly reducing emissions, as well as their relative importance in doing so.

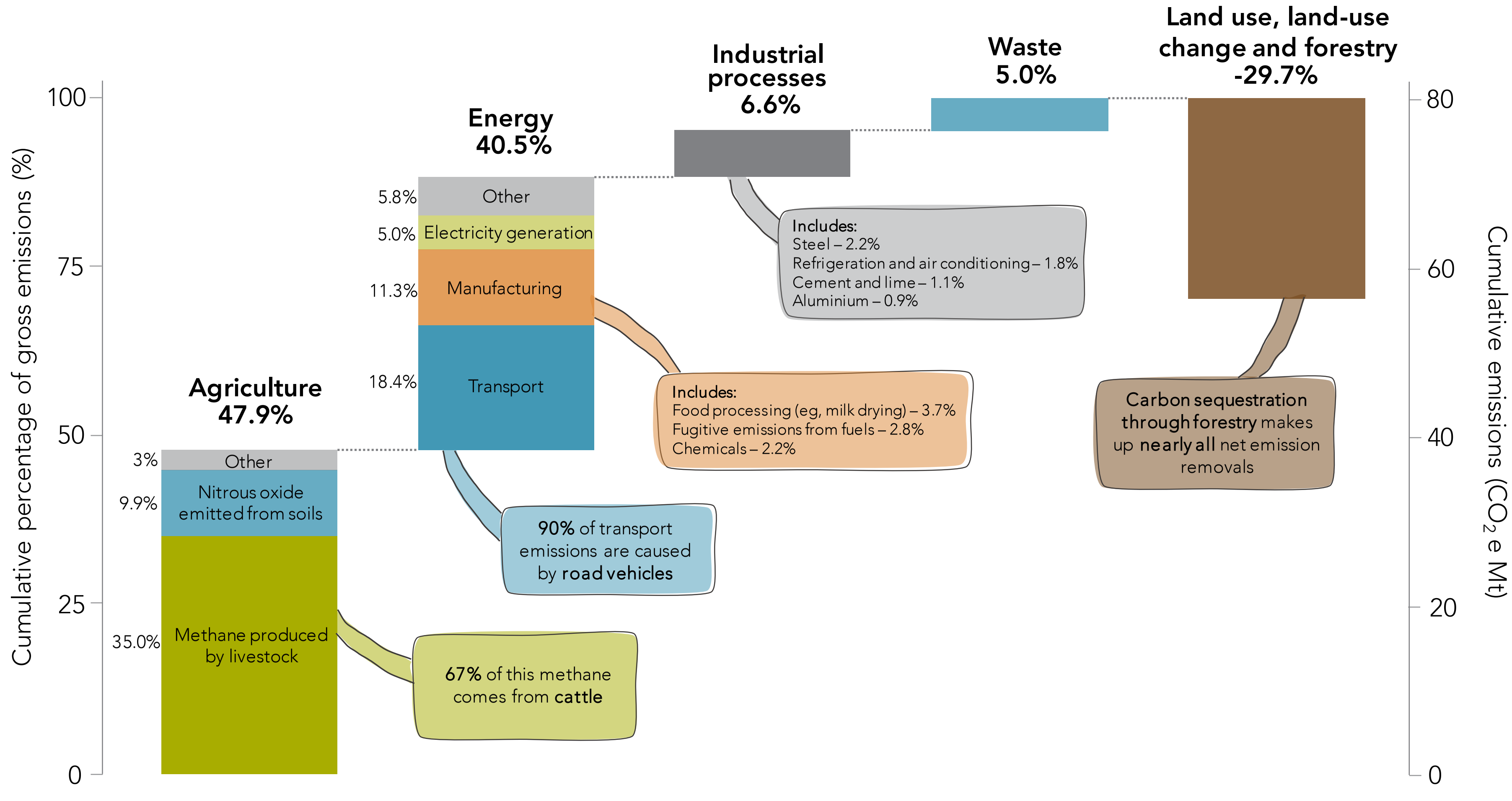
Figure 10 shows that agriculture is the largest source of emissions (primarily methane). The second largest source is transport – particularly road transport. Together, these sources account for two thirds of emissions. Forestry sequesters almost 30% of gross emissions.

While these data account for emissions by source, it may be useful to also consider derived demand. For instance, buildings use materials which, through their production, generate emissions. The design of buildings affects the efficiency with which energy is used; and the owners and occupiers of buildings choose sources of energy for space heating which may or may not use fossil fuels. Buildings are discussed below.

Similarly, it could, for example, be useful to look at consumption choices, their effect on the demand for emissions and the policies and instruments that affect those choices; or the design of cities and effects on demand for transport, and the choice of transport modes.

[9] The inventory is based on international definitions of sectors and methodologies.

Figure 10 GHG emissions and removals by source, 2015



Sources: MfE (2017d, 2017f)

Note: Emissions from industrial processes excludes emissions from the generation of energy to power those processes.

Q2 **Chapter 3 of this issues paper mostly looks at ways to reduce emissions directly at their source. What other approaches would help identify opportunities to effectively reduce emissions?**

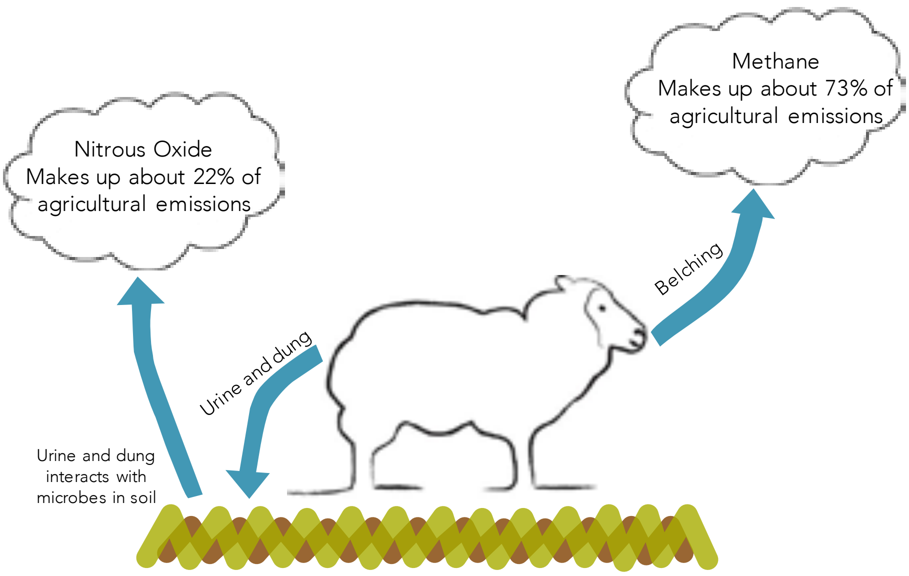
Agriculture

Agriculture plays an important role in the economy. Pastoral agriculture, the main source of agricultural emissions, contributes approximately 3% of GDP.[10] Dairy, sheep and beef together accounts for around 40% of New Zealand's goods exports (Statistics New Zealand, 2017a).

Agriculture accounts for nearly half of New Zealand's total emissions, high for a developed country (Chapter 2). However, New Zealand is recognised as being one of the lowest emitters of agricultural emissions, per unit of agricultural output (PCE, 2016).

Most of New Zealand's agricultural emissions are methane (CH_4) and nitrous oxide (N_2O) gases produced biologically. Livestock, such as sheep and cattle, cause nearly all these emissions. These animals burp CH_4 gases that are produced in their stomach as they digest their food through enteric fermentation. Also, the urine and dung that farm animals excrete and fertilisers applied to pastures interact with microbes in soil to produce N_2O (Figure 11).

Figure 11 How livestock emit greenhouse gases



Source: Based on PCE (2016)

Opportunities and challenges for reducing emissions

Approaches to reducing agricultural emissions include:

- improving farm-management practices;

[10] Pastoral agriculture comprises sheep, beef and dairy cattle farming; and grain, poultry, deer and other livestock farming.

- targeting the amount of CH_4 an animal produces in its rumen;
- reducing the amount of nitrous oxide emitted from soils; and
- reducing livestock numbers (see discussion of land-use change below).

Improving farm-management practices, such as making changes to feeds, stocking rates and fertiliser application, offers a low-cost way of achieving modest reductions in biological emissions. Modelling suggests this can reduce emissions by 10% on some farms, and increase farm productivity and profitability (PCE, 2016).

New Zealand is at the fore of international research on low-cost ways of reducing emissions from animals. Several promising technologies are in development (Box 3).

Box 3 **Potential technologies to reduce New Zealand's biological emissions**

- *Methane vaccine* – a vaccine that triggers an animal's immune system to generate antibodies that suppress the CH_4-producing methanogens in an animal's rumen.
- *Methane inhibitor* – a chemical compound fed to an animal to target the methanogens by either killing them, or depriving them of the hydrogen they need to produce CH_4.
- *Targeted breeding* – identifying genes unique to animals that naturally emit lower levels of methane to selectively breed low-emitting sheep and cattle.
- *Nitrogen inhibitor* – a chemical compound applied to pastures to slow the process of nitrification in soils, and thus reduce the loss of N_2O.
- *Low-emission feed* – identifying, and genetically modifying feeds that reduce an animal's CH_4 and N_2O emissions (eg, increasing the fat content in an animal's feed to reduce CH_4 emissions).

Source: NZAGRC and PGGRC (2014), PCE (2016)

Some hold the view that a methane vaccine has the greatest potential to reduce emissions.

> Development of a vaccine could have the single greatest impact on agricultural emissions… If a vaccine is successfully developed and demonstrated, with the right policy support for dissemination, it could have a major impact on New Zealand's agricultural emissions profile (Vivid Economics, 2017, p. 58).

> A methane vaccine would be so valuable that the research aimed at developing it should be ramped up as much as possible (PCE, 2016, p. 83).

Moderate emissions cuts are possible from certain agricultural technologies (eg, low-emission feeds). However, a low-cost technology that delivers dramatic reductions in biological emissions appears far off, and may not emerge. While a methane vaccine could reduce CH_4 emissions by up to 40%, no successful trials of such a vaccine have so far occurred (PCE, 2016). The process from initial concept of a technology to commercialisation is typically long and complex. Even once a technology proves technically effective, scientists and farmers must consider its cost-effectiveness, impact on farm productivity, risk of facing consumer resistance, and how easily it can be integrated into New Zealand's farming system (PCE, 2016).

At present, New Zealand farmers bear no cost for their emissions and so have no financial incentive to reduce emissions, beyond adopting practices that increase their profitability. Barriers, such as the high upfront costs of mitigation and exposure to international competition, also discourage mitigation (Vivid Economics, 2017).

The environmental co-benefits from reducing agricultural emissions are significant. For example, reducing N_2O emissions could potentially substantially reduce nitrate leaching from soils and improve the quality of freshwater bodies (Vivid Economics, 2017).

Current policy and options

If New Zealand successfully develops and commercialises a low-cost technology for mitigating biological emissions, this could be used to achieve emissions reductions here and sold or licensed for international use. New Zealand invests significantly in developing technologies to reduce agricultural emissions.

- The New Zealand Greenhouse Gas Agricultural Research Centre was formed in 2009 to research ways to reduce CH_4 and N_2O emissions, while improving productivity. The Government has invested over $43 million in this research, for the ten years to 2019.
- The Government helped establish the Global Research Alliance (GRA) on Agricultural Greenhouse Gases, to find ways to lower GHG emissions in the production of food. New Zealand has contributed $65 million to fund the GRA's activities between 2010 and 2020.

The Government also recently set up the Biological Emissions Reference Group (BERG) to build a robust evidence base around the opportunities to mitigate on-farm emissions. The Group will publish a synthesis report in late 2017.

Putting a financial cost on agricultural GHG emissions should, in theory, incentivise farmers to reduce them (Chapter 4). There is an ongoing and active debate in New Zealand over whether and how to do this. The New Zealand Emissions Trading Scheme (NZ ETS), for instance, could require individual farms to surrender units corresponding to their on-farm emissions.

The technical feasibility and economic costs of monitoring on-farm emissions may make including agriculture in the NZ ETS at the farm level impractical. Current technologies may not be able to accurately measure biological emissions and a farm's incremental emission reductions. There are also questions around the cost of monitoring on-farm emissions. The BERG is currently investigating the suitability of existing tools used to estimate farm emissions (MPI, 2017a). Recently, Fonterra committed to undertaking similar work (DairyNZ, 2017).

Q3 **To what extent is it technically and economically feasible to reliably measure biological emissions at a farm level?**

Q4 **What are the main opportunities and barriers to reducing emissions in agriculture?**

Land-use change

Given feasible technologies and farm management practices, agriculture will always produce some emissions (RSNZ, 2016). Forestry, discussed below, is a comparatively lower-emissions land use. It has the added benefit of sequestering carbon while trees grow and reducing erosion and siltation of waterways. Horticulture would also produce lower emissions than agriculture, while potentially being an equally productive and profitable use of land in some areas. A switch to horticulture could also improve freshwater quality, depending on the specific crops and farm management practices, such as use of sprays and fertilisers.

Changing the use of agricultural land is largely in the hands of private owners. The economics of changing to another use will depend on factors such as the price of the land and its suitability for other uses. The availability of downstream processing infrastructure, supply chains and marketing; the availability of knowledge, skills and technology to support the alternative land use; and the prospective price in world markets for the produce are also important. New Zealand's existing investments in agricultural capacity and highly productive pastoral management could weigh against change. On the other hand, the possible emergence of synthetic milk and meat on the global market could disrupt existing patterns of agricultural production (Scott, 2017). Obviously, a price on agricultural emissions would also affect the economics of alternative land use.

Owners and processors may need a long lead-in time to make the investments required to enable alternative profitable use of land. If the incentives for changing land use were altered by government policy (for instance by placing a price on agricultural emissions), government may also have a role in easing the transition. This could be, for example, through supporting research and development, marketing and skills acquisition. The sector, itself, through leading producers and industry organisations, is also likely to develop strategic responses to changing economic conditions.

Q5 **What are the issues for government to consider in encouraging alternative low-emissions land uses?**

Forestry

Indigenous forests cover 29% of New Zealand's land area, while a further 8% is planted in commercial forests (MfE, 2017d). For the purposes of GHG emissions accounting, mature forests that replenish themselves naturally, and commercial forests that are harvested and equivalently replanted, are carbon neutral (on natural forests see Holdaway et al., 2016).[11]

New Zealand's forests currently sequester carbon that offsets 30% of gross GHG emissions, or around 23 mt CO_2 each year (MfE, 2017d). Yet, between 2000 and 2015 the area of commercial forests declined from 1.77 to 1.72 million hectares (RSNZ, 2016). In 2015 only around 2 400 hectares of new forests were planted, while over 5 400 hectares of forest land was converted to other uses (MfE, 2017d). The Royal Society concludes that "[r]ecent new forest planting rates in New Zealand have been too small to significantly offset future CO_2 emissions" (RSNZ, 2016, p.

[11] In practice, the sequestration of carbon over time, and so carbon neutrality, will depend on what happens to wood once it is harvested, and, particularly the durability of wood products.

148). The relative profitability of pastoral agriculture, the availability of cheap international carbon credits and a low domestic carbon price are likely to have contributed to an increase in deforestation and a reduction in new forest plantings over this period. Importantly, many forests planted in the early 1990s are reaching maturity and when harvested will significantly increase emissions (at least as currently accounted for in New Zealand's inventory).

Indigenous forests are more expensive to plant (than exotic) (Carver & Kerr, 2017). If left to regenerate naturally, their growth is slow, and pest control is needed (RSNZ, 2016). Regenerating indigenous forests are currently sequestering around 6 mt CO_2 per year (MfE, 2017d). Indigenous forests help maintain biodiversity, provide increased habitat for other indigenous fauna and flora, and afford important cultural and aesthetic benefits, particularly to tangata whenua (Carver & Kerr, 2017).

Opportunities and challenges for reducing emissions

At present, "[e]stablishing new forests is currently the only large-scale mitigation option that can easily be implemented to sequester large amounts of carbon dioxide from the atmosphere" (RSNZ, 2016, p. 148). A number of studies have identified the potential, though the size of effects varies across studies and the assumptions used (RSNZ, 2016).

Mason and Morgenroth (2017), for example, identify 1.3 million hectares of highly erodible land that could be used for planting forests. Planting would require "minimal" livestock reductions and would have co-benefits in reducing erosion and siltation of waterways (p. 13). The study models planting of different species and assesses the carbon sequestered over 60 years, assuming planting 50 000 hectares each year for 26 years. If radiata pine were planted and left, New Zealand could be completely carbon neutral for part of the period. Growing forests could offset as much as 80 million tonnes of CO_2e in a year as sequestration reached a peak.

The economics of afforestation depend on the price and type of land used, the particular planting and management regime, the carbon price, and the prospective price of forestry products and the products of alternative land uses. On some marginal lands the most profitable approach, depending on the carbon price, may be simply to plant and leave radiata pine to grow and eventually revert to native forests as native species re-establish naturally (Mason & Morgenroth, 2017). In the long-run carbon sequestration will reach a limit as economically viable land for new forests is used up (RSNZ, 2016; Vivid Economics, 2017).

Current policy and options

Participation in the ETS is mandatory for pre-1990 planted forests, and voluntary for post-1989 forests (if the owners have entered into a forest sink covenant under the Forests Act 1949).

Three government programmes currently encourage afforestation.

- The Afforestation Grant Scheme gives foresters $1 300 for every hectare of new forest planted. The scheme aims to achieve 15 000 hectares of new plantings between 2015 and 2020.
- The Permanent Forest Sinks Programme grants New Zealand Units under the NZ ETS to foresters who plant new permanent forests. They can sell these credits to other NZ ETS participants or surrender them if they need to pay for their own emissions.
- The Erosion Control Forest Programme was established in Gisborne in 1992 and provides grants that can be used to plant trees or encourage natural reversion to native bush.

During 2015 and 2016 the Government undertook a review of the NZ ETS. The review included a particular focus on forestry. Some submitters argued that reducing liabilities at harvest, for instance by accounting for average harvesting and replanting over time, would reduce the risks of entering the scheme for small foresters and be simpler to comply with (MfE, 2016b). Averaging would mean that foresters would not have to surrender units at harvest, provided forest is re-established on the land. The rules could also potentially recognise the carbon that continues to be stored in short- and long-lived harvested wood products (MfE, 2016c).

The complexity of the NZ ETS rules make it unattractive for small-forest owners (post-1990) to participate (Carver & Kerr, 2017). Counting rules mean that technically relevant plantings (eg, riparian plantings of less than 30m width) are not included. New technology would allow finer scale definition of forests plantings for the purpose of the NZ ETS. Yet a number of issues stand in the way of doing so. Incentivising such planting outside of the NZ ETS might be preferable (Carver & Kerr, 2017).

A substantial increase in afforestation might involve greater use of permanent forest sinks in remote areas unsuitable for harvesting. The conditions to make this commercially viable need further examination. A possible variant is for Government to play a greater role in promoting the establishing of such forests on suitable parts of Crown land.

The Commission welcomes submissions on these issues. Submitters may draw on their previous submissions on the 2015/16 NZ ETS review.

Q6 **What are the main barriers to sequestering carbon in forests in New Zealand?**

Q7 **What policies, including adjustments to the New Zealand Emissions Trading Scheme, will encourage more sequestering of carbon in forests?**

Transport

Transport is the second biggest source of emissions in New Zealand, making up around 19% of gross emissions. Road vehicles are responsible for over 90% of transport emissions. Nearly all emissions directly caused by households come from vehicles (Concept Consulting Group, 2016). Mitigating these emissions will also reduce emissions that harm health, such as carbon monoxide and nitrogen dioxide.

New Zealand's level of vehicle ownership is among the highest in the world. In addition, New Zealand's light vehicle fleet is one of the oldest among developed countries (MoT, 2015). Older vehicles tend to emit more than newer vehicles.

Opportunities and challenges for reducing emissions

The largest reductions in transport emissions will likely come from two main areas:

- switching from liquid fossil fuels to renewable sources of energy (particularly using electric vehicles); and

- reducing the use of vehicles and improving the efficiency of transport systems through, for example, intelligent transport systems and greater use of public transport.

Electric Vehicles

Electric vehicles (EVs), powered by batteries, offer by far the greatest opportunity to reduce transport emissions in New Zealand. An EV does not directly produce any GHG emissions while it is on the road.[12] Indirect emissions depend on the extent to which electricity used to charge batteries is generated from fossil fuels. New Zealand is particularly well placed to benefit from the use of EVs because of its abundant sources of renewable energy.

Figure 12 provides a breakdown of some of the strengths and weaknesses of EVs as a mitigation option; and the barriers to, and possible opportunities to improve, the uptake of EVs.

Figure 12 Summary of the strengths, weaknesses, barriers and possible opportunities associated with the uptake of EVs

Strengths	Weaknesses	Current barriers	Possible opportunities
• Proven to substantially reduce emissions, compared with internal combustion vehicles (ICVs) • EVs already used in NZ • Similar road performance to an ICV • Substantially cheaper to use than an ICV (equivalent to about 30c per litre) • Electricity grid already established • Most of New Zealand's electricity is generated using renewable energy • Able to charge EVs by plugging in at home • Cost of EV battery likely to fall dramatically over time	• Developing on-road charging infrastructure is expensive • At present, smaller travel range than an ICV • Manufacturing an EV battery produces higher emissions than manufacturing an ICV • Charging of EVs adds demand to the electricity grid • Currently slower to recharge an EV than to refuel an ICV • Disposal of EV batteries can cause negative environmental impacts	• Currently more expensive to purchase an EV than an equivalent ICV • Absence of policy measures that properly price or regulate the adverse effects of ICVs • Public perception of electric vehicles (eg, range anxiety) • Lack of charging infrastructure, and varying recharging standards • Limited range of EV models available in New Zealand	• Measures to encourage the growth of publicly available charging infrastructure • Greater price pressure on fuels through the NZ ETS • Basing vehicle registration fees on a vehicle's emissions potential • Minimum vehicle emissions standards • Improving awareness and education around EVs • Government subsidies • Electrification of government vehicle fleet

Source: Barton and Schütte (2015); Concept Consulting Group (2016); EECA (2017); RSNZ (2016)

The number of EVs registered here rose from 350 in May 2014 to over 3 800 (about 0.03% of the light vehicle fleet) in June 2017. More than half are imported used cars.

The Government aims to improve public awareness and perception around EVs, and facilitate the development of the charging infrastructure. The 2017 Electric Vehicles Programme sets a target of 64 000 vehicles on the road by 2021. Policies to support this include:

- a contestable fund of up to $6 million per year to support low emission vehicle projects;
- investing $1 million annually in a nation-wide EV information and promotion campaign; and

[12] The manufacturing of lithium-ion batteries that power EVs is a source of CO_2 emissions (Concept Consulting Group, 2016). However, these embodied emissions are not attributed to New Zealand because EV batteries are manufactured overseas.

- exempting light and heavy electric vehicles from road user charges until they make up 2% of their respective vehicle fleets.

Q8 **What are the main barriers to the uptake of electric vehicles in New Zealand?**

Q9 **What policies would best encourage the uptake of electric vehicles in New Zealand?**

Other transport mitigation opportunities

The use of biofuels as a substitute for petrol and diesel could complement EVs in reducing vehicle emissions. The Ministry of Business, Innovation and Employment (MBIE) (2015) notes that a typical blend of biofuel leads to a 5-6.5% reduction in GHG emissions per litre of fuel compared to regular fuels. While traditional sources of biofuel have limited supply (PCE, 2010), new technologies for producing biofuels from sources including wood and agricultural wastes hold potential (RSNZ, 2016).

Hydrogen fuel-cells are another low-emissions technology that could become important in transport. Compared to EVs, hydrogen-powered cars are quicker to refuel and have a longer range. While it is technically possible to use biomass or renewable electricity to produce hydrogen, currently manufacturers generally use fossil fuels to do so. The establishment of infrastructure to supply hydrogen around the country is also likely to be expensive (AA Motoring, 2015; Harwell, 2015; Reidy, 2017).

Barton and Schütte (2015) suggest that approaches to encourage the use of lower-emissions vehicles could include:

- basing vehicle registration fees on a vehicle's emissions; and
- setting fuel efficiency standards. New Zealand is one of the very few developed countries without such standards, requiring only fuel efficiency labels on vehicles.

Heavy vehicles contribute about 22% of transport emissions and are more difficult to electrify. Vivid Economics (2017) argues that switching freight from road transport to rail or coastal shipping is a relatively low-cost way of mitigating emissions produced by heavy vehicles.

Emissions from trains currently make up only 0.2% of New Zealand's total emissions. While some train lines are electrified, most use diesel locomotives. The costs of electrifying are likely to be high (Vivid Economics, 2017).

In addition, improving the efficiency of the transport system and reducing the use of cars can reduce emissions and lower levels of traffic congestion. Intelligent transport systems that use traffic information and data in order to smooth traffic flows, and the further development of autonomous vehicles can play a role in mitigating emissions. Switching modes of transport towards public transport, cycling and walking, and increasing the use of novel car-sharing technologies, will help to reduce car usage (RSNZ, 2016). Encouraging individuals to cycle and walk more also has potential health benefits.

Q10 **In addition to encouraging the use of electric vehicles, what are the main opportunities and barriers to reducing emissions in transport?**

Energy for manufacturing

Around 11% of New Zealand's GHG emissions arise from using fossil fuels in manufacturing, particularly to produce process heat (for instance, in the drying of milk powder, or the production of chemicals).[13] Fossil fuels generate around 68% of industrial process heat (RSNZ, 2016).

Opportunities and challenges for reducing emissions

Better energy efficiency (at the same time raising productivity) and a shift away from fossil fuels are the main options for reducing emissions from energy used in industry.

Manufacturers could improve energy efficiency through employing technologies such as:

- integrated control systems, using sensors to adapt process conditions;
- sub-metering (monitoring energy used by specific equipment or parts of a plant); or
- better flue-gas monitoring for boilers and dryers.

Yet the benefits of lower emissions will not materialise without substantial further innovation and commercialisation effort (ICF International, 2015).

Broad scope exists to switch from fossil fuels to renewable energy to generate process heat. For instance:

- Asaleo Care, in partnership with a Ngāti Tuwharetoa Trust, began using geothermal steam to produce tissue paper at Kawerau in 2010, resulting in a 46% reduction in GHG emissions (GNS Science, 2017); and
- Wood Energy South, a Venture Southland and EECA initiative, aims to establish new commercial and industrial heating systems fuelled by wood and woody biomass (Wood Energy South, 2017).

Yet providing adequately high process heat from renewable energy is a major challenge for some manufacturing. The calcination of lime to make cement, for example, requires very high heat (in excess of 850°C), making the use of electricity impractical. Biomass, waste and other renewable sources can produce high process heat of up to 1 300˚C. Yet, to be cost competitive with fossil fuels, such technology requires "major technology and supply chain improvements" (ARENA, 2017). A recent New Zealand initiative will use waste tyres to produce the heat required to make cement (Box 4).

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[13] This excludes any fossil fuels used to generate electricity that is used in manufacturing.

Box 4 **Burning tyres to make cement**

In June 2017, the Government announced funding of $18.6 million to shift the heat source for the production of cement from coal to waste tyres (Smith, 2017).

New Zealand generates approximately 5 million unwanted tyres a year, making them a viable ongoing industrial fuel source. The substitution of rubber biofuel for coal by one of the major grant recipients, Golden Bay Cement (New Zealand's fifth largest single emitter of GHGs), will reduce emissions by 13 000 tonnes a year. Golden Bay Cement will burn 3.1 million waste tyres a year – the equivalent of taking approximately 6 000 cars off the road.

This funding is a good example of public intervention to address a one-off market failure (private sector unwillingness to invest in technology that provides a public good) in order to stimulate the transition to a low-emissions economy.

The Royal Society estimates that GHG emissions from industrial process heat could be reduced by approximately 35% by 2035 through improving energy efficiency and greater uptake of renewable energy (RSNZ, 2016). Reducing the use of fossil fuels in industry will improve air quality and have health benefits as a result (Hasanbeigi et al., 2013).

Current policy and options

The government currently has a target to reduce industrial emissions by at least 1% each year between 2017 and 2022, with a particular focus on process heat (MBIE, 2017b).

Emissions intensive and trade exposed industries are freely allocated the majority of their NZU requirements under the NZ ETS to support their international competitiveness and prevent leakage of production and emissions offshore. These allocations are based on the emissions arising both from energy use (including electricity) and from industrial processes (discussed below). Emitters still face the marginal cost of their emissions and so have incentives to reduce them. If free allocations were removed, some high emitters could exit the market altogether. Chapter 4 discusses this policy further.

The Energy Efficiency and Conservation Authority (EECA) works directly with large energy users, and through energy management experts with medium-sized businesses, to promote more efficient and lower-emissions energy options. EECA provides advice to other businesses through industry associations and web-based information and tools (EECA, 2017).

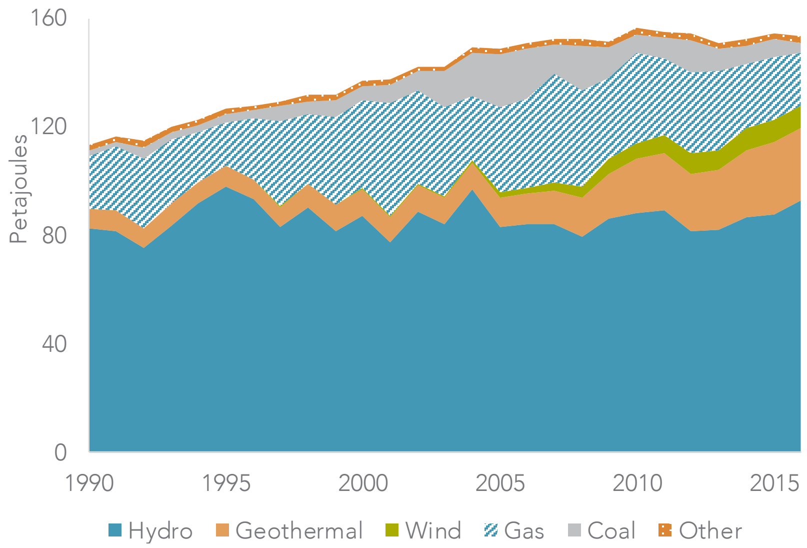
Q11 **What are the main opportunities and barriers to reducing emissions from the use of fossil fuels to generate energy in manufacturing?**

Electricity generation

In 2016, 85% of New Zealand's electricity was produced from renewable sources, mostly hydro (MBIE, 2016b). Electricity generation from fossil fuels produces around 5% of New Zealand's GHG emissions. Coal-fired stations, mostly used to meet peak winter loads, produce 70% of these emissions, with gas-fired stations producing the remainder. Coal is much more emissions intensive than gas. Despite accounting for only 30% of emissions, gas produced more than three times as much electricity than coal in 2015 (MBIE, 2016a). Two major gas plants were closed in 2015, and Genesis Energy has announced that the gas and coal-fired Huntly Power Station is expected to close in December 2022.

Total electricity generated rose strongly in the decade to 2004 but has grown only slowly and unevenly since then. From around 2005 there have been increases, from relatively low bases, in the proportion of electricity generated from geothermal and wind energy (Figure 13). The proportion fluctuates from year to year, depending on hydrological conditions and the subsequent use of fossil fuels to meet peak loads.

Figure 13 Sources of electricity generation in New Zealand, 1990-2016



Source: MBIE (2016b)

Homes consume 32% of all electricity and commercial buildings and institutions (such as schools and hospitals) roughly a further 24%.[14] The production of basic metals (predominantly aluminium) uses 16%. Primary industry and manufacturing use the remaining 28% (MBIE, 2016a).

Opportunities and challenges for reducing emissions

A switch from fossil fuels for transport, space heating, and industrial process heat, will result in a much greater proportion of New Zealand's demand for energy being met from electricity in the future. There are no technical barriers to the generation of more electricity from renewable sources. The relative cost and efficiency of renewables, such as wind power, now make them a price competitive option (Concept Consulting Group, 2016; RSNZ, 2016). Complementary technologies, particularly batteries, are also falling in price. New Zealand's seasonal pattern of demand favours more use of wind than solar power.

Concept Consulting shows that wind generation could meet all the increased demand from the uptake of EVs in the period up to 2040, with charging of EVs at times of the day when there is

[14] The "commercial" sector in this data includes the service industries (such as wholesale, retail, transport, finance, telecommunications, education and health) and government.

lower grid demand (ie, late at night). In the Concept Consulting model of the energy sector, the storage capacity of hydro generation complements wind generation. If hydro is used to meet daily fluctuations in demand, then wind generation in aggregate (ie, multiple wind farms) can operate in baseload mode (Concept Consulting Group, 2016; see also RSNZ, 2016).

Increased reliance on renewable sources of electricity will pose challenges for New Zealand's current regulatory, institutional and infrastructural arrangements for the supply of electricity.

- Relying on fossil fuels to meet infrequent peak "dry-year" loads in a system supplied primarily from renewable sources may become commercially unviable or require payments to hold peak generating capacity (RSNZ, 2016). The Royal Society even suggests that some form of government ownership might be required "solely for security of supply" (2016, p. 86). Some models suggest that supply reliability in dry years could be managed through renewables (Mason et al., 2013), but the commercial viability of this is also uncertain.
- Increased "spilling" of energy sources (such as water and wind) and lower load factors, especially in summer, might entail greater generating costs per unit of electricity delivered (RSNZ, 2016).
- Distributed generation and the possible use of batteries to even out peak load, and of EVs as "batteries", are likely to require more flexible pricing and network technical capabilities than now. This may require "smart grids …linked with small local generation systems, smart-meters, intelligent appliances with fast response times" (RSNZ, 2016, p. 86).

Using "time-of-use" pricing to manage demand, particularly the timing of charging of EVs, could help raise average demand relative to peak, thus reducing the need for daily peaking capacity. This would support more efficient use of generating capacity. In 2014, peak demand was 45% higher than average demand (RSNZ, 2016).

Q12 **What changes will be required to New Zealand's regulatory, institutional and infrastructural arrangements for the electricity market, to facilitate greater reliance on renewable sources of energy across the economy?**

Another issue for the future is that climate change may affect sources of renewable electricity generation, for instance, by altering wind, solar and hydrological patterns.

Q13 **What evidence is there on the possible physical effects of future climate change on sources of renewable energy in New Zealand, such as wind, solar and hydro power?**

Current policy and options

The government has announced a target to increase the proportion of renewable electricity generation to 90% by 2025 (in an average hydrological year) (MBIE, 2017b).

Policies to reduce emissions from electricity generation cover improving energy efficiency, and increasing renewable electricity generation. Examples of each include:

- efficiency performance standards under the Energy Efficiency and Conservation Act 2000, and regulations mandating labelling of appliance energy efficiency; and
- creation of the National Policy Statement for Renewable Electricity Generation 2011 under the Resource Management Act 1991 to support, and provide guidance on the consenting of, renewable electricity projects.

As discussed above, future policy to facilitate greater reliance on renewable sources of electricity will likely require significant changes to the regulation and operation of electricity market.

Q14 **Apart from the regulation and operation of the electricity market, what are the main opportunities and barriers to reducing emissions in electricity generation?**

Industrial processes and products

Industrial processes and product use produce around 7% of New Zealand's gross emissions (5.3 Mt CO_2e) (MfE, 2017d). This is different from and in addition to any emissions from the production of energy for manufacturing (see above). The main GHGs directly emitted by industry are CO_2 (two thirds of emissions), followed by hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

The metal industry, mostly iron, steel and aluminium production, contributes the majority of industrial emissions (about 3% of New Zealand's total). Carbon, in the form of coal, is used as a reductant in producing iron and steel; while aluminium production, though powered by renewable energy in New Zealand, requires the oxidation of carbon anodes. For every tonne of aluminium produced, approximately 1.5 tonnes of CO_2 are produced (Alamdari, 2017).

The next biggest source of industrial emissions comes from HFCs used to replace ozone-depleting substances in refrigeration and air conditioning. Increased demand for air conditioning due to rising average temperatures will likely mean these emissions will remain a substantial proportion of New Zealand's industrial emissions profile. The calcination of limestone at high temperatures in the manufacture of cement and lime produces just over 1% of all New Zealand's GHG emissions.

Opportunities and challenges for reducing emissions

The emissions from industrial processes and products are intrinsic to the physical processes involved in production and in product use. Existing plants (such as steel mills and aluminium smelters) use technologies founded on these physical processes.

In the long run, new low-carbon technologies to produce these materials or shifting end use to other (perhaps new) low-carbon products, may be possible. For instance, in some countries by-products from steel making or from burning coal to make electricity are used to make cement, instead of using calcinated lime. New York is using ground glass from waste for the same purpose (Hawken, 2017). These alternatives may not be relevant in New Zealand, but technology could evolve to produce options that work here.

One other option, suitable to single-point sources of significant carbon emissions such as steel, aluminium and cement manufacture, is carbon capture and sequestration (CCS) (RSNZ, 2016).

CCS involves capturing, compressing, transporting and permanently storing CO_2 in porous rock. Yet CCS is an expensive and complex process that requires a large upfront capital outlay followed by high operating costs, including potentially high energy needs. The carbon price needed for a retrofitted CCS project to break even is $125 per tonne of CO_2e (Transfield Worley, 2011). There are 22 large-scale CCS projects globally either in existence or under construction. Yet, given the small quantity of point-source industrial emissions in New Zealand, large-scale investment in CCS is likely to remain economically unviable in the near future (MBIE, 2017a).

Q15 **What are the main opportunities and barriers to reducing emissions in industrial processes (such as the production of steel, aluminium and cement) and in product use (such as the use of hydrofluorocarbons in refrigeration and air conditioning equipment)?**

Buildings

The commercial and residential sectors account for 2% of emissions (excluding those attributable to the use of electricity).[15] A large proportion of these emissions arise from the use of fossil fuels for space heating of buildings. While this is a small proportion of all emissions, the design and operation of buildings is important because:

- buildings are long lived, so that most of the 2050 building stock already exists, and small reductions in annual emissions will accumulate over the lifetime of a building;
- building materials (particularly steel, cement and harvested wood) incorporate significant emissions from a range of sources;
- careful design, including retrofitting of existing buildings, can yield significant energy efficiency gains;
- cost-effective options for renewable sources for space heating are readily available;
- improving the energy efficiency of buildings has co-benefits of improved comfort and health for occupants; and
- consumers and workers spend large periods of their life in buildings – the low-emissions design and heating of buildings can likely help engage citizens in the wider project of building a low-emissions economy.

Households and businesses are using less coal and more gas and electricity to heat buildings (RSNZ, 2016). In addition, they have been using less energy on average for each building (RSNZ, 2016), though the number of buildings and total energy used is rising with population increase.

Opportunities and challenges for reducing emissions

Little data is available to estimate potential mitigation from buildings, or the costs and priorities (RSNZ, 2016). Reductions in emissions could be achieved through:

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[15] Including those attributable to electricity use, commercial and residential buildings are responsible for around 20% of New Zealand's energy related emissions, or 8% of total emissions (RSNZ, 2016).

- design of new buildings for better energy performance (through insulation; or orientation and materials to support passive heating and cooling) and incorporating low-emissions building materials;
- design of new buildings to promote more energy efficient use of the building (for instance in the location and salience of stairs);
- retrofitting existing buildings to achieve greater energy efficiency;[16] and
- more use of renewable sources of energy for heating (such as Christchurch Airport's use of geothermal heat exchange).

Current policy and options

The New Zealand Building Code sets out energy efficiency standards. Yet the Royal Society argues that they "should be made far more stringent than they currently are, given that a new building will be consuming energy over its 50 year or more lifetime" (2016, p. 114).

Subsidies to improve building energy efficiency (and also obtain health and other benefits) are another possible approach. The Warm Up New Zealand programme, which provided subsidies for the retrofitting of home insulation, has now been discontinued.

There are voluntary schemes to improve building energy efficiency. For example:

- Green Star is a tool that rates and communicates the sustainability of New Zealand's commercial buildings, under the auspices of the New Zealand Green Building Council (NZGBC, 2017); and
- NABERSNZ is "a system for rating the energy efficiency of office buildings. It is an independent tool, backed by the New Zealand government" (NABERSNZ, 2017).

The Royal Society proposes education and training on low-emissions options for people designing, constructing, installing and using buildings (RSNZ, 2016).

Q16 **What policies and initiatives would best promote the design and use of buildings that produce low greenhouse gas emissions?**

Waste

Waste is the smallest of the broad sources accounted for in New Zealand's emissions greenhouse gas inventory, producing 5% (4.1 Mt CO_2e) of gross emissions (MfE, 2017d). Solid waste disposal produces most of these emissions. Emissions peaked in the early 2000s and have decreased since then, mostly due to better landfill management practices such as CH_4 recovery.

[16] For example, Conservation House in central Wellington was redeveloped from a disused cinema complex around 2006, receiving the Property Council of New Zealand Commercial Office Energy Efficiency Award in 2007 (Architecture+, 2017). The renovation of Te Puni Kōkiri House, a commercial building in Wellington, resulted in a 30% reduction in energy use (NABERSNZ, 2017).

Opportunities and challenges for reducing emissions

New Zealand's waste emissions per person are the second highest compared to other developed countries, suggesting significant opportunities to lower emissions, particularly from landfills. There has been a 93% decrease in the number of municipal waste sites since 1971 (MfE, 2017d), but a substantial number of small, unmanaged waste sites remain (including on-farm waste disposal known as farm fills). These contribute the majority of the CH_4 emissions from solid waste disposal and are not subject to the NZ ETS (MfE, 2017d). Better CH_4 capture technologies or inclusion in the NZ ETS could help to reduce emissions.

There is scope to reduce emissions by disposing of biodegradable waste in other ways (eg, by composting or separate food waste collection in urban areas). However, care must be taken in the design of alternative waste disposal mechanisms – for example, transport emissions from additional organic waste collections may be higher than the original emissions from landfill disposal (Lundie & Peters, 2005).

Avoiding the creation of waste is the most effective way to reduce emissions – especially given that disposal of commercial waste in New Zealand costs approximately $100 per tonne (Nana et al., 2011; UNEP, 2010). The next step down the "waste hierarchy" is re-use. Reusing what is considered waste in one sector as an input in another sector or product is an important component of what is known as the circular economy. This is one where "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (European Commission, 2015, p. 2). Making cement from tyres (Box 4) and generating electricity from waste (Box 5) are examples of the circular economy.

Box 5 **Generating electricity from waste**

Nana et al. estimated in 2011 that up to 630 000 MWh per year of renewable electricity could be produced from waste in New Zealand. This included using effluent from the meat and dairy sectors, with the subsequent 1 petajoule[17] of methane biofuel sufficient to replace 2% of the current national power production from natural gas (Nana et al., 2011).

Burning waste to produce electricity is known as waste-to-energy (WtE). The Buller District Council is proposing a $250 million WtE plant in Westport to encourage employment and reduce emissions (Buller District Council, 2016). Source materials for WtE plants include domestic waste, timber processing residues, or bio-solids. WtE is generally more costly in the short term as compared to landfill. However, in the longer term, and depending on system characteristics (such as the distance between the WtE plant and the waste source), the potential emissions reductions benefits and co-benefits can make WtE plants an attractive economic proposition (Assamoi & Lawryshyn, 2012).

While domestic waste is commonly used in WtE plants internationally, public acceptance and consenting processes under the Resource Management Act make this difficult in New Zealand (EFI, 2008). Incorporating the emissions reduction potential of an activity as part of the consenting process could help to address this issue.

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[17] A petajoule is a unit of energy. One petajoule equals one quadrillion (10^{15}) joules, or approximately 163,400 barrels of oil.

Current policy and options

The New Zealand Waste Strategy (MfE, 2010) aims to reduce the harmful effects of waste and improve the efficiency of resource use. While the Strategy identifies the Climate Change Response Act 2002 as a key part of the toolkit for managing and minimising waste in New Zealand, the Waste Minimisation Act 2008 itself does not mention climate change or GHG emissions. Legislation could provide better guidance on the role of the circular economy and other approaches to reducing emissions in waste disposal.

Government policy already provides some support for acquiring lower-emissions technology (eg, Box 4). It could also directly encourage research and development, and subsequent practice improvements. For example, Queensland University of Technology, in conjunction with Meat & Livestock Australia, is leading an A$14 million publicly-funded project to develop profitable processes for turning livestock industry wastes into bioenergy and bioproducts (Queensland University of Technology, 2017).

Under the Waste Management Act, all territorial authorities must review their waste management and minimisation plans every six years. The Government could provide better guidance through dissemination of information on best available technology, similar to that produced by the European Commission for waste incineration and treatment (EC JRC, 2017).

Q17 **What are the main opportunities and barriers to reducing emissions in waste?**

Cross-cutting issues

Innovation and technology diffusion

The majority of the opportunities to transition to a low-emissions economy covered in this chapter involve either the search for and creation, or the commercialisation and diffusion, of new technologies. In some areas, such as ways of reducing agricultural emissions, New Zealand is a world leader, building on its long experience in agricultural research and production. In other areas, for instance electric vehicles, New Zealand is a technology taker, with a major task being the creation of an infrastructure that will support rapid uptake. In many other areas, such as the generation of process heat from renewable sources, and improving energy efficiency, the successful diffusion of known technologies across firms and households is key.

Examining the conditions for New Zealand to perform well in creating and utilising world-leading technology across the economy will be a central aspect of a transition to a successful low-emissions economy (Chapter 4). The Commission has previously looked at these conditions in the context of achieving New Zealand's productivity potential (Conway, 2016).

Linkages across emissions sources, technologies and processes

Policies and interventions to reduce emissions in some parts of the economy can have flow on effects for demand and opportunities to reduce emissions in other parts of the economy. Policy makers will need to consider these interactions in finding an efficient pathway to a low-emissions economy.

For instance, conversion of the vehicle fleet to electricity will increase the demand for electricity generation. This in turn will increase the demand for new renewable sources of energy, if New

Zealand is to meet its mitigation targets. Effects of EVs on the overall demand for renewable electricity, could, in turn be managed through timing the charging of EVs, and the possible use of EVs as "batteries" to store electricity for sale back to the grid (Massey, 2013; RSNZ, 2016). Increasing the energy efficiency of buildings will lower the demand for electricity, but substituting electricity for fossil fuels to heat buildings will increase the demand.

Another example follows from including some land-based industries in the NZ ETS (forestry) but excluding others (agriculture). Foresters and others argue that this exclusion distorts choices away from other potentially economically viable uses of land that could produce lower net emissions (PCE, 2016; RSNZ, 2016).

Forests could be used to produce a renewable source of woody biomass to generate heat for industry or biofuels (RSNZ, 2016). Fonterra is investigating the former for its milk drying operations (Fonterra, 2016). Norske Skog Tasman and Z Energy recently investigated the latter possibility in New Zealand. The evaluation concluded that, while technically feasible, using biomass to produce fuel was of doubtful commercial viability given "the current global economic and energy outlook" (Martin Jenkins, 2015, p. 2). The commercial viability of using biomass for energy requires low-value feedstocks (whether from forests or otherwise), very short transport lines, and efficient digestion of biomass.

Using biomass to produce energy could be combined with carbon capture and sequestration (CCS). This involves growing plant material, burning it for energy and then capturing the CO_2 emissions with future potential for achieving negative emissions (EPTP & ZEP, 2012). Yet currently and in the near future, using biomass with CCS is commercially challenging because of its high costs (Venton, 2016).

Q18 **Policies to lower emissions from particular sources, technologies and processes can have interactions with emission sources in other parts of the economy. What are the most important interactions to consider for a transition to a low emission economy?**

Costs of abatement and an effective price of carbon

This chapter has identified a range of ways in which emissions from particular sources could be reduced by changes in technology, changes in energy sources and through shifts in production to other products. Current emissions are spread unevenly across different parts of the economy. In turn, different emissions sources offer more or less feasible and more or less costly opportunities to reduce emissions. The next chapter considers policies and instruments that will guide choices of the most efficient way to reduce emissions across the economy.

A key policy approach to achieving efficient reductions across the economy is to place a price on carbon (Chapter 4). The NZ ETS intends to price carbon to encourage businesses and households to choose low-emissions options (Chapter 2). Yet so far, the current price of New Zealand Units in the scheme has been too low to influence behaviour (MfE, 2017e). A low carbon price has contributed to many of the opportunities identified in this chapter not being actively pursued.

4 Policies and institutions

"Core" policies identified by the Commission relevant to addressing climate change are direct regulation, market-based approaches, support for innovation and technology, and a variety of other approaches (such as providing green infrastructure). These policies all require supportive institutions to, for example, enforce regulatory standards and shape behaviour, monitor emissions, organise research funding, or direct finance towards low-emissions technologies.

Direct regulation

By identifying what is permitted and what is illegal, direct regulation defines the way in which a policy goal will be achieved (McManus, 2009). Regulations are made up of:

- "commands" in the form of detailed and comprehensive rules of behaviour; and
- "controls" to enforce the regulation, including punishments for failure to comply.

Standards are a fundamental part of direct regulation in the context of environmental policy.

- Ambient standards specify the amount of a pollutant permitted within a specific environment eg, the amount of a GHG in the atmosphere expressed in parts per million.
- Emissions standards specify the amount of emissions that can be released by a particular agent or unit eg, by an individual firm or a single vehicle. They are sometimes referred to as performance or outcome standards because they focus on a desired level of performance or achievement rather than prescribing how the standard should be achieved.
- Technology standards force the use of a specific type of technology, technique or practice to reduce emissions eg, using scrubbers on industrial smokestacks (Asafu-Adjaye, 2005).

Direct regulation is a well-established foundation of many countries' environmental policies. For example, ambient and technology standards underpin the United States' 1963 Clean Air Act designed to combat air pollution. However, few countries have implemented direct regulations solely in order to reduce GHG emissions. Climate change benefits largely accrue as a positive side-effect from other main policy goals (such as reducing energy demand).

Direct regulations may work against a low-emissions transition. For example, in the UK, emissions performance standards exist that allow for the operation of gas-fired power stations without carbon capture until 2045. White (2014) claims these standards are a clear threat to the feasibility of achieving the UK's emissions reductions targets.

To effectively implement direct regulations, regulatory institutions must exist to, among other tasks, specify standards, monitor their effectiveness towards achieving the policy goal, and ensure that minimum standards are being met (NZPC, 2014b). For example, the key regulatory institution responsible for the 2007 Land Transport Rule on Vehicle Exhaust Emissions (Table 4-1) is the New Zealand Transport Agency (NZTA). NZTA develops specific elements of the Rule (such as making amendments to reflect new technologies) and ensures that vehicle inspectors and inspecting organisations are adequately certified and registered to enforce the Rule.

Table 4-1 highlights some of the main advantages and disadvantages of direct regulatory approaches, and provides some New Zealand and international examples.

Table 4-1 Advantages, disadvantages and examples of direct regulation

Advantages	Disadvantages	Examples
• Establishes simple, direct, certain and easily understandable goals that can be precisely tailored to specific circumstances • Can be quicker to implement, especially if inadequate information on firms' behaviour is available to develop a market-based approach • Often easier to monitor and enforce, using random monitoring in conjunction with large potential penalties to discourage non-compliance • Particularly suitable when firms are less responsive to price signals, when direct monitoring and enforcement of all firms is difficult, when abatement costs are homogeneous, or limited technology exists to achieve required emissions reductions	• Inflexible (doesn't achieve emissions reductions at overall least cost to the economy) • Can limit innovation by specifying particular technologies or ways of achieving the policy goal, and because no incentive exists to reduce emissions beyond a specified minimum standard • Can be challenging for regulators to obtain adequate information to set accurate and innovation-forcing minimum standards • Open to distortionary lobbying	• The 2007 Land Transport Rule, Vehicle Exhaust Emissions sets vehicle exhaust emission standards for new and used vehicles entering the fleet • France is banning the sale of petrol and diesel cars by 2040 • The Energy Efficiency and Conservation Authority (EECA)'s Equipment Energy Efficiency Programme comprises minimum energy performance standards and mandatory energy performance labelling • The UK Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 requires mandatory reporting of GHG emissions in annual directors' reports or strategic reports

Source: Asafu-Adjaye (2005); Coglianese et al. (2002); IPCC (2007); NZPC (2014b)

Q19 **What type of direct regulation would best help New Zealand transition to a low-emissions economy?**

Market-based approaches

Market-based approaches identify and make explicit the source of so-called "negative externalities" (in this case, GHG emissions). This is so that economic activities resulting in GHG emissions created by one person or firm are paid for by that person or firm, and not by society as a whole (Heal, 2017).

A key way of addressing negative externalities is by giving them a price so that the "polluter pays" for their emissions. Under a market-based approach, putting a price on emissions should encourage participants to look for and use the most efficient way of reducing emissions. This will result in the lowest cost ways of abating emissions being implemented across the economy. Costs to reduce emissions will differ depending on the type of technologies used, the activities of a firm, or the quantity of emissions needing to be abated.

To enact a market-based approach, there are three main types of instruments: taxes or charges based on emissions volumes, subsidies, and transferable permit schemes.

Taxes and charges

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

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

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

Subsidies

Subsidy mechanisms aim to incentivise emissions reductions through rewarding certain behaviours or activity, and include tax exemptions, financial subsidies (such as preferential financing or credit guarantees), and feed-in tariffs.[18]

Subsidies, such as those for fossil fuel exploration and investment, can work against reducing emissions (Chapman, 2015; OECD, 2017b).[19] Not putting a price on a negative externality is, in effect, a subsidy from a social good point of view – that is, by not requiring an emitter to face the full cost of their actions, society is effectively subsidising their actions.

Transferable permit schemes

Transferable permit schemes work by setting a cap on the total quantity of allowable emissions, with participants trading emissions allowances amongst themselves. This means that if

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

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

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

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

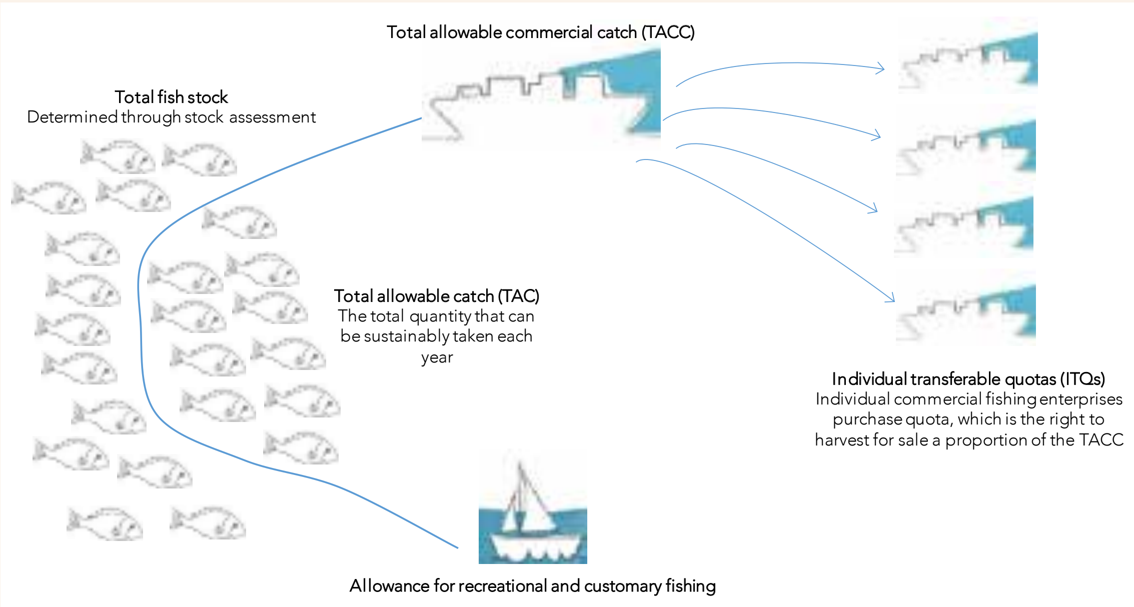
Transferable permit schemes therefore effectively create a property right in relation to a permitted level of emissions (Nielson, 2010). Box 6 describes how a property right has been created as part of a transferable permit system for New Zealand's fishing industry.

Box 6 **Fisheries and individual transferable quotas**

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

The ITQ system is part of a wider quota management system based on the principle of achieving a maximum sustainable yield (MSY). With reference to environmental, economic and social factors, every year the Minister of Fisheries sets an annual total allowable catch (TAC) for each fish species within each fisheries management area of New Zealand's exclusive economic zone. The level of the TAC is designed to sustain the MSY for each species, and is further specified into a total allowable commercial catch (TACC) – this is the TAC minus allowances for recreational and Māori customary fishing (Figure 14).

Figure 14 Simplified model of the quota management system



Source: MPI (2017b)

Each TACC is divided into ITQs that may be held by individuals or companies, and which has an associated annual catch entitlement. This entitlement is the amount of a particular species that can be fished each year by the ITQ owner. Quotas are allocated to each fisher and, with minor exceptions, quota holders may trade their quotas within the TACC for each species (Lock & Leslie, 2007). There is no centralised trading exchange, with quota holders free to buy and sell quotas without restriction.

Concerns about certain aspects of the ITQ system have been raised, such as aggregation of quota by large companies and subsequent exclusion of smaller fishers, with impacts on local communities (Gibbs, 2008). Yet, on balance, analysis suggests that the positives of the system have considerably outweighed any negatives (Mace et al., 2014).

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

Without a property right, there is the potential for a "tragedy of the commons". This is a negative externality that occurs when many people have rights in common to use property, rather than the exclusive rights of a private owner. In such cases, people typically do not take into account any negative impacts that their use may have on the productivity of the resource for others. People rationally focus on satisfying their own resource needs first and foremost.

If everyone behaves rationally from an individual perspective, the resource can be overused and become depleted, even to the point of its productivity falling to zero (see Box 7 for an example). Climate change is an example of a tragedy of the commons on a global scale where the common property is the earth's atmosphere that everyone shares and depends on.

Box 7 **The collapse of the Atlantic cod fishery: A cautionary tale**

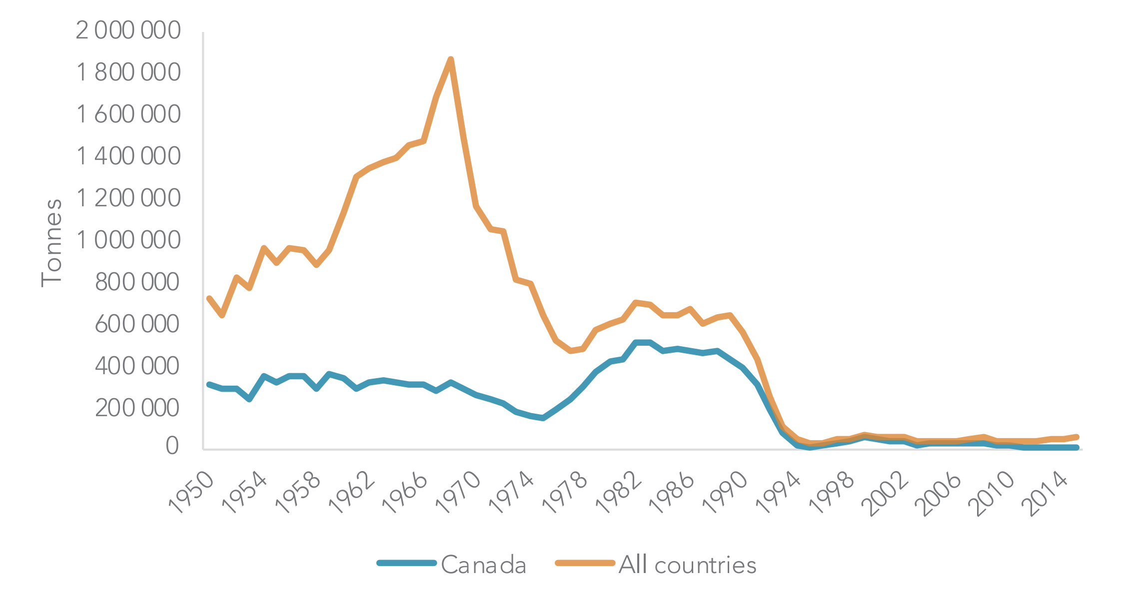
For 400 years off the eastern coast of Canada, the Newfoundland Grand Banks cod fishery was one of the most abundant in the world. Colonial settlers recounted stories of lowering baskets into the ocean and pulling them up, teeming with Atlantic cod, *Gadus morhua*.

Between the mid-19th and 20th centuries, annual catches in the northwest Atlantic were reasonably stable. But by the late 1960s, nearly 2 million tonnes of cod were caught per year. This dramatic peak precipitated a crash in fish populations. By 1992, the fishery had completely collapsed (Figure 15).

The collapse of the fishery was the result of a number of issues.

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

Figure 15 Gadus morhua capture in the Northwest Atlantic



Source: FAO (2016)

The fishery collapsed due to over-fishing (Hutchings & Myers, 1994). Climate change has however contributed to the collapse of similar fisheries, with overfishing resulting from a failure to recognise the impact of warming on cod numbers (Pershing, 2015).

The New Zealand Emissions Trading Scheme (NZ ETS)

As introduced in Chapter 2, the New Zealand Emissions Trading Scheme (NZ ETS) is the Government's principal response to climate change and is a type of transferable permit scheme. Despite its initial design as an "all-sectors, all-gases" scheme, its implementation has diverged from this intention. Notable changes to the scheme since its establishment include the indefinite exclusion of agriculture since 2013[20] and the exclusion of international units since mid-2015 as a result of New Zealand's decision not to participate in the second round of the Kyoto Protocol.

Another key aspect of the NZ ETS is despite originally being designed as a cap-and-trade scheme, the scheme has no cap. The uncapped approach to allocations of NZUs extends back to 2009 and is explicitly tied to retaining the international competitiveness of New Zealand businesses (New Zealand Government, 2009).

OECD modelling work (based on a carbon price of $5 per tonne of CO_2e over the next 15 years) suggests that the NZ ETS (along with other quantifiable policy measures) will only contribute towards an 0.4% reduction of gross domestic emissions and a 4.1% reduction of net domestic

[20] The agriculture sector currently has reporting obligations, but does not have corresponding obligations to purchase or surrender emissions units.

emissions by 2030 as compared to business-as-usual activities (OECD, 2015). Supporting the finding from Richter and Chambers that two-thirds of emitters in the NZ ETS considered it has had no effect on reducing their emissions, the Ministry for the Environment's (MFE's) own evaluation of the NZ ETS found it has "not significantly influenced domestic emissions or business decisions" (2016a, p. 5).

MfE is currently reviewing the operation and effectiveness of the NZ ETS (MfE, 2017g). Key themes from review submissions included a strong desire for regulatory certainty (with the forestry sector in particular calling for a stable NZU price to incentivise investment), and the need for a long-term plan for how the NZ ETS will help New Zealand meet its targets.

In July 2017 the Government announced four, in-principle, decisions arising from this second stage (the details of which will be further developed over the next year). These relate to:

- introducing auctioning (ie, selling NZUs through a competitive bidding process);
- limiting participants' use of international units (on the assumption that the NZ ETS will re-open to international carbon markets);
- developing a volume-limited price ceiling to replace the $25 fixed-price option for NZUs; and
- coordinating decisions on the supply settings in the NZ ETS over rolling five-year periods (MfE, 2017a).

The Commission notes that many submitters to this inquiry may have already made submissions to the NZ ETS Review 2015/16 and so welcomes those submissions in part or in full, as deemed relevant by the submitter, addressed to this inquiry.

Q20 **Acknowledging the current review, what changes to the New Zealand Emissions Trading Scheme are needed if it is to play an important part of New Zealand's transition to a low-emissions future?**

Institutions supporting market-based approaches

Because of their complexity, market-based approaches require strong institutional capacity to operate effectively. For example, it is crucial that tradable permit schemes are designed to effectively influence behaviour, and provide confidence in the scheme's integrity.

Monitoring, reporting and verification (MRV) of emissions is a key function for market-based approaches. Referring to the European Union Emissions Trading System, the European Commission argues that MRV must be "robust, transparent, consistent and accurate" (European Commission, 2017) in order for it to operate effectively. The relatively smaller scale of the NZ ETS makes this task somewhat easier, but other challenges exist such as the feasibility and accuracy of on-farm MRV systems if agriculture was brought fully into the scheme.

In New Zealand, a complex set of institutions and institutional frameworks support market-based approaches, including governing the NZ ETS.

- MfE is the lead agency responsible for policy development for the NZ ETS, and is also responsible for producing and submitting New Zealand's Greenhous Gas Inventory every year under the UNFCCC.

- The Environmental Protection Authority (EPA) maintains the register of emission units under the NZ ETS, and monitors and enforces the obligations of emitters covered by the scheme.
- The Ministry for Primary Industries administers the NZ ETS for the forestry sector in partnership with MfE and the EPA.

Table 4-2 highlights some of the main advantages and disadvantages of market-based approaches, and provides some New Zealand and international examples.

Table 4-2 Advantages, disadvantages and examples of market-based approaches

Advantages	Disadvantages	Examples
• Flexibility (do not specify how to mitigate emissions) with incentives to invest in the least-cost pollution abatement technology, therefore can achieve policy objectives at lower overall costs across the economy • Have specific relative merits eg, taxes and charges provide predictability and transparency, are relatively quick to implement and simple to administer; transferable permit systems are more complex but provide potentially greater certainty on the quantity of emissions reductions (ie, via the cap) • Can raise Government revenue (either for general expenditure or targeted to support abatement)	• Can have regressive effects on poor households • Require strong regulatory capacity if optimum design is to be achieved eg, taxes are unlikely to be set at an optimum rate because demand and supply curves for pollution abatement are not known with certainty by regulators • Transferable permit systems can make for price uncertainty and be complex with high transaction costs eg, for monitoring and reporting • May not be suitable for all sectors due to measurement challenges at the point of obligation	• In Ireland, vehicle registration and annual circulation taxes are linked to CO_2 emissions • The 2016 Electric Vehicles Programme exempts light and heavy electric vehicles from Road User Charges until they make up 2% of their respective fleets • A carbon tax has existed in Denmark since 1991 for both households and industries (the rate differs but is approximately NZ$36 per tonne of CO_2e)

Source: Asafu-Adjaye (2005); C2ES (2015); Nielson (2010); NZPC (2014b); Partnership for Market Readiness (2017); Tietenberg (2007)

Q21 **What type of market-based instruments would best help New Zealand transition to a low-emissions economy?**

Support for innovation and technology

Innovation and disruptive new technologies will play a critical role in reducing GHG emissions. For example, completely transparent solar cells developed today may eventually replace glass windows on city high-rises – powering the high-rise itself as well as neighbouring apartments (Klimov, 2016). Large-scale deployment of "smart grid" systems using sensor data from appliances and other devices could reduce energy consumption significantly; current estimates predict a reduction in total energy consumption in the United States of 5% by 2030 (PNNL, 2010).

But how do we ensure that innovation, and its subsequent uptake, happens at the scale and speed required? If emitters are required to face the full cost of their actions, this will incentivise them to reduce emissions where the cost of abatement is less than the carbon price. Ensuring this cost is internalised in itself spurs innovation and technological development. In essence, entrepreneurs that come up with new low-cost ways to save emissions will make ready profits.

However, this may not be enough. If innovators and inventors are not directly rewarded, there will be too little innovation and invention. Patents and other forms of intellectual property incentivise innovation, yet they do so at the cost of providing a temporary monopoly on intellectual property. This limits the ability to achieve "knowledge spillovers". These are a type of public good whereby innovation spreads beyond the original innovator, for example, as a result of the close proximity of innovative firms (such as is the case in Silicon Valley).

The "non-rival" nature of knowledge is important here – this means that one person's use of the knowledge doesn't preclude another person from using it at the same time (The Treasury, 2008). If an innovator tries to restrict supply of the knowledge in question in order to earn high profits, there will be fewer applications of the new technology or benefits from it. This could have very high social opportunity costs in a world racing to limit GHG emissions.

Therefore, given the tension between incentivising innovation and extending its reach, a case exists to complement commercial research and development (R&D) with public support for developing clean technologies (Acemoglu et al., 2012; OECD, 2008). This applies particularly at the basic-research end of the R&D spectrum where uncertainty abounds and there is no clear pathway to a commercial product. Public support could take different forms, including:

- tax incentives or grants for R&D within private firms;
- direct funding for researchers in universities or public research organisations; or
- patent buyouts or prizes for particularly important breakthrough achievements.

New Zealand has particular areas of interest and expertise given its emissions profile. Achieving a research breakthrough in emissions reductions, such as in reducing agricultural emissions, is arguably New Zealand's best opportunity to make a difference to climate change on a global scale. Yet New Zealand is a small player in global research on most new clean technologies.

This raises questions about the best public R&D strategy for a small developed country with a distinctive emissions profile. Should it, for example, focus on a few niche areas of high importance given its emissions, and for the rest focus on being a smart follower? The dissemination and uptake of new technologies and innovations can be very slow – a particularly important point when thinking about the speed at which GHG emissions need to decrease. New Zealand may not need to develop many of the technologies required itself, but it does need to ensure they are able to be used effectively (Conway, 2016) – the uptake of electric vehicles in New Zealand is a perfect illustration of this point.

Potential barriers to technology uptake include lack of access to capital, knowledge or skills, infrastructure, or regulatory obstacles. To remove some of these barriers, the European

Commission provides reference documents on best available technology for activities such as iron and steel production, waste treatment or chemical production (EC JRC, 2017).

A number of institutions support innovation and technology in New Zealand. For example:

- universities carry out "blue sky" and/or targeted research, such as through the Centre of Excellence in Electric Power Engineering at the University of Canterbury;
- the Ministry of Business, Innovation and Employment (MBIE) funds the National science challenges, such as the Deep South Challenge aiming to enable New Zealanders to adapt, manage risk, and thrive in a changing climate;
- Crown Research Institutes, with dedicated interests in agriculture, land care, and forestry, undertake applied research into ways of reducing or absorbing emissions;
- the Global Research Alliance on Agricultural Greenhouse Gases, substantially funded by the New Zealand Government, aims to reduce agricultural GHGs while maintaining global food security (see Chapter 3); and
- Motu Economic and Public Policy Research, a non-government trust, led a programme of work on *Shaping New Zealand's low emissions future* (Motu, 2017).

Financial institutions are also critically relevant. Box 8 explains the importance of ensuring finance is directed towards innovation and technology supportive of a low-emissions transition.

Box 8 **Mobilising finance towards innovation and clean technology**

Banks and other large financial institutions can have a major influence in the direction of an economy. They can actively invest in low-emissions activities, such as Australia's Clean Energy Finance Corporation, a Government-owned green bank aiming to increase finance into renewable energy, energy efficiency and low-emissions technology (CEFC, 2017). Types of climate-related financial instruments include providing project-level equity, grants, balance sheet financing or low-cost project debt.

Investment can also push in the opposite direction to a low-emissions transition. A recent study found that corporate bond purchases by the Bank of England and the European Central Bank are disproportionately favouring carbon-intensive manufacturing and utilities (Matikainen et al., 2017). This is because these firms do not adequately face the cost of their emissions, and so, at least in the present, remain an attractive investment proposition.

Key activities relevant for mobilising finance effectively include:

- low-carbon and energy-efficiency finance and investment (eg, pension fund allocation strategies, supporting renewable energy projects, or green bond market development);
- effective measurement, transparency and disclosure in climate change reporting; and
- greater engagement between the sector, companies and policy makers (UNEP & World Bank, 2014).

Banks and other private financial institutions may be reluctant to invest in risky technology projects – the lack of immediate return and/or collateral assets and the large inherent uncertainties are off-putting. Clean-tech venture capital and government finance can help to fill this gap. Over the last decade, the New Zealand Government has supported the development of private venture and angel capital through its Venture Investment Fund and Seed Investment Fund; however clean-tech is not a particular focus of these initiatives.

Table 4-3 highlights the main advantages and disadvantages of approaches to supporting innovation and technology, and provides some New Zealand and international examples.

Table 4-3 Advantages, disadvantages and examples of support for innovation and technology

Advantages	Disadvantages	Examples
• Public support for R&D reduces the costs and risks for firms investing in innovation and new technology • Targeted R&D expenditure directs investment away from polluting technologies • Innovation and technologies can be commercialised and exported, achieving benefits far beyond an individual firm	• Determining the optimum level and types of R&D support to encourage the greatest public return is difficult • Particularly for highly targeted support at the non-basic level it is technically and politically challenging for policy officials to "pick winners" • The fiscal cost of providing support could be substantial, with necessary trade-offs as regards other types of public spending	• The United States Wind Energy Technologies Office provides targeted R&D funding eg, developing and demonstrating effective turbine technology and overcoming barriers to turbine deployment • The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) invests $4.8 million per year to develop agricultural emissions reducing technologies and practices

Source: Bloom et al. (2002); Bosetti et al. (2009); Brown et al. (2017); Dechezleprêtre et al. (2016); Hall and Van Reenen (2000); Newell (2010)

Q22 **What type of support for innovation and technology would best help New Zealand transition to a low-emissions economy?**

Alternative approaches

In addition to direct regulation, market-based instruments and support for innovation and technology, many other types of policies also exist that could support the transition to a low-emissions economy. These alternative approaches include:

- voluntary approaches, such as unilateral commitments made by polluters (also known as voluntary actions), or voluntary agreements between governments and the private sector;
- education, information campaigns and demonstration projects;

- behavioural strategies based on framing, nudging and social norms; or
- support for low-emissions infrastructure.

Box 9 goes into more detail on one of these approaches – how change can be encouraged through a better understanding of what motivates human behaviour.

Box 9 **Framing, nudging and social norms**

A better understanding of behaviour can make efforts to encourage emissions reductions more effective. For example, it is important to avoid framing the desired changes as a loss. Humans prefer to avoid making a loss rather than to make an equivalent gain (Kahneman & Tversky, 1984). People are more willing to reduce emissions

> when the costs to future national income are framed as a ''foregone-gain''—incomes rise in the future but not by as much as in the absence of emission cuts—rather than as a ''loss''— incomes decrease relative to the baseline expected future levels (Hurlstone et al., 2014, p. 1).

"Nudging" is another behavioural strategy. It works by making changes to the context in which a decision is made so as to make a particular choice seem, subconsciously, more desirable. One study found that providing rubbish and recycling containers with lids (for rubbish, a flap lid; for cans and bottles, lids with round holes; and for paper, lids with narrow slits), increased recycling rates by 34% as compared to providing the same containers without any lids (Duffy & Verges, 2008).

Combining nudging with knowledge of social norms (ie, the informal rules of acceptable behaviour within a group) is also powerful. For example, when individuals are informed about how much energy is consumed on average by their neighbours, their energy use tends to adjust to the neighbourhood norm (van der Linden et al., 2015). Elinor Ostrom (2012) also demonstrated how relationships, social norms and sanctions can play effective roles in generating the cooperation necessary to avoid tragedy of the commons outcomes.

The institutions required to support these non-regulatory interventions are diverse. For instance, central and local government support for low-emissions infrastructure is fundamental. Public or private bodies that direct finance and investment flows will also be key (OECD, 2013). Financial institutions play a crucial role through their intermediary role of funnelling savings to investment opportunities that offer attractive financial returns. Box 10 examines how the risk-avoidance strategies of financial institutions can help the transition to a low-emissions economy.

Box 10 **Harnessing the power of financial institutions: Risk aversion in a low-emissions transition**

Financial intermediaries are increasingly interested in low-emissions investments because they offer ways to reduce risk. Insurers want to minimise their liability to loss and damage suffered by their clients, and banks want to be able to meet their monetary and financial stability objectives – something that would be difficult in a world where climate-related impacts are increasingly common (Bank of England Prudential Regulation Authority, 2015).

Another risk that financial institutions want to avoid is that of "stranded assets". This is where the value of an investment is unable to be recovered as originally intended – its value is lost because of changes in external circumstances such as policy change (eg, the introduction of a high carbon price) or changes in consumer preferences.

Many large institutional investors are divesting from high-carbon activities to avoid the risk of stranded assets. Norway's government pension fund is divesting from coal, and New Zealand's Super Fund is divesting from global companies which themselves have large exposure to climate risk from carbon pricing or other market mechanisms (NZ Super Fund, 2016). The Bank of England has also recently launched a review of climate-related risks in the UK banking sector (Scott et al., 2017).

Heal (2017) describes a very large US pension fund that chooses to invest only in companies aligned with environmental sustainability. The size of the fund in effect means

> it owns a share of the global economy, and anything that harms the global economy harms the performance of the fund… Climate change, for example could become a real and present problem for some of its investments within the lifetime of many of its contributors … So this fund, like many others of its size puts pressure on corporate management to adhere to environmentally and socially responsible practices (Heal, 2017, pp. 59-60).

Q23 **How can New Zealand harness the power of financial institutions to support a low-emissions transition?**

Table 4-4 highlights some of the main advantages and disadvantages of other types of interventions, and provides some New Zealand and international examples.

Table 4-4 Advantages, disadvantages and examples of other types of interventions

Advantages	Disadvantages	Examples
• Firms participating in voluntary approaches encouraged to invest in technology, innovation and resource efficiency can be more profitable • Reputational benefits and greater market share can accrue to firms making climate-based pledges • Firms can stay ahead of regulatory change and increase investor confidence and credibility	• Voluntary approaches are limited in their ability to achieve emissions reductions targets • The existence of voluntary approaches may mean alternative, more effective, approaches are not implemented • Information/awareness raising about climate change has limited	• Participant firms of the Science Based Targets initiative such as Coca Cola Enterprises, Kellogg, and Procter & Gamble voluntarily commit to setting firm-specific, science-based emissions reductions targets • Climate change education is delivered via initiatives such as UNICEF's Child Friendly Schools initiative and UNESCO's Global

Advantages	Disadvantages	Examples
• Education and behavioural approaches can be effective in changing emissions-intensive behaviour at low cost • Low-emissions infrastructure can provide substantial co-benefits eg, reduced congestion, increased public health and safety, and reduced air and noise pollution	effectiveness on behaviour due to the "attitude-behaviour" gap • Poorly designed infrastructure can lead to lock-in to emissions-intensive ways of life	Action Programme on Education for Sustainable Development. • The Urban Cycleways Programme has received $333 million to-date to expand and improve New Zealand's cycling network

Source: GIZ (2015); Goodwin (2012); Griffin and Sun (2013); Leining (2015); Lorenzoni et al. (2007); OECD (2003); Tauringana and Chithambo (2015)

Q24 **What type of alternative approaches (such as voluntary agreements or support for green infrastructure) would best help New Zealand transition to a low-emissions economy?**

Complementary policies and institutions

This chapter has focused on what may be thought of as "core" climate policies and institutions. However, many other policy and institutional settings are likely to be relevant to a successful low-emissions transition, including, but not limited to, skills, education and employment; financial; competition; or social policies and institutions (OECD, 2017b). Specific regulatory settings, such as those governing the electricity industry, are also likely to be pertinent.

An example is the role of public procurement which can "create lead markets for innovative, low-GHG industrial materials and infrastructure choices" (OECD, 2017b, p. 32). In New Zealand, public procurement makes up approximately 36% of total government expenditure (OECD, 2017a). If even a subset of this expenditure, for example that directed towards purchasing infrastructure-related goods and services, was encouraged to take account of life-cycle GHG emissions, this could act as an important policy lever to encourage low-emissions investment.

Q25 **In addition to "core" climate policies and institutions, what other changes to policy settings or institutional frameworks are required to effectively transition New Zealand to a low-emissions economy?**

5 Achieving a low-emissions economy

One way of thinking about mitigation opportunities within and across emissions sources, as well as the policies and institutions required to achieve those opportunities, is the idea of the low-emissions economy as a system. This approach focuses on the interrelated and self-reinforcing aspects of the economy, paying attention to pervasive issues such as institutional, regulatory and statutory frameworks; innovation, legislative and regulatory barriers; or the political economy.

It also helps to highlight the substantial scale and nature of the adjustment needed across the economy to achieve New Zealand's targets, including trade-offs between different policy choices. As Vivid Economics (2017) highlights in its four scenarios of the future, marked changes in technology, land-use patterns, and industrial activities are likely to be required for New Zealand to meet its commitments.

Systems architecture

In order to ensure a system that effectively and coherently reduces emissions at least cost and greatest net benefit to New Zealand, the underlying institutional foundation, or "systems architecture", must be well designed.

Looking to the future

A common theme across most of the work focusing on how to transition to a low-emissions future is the importance of the long-term. As the World Bank (2015, p. 6) notes, using longer timeframes and constantly keeping an "eye on the end goal [of decarbonisation]" changes the optimal policy mix. This is because the costs, mitigation potential and time needed for each option will be different according to different time horizons.

Another argument for a long-term focus is the need to be able to respond to the enormous number of scientific, technological, political and economic uncertainties that lie ahead in relation to climate change. The system must be able to adjust to these uncertainties, but also be credible and predictable enough to provide confidence to households or firms investing in low-carbon technology or production (Acworth et al., 2017; OECD, 2008). As the Climate Change Iwi Leaders Group (2016, p. 15) contends in relation to the New Zealand Emissions Trading Scheme (NZ ETS), "constant changes are a disincentive for participants to make the long term decisions that are required".

Q26 **What are the main uncertainties affecting New Zealand businesses and households in considering investments relevant to a low-emissions future? What policies and institutions would provide greater confidence for investors?**

Ensuring that the system is designed to focus on the long-term can also help to insulate it from the effects of pressures from the "political economy". This, broadly speaking, refers to the important role of political factors in determining economic outcomes. It highlights, for example, the way tensions between social, political or economic factors can influence government decision-making – as the World Bank (2015, p. 3) notes, "reforms live or die on the basis of how well the political economy is managed".

Given the importance of the political economy, communicating the importance of the need to transition, as well as the benefits that are likely to accrue to New Zealand as a result, will be critical in mobilising the required social and political will. It is a political reality that if the public does not accept the need to change, as well as the fact that the change is likely to be uneven (ie, it will affect some people more than others), it will be very difficult for politicians to enact policies required to transition to a low-emissions economy.

Q27 **What approaches, such as regulatory frameworks or policy settings, would help embed wide support among New Zealanders for effective reduction of domestic greenhouse gas emissions?**

The legislative framework

One of the main ways to help retain a long-term focus is by using legislation. This "commitment institution" enables the public and successive governments not to lose sight of the long-term goal of a low-emissions economy (Boston, 2016). It is however a challenge to ensure that the legislative foundation for a low-emissions transition is robust and stable, and drives forward the changes needed at the speed required, yet offers the flexibility needed to adapt to changing technologies and circumstances.

The Climate Change Response Act 2002 is the main legal framework for emissions reductions in New Zealand and was established to provide the legal framework for New Zealand to meet its international obligations under the Kyoto Protocol. Some commentators have voiced strong criticism of the CCRA. Sir Geoffrey Palmer argues that amendments to the Act have negatively influenced its coherence. He contends that the Act was

> substantially weakened, obligations were deferred and the changes favoured emitters. The Act suffers now from a myriad of public law problems… [It is now] a treasure trove of doubt, difficulty and obstacles (Palmer, 2015, p. 18).

The recently released report on climate change by the Parliamentary Commissioner for the Environment (2017) recommends establishing a model very similar to the United Kingdom (UK)'s Climate Change Act in New Zealand. The Commissioner highlights the importance of having emissions targets in law, carbon budgets, an independent expert commission on climate change, and the requirement for the Government to develop policies that enable the budgets to be met. Box 11 describes the UK approach in more detail.

Box 11 **The UK Climate Change Act (2008)**

The UK Climate Change Act (2008) sets a long-term 2050 target for an 80% reduction in GHG emissions and is based on a structure of "carbon budgets". Carbon budgets set a ceiling on the allowable level of emissions over five year periods that begin approximately 12 years into the future, and are intended to provide forward-looking certainty to investors in low-carbon technologies and infrastructure. They are divided into the "traded" sector of the economy which are mostly industries covered by the European Union Emissions Trading System (EU ETS), and the "non-traded" sector, which includes households and transport. The current, fifth, carbon budget sets emissions limits for 2028-2032.

The Act also established the Committee on Climate Change (CCC). The CCC's role is to recommend carbon targets and budgets (including proposals and policies for meeting these targets), and to hold the sitting Government to account on its climate change commitments. Once budgets are accepted by the Government, the Act legally binds future Governments to meet these carbon budgets in order to achieve the 2050 target.

The CCC comprises a Chair and eight independent, expert members with a secretariat of 30 staff providing analytical and corporate support. The CCC also assesses the Government's plans in response to their recommendations in annual progress reports.

The passage of the Act was notable for its overwhelming cross-party political support. However, it has not always been smooth sailing. While the Government accepted the fifth carbon budget in 2016, there was intense lobbying over the fourth carbon budget in 2011. Arguments centered on threats to the competitiveness of UK industry, particularly because they set emissions reductions at a level greater than existing commitments by the EU.

Another challenge is that the CCC's recommendations to Government on the carbon budget are not in and of themselves legally binding. Its influence has been identified as more due to its reputation and authority in the economics and science of climate change rather than formal powers. While the Government could face legal challenge and judicial review if it did not accept the carbon budget, whether this would be realistically feasible is unclear. However, the overall worth of the Act and the CCC is not disputed, as

> it is quite likely that without a law with long term targets and an institution like the Committee on Climate Change standing behind it, a carbon budget for the 2020s would never have been agreed to by the Government (Lockwood, 2013, p. 1346).

Source: Committee on Climate Change (2008, 2017); Fankhauser (2011); Lockwood (2013)

Another legislative proposal is Generation Zero's *Zero Carbon Act*. This is also based on the UK Climate Change Act's model of carbon budgets, but also incorporates the "two-baskets" approach (see later in this chapter) and a "firewall" principle. The latter means that targets contained in law would apply only to domestic emissions – essentially removing the possibility of using international trading in permits to achieve targets (Generation Zero, 2017).

The UK's CCC provides an example of safeguarding the regulatory independence needed to insulate the system from short-term political pressures. In its 2014 report, *Regulatory institutions and practices*, the Commission identified a range of features that indicate more or less of a need for regulatory independence. Those on the side of more regulatory independence and which reflect the nature of climate change as a policy problem include:

- decisions where costs are long term, and are undervalued due to a focus on electoral cycles;

- decisions weighing a politically powerful private interest against a dispersed public interest;
- decisions requiring a substantial degree of technical expertise, or expert judgment of expert analysis;
- decisions where the casual relationship between the policy instrument and the desired outcomes is complex and uncertain;
- regulatory regimes where a consistent approach over a long period of time is needed to create a stable environment;
- where decisions need to be taken urgently; and
- where public confidence that the regulator is impartial is important (NZPC, 2014b).

Legislation relevant to a low-emissions economy is however not limited to laws with climate change as the primary topic. Energy legislation has a major role to play for instance. In New Zealand, this includes the Energy Efficiency and Conservation Act 2000, the Electricity (Renewable Preference) Amendment Act 2008, and the Energy Innovation (Electric Vehicles and Other Matters) Amendment Act 2017.

In France, the Energy Transition for Green Growth Law 2015 specifies targets for reducing GHG emissions and energy consumption. It sets out a roadmap for diversifying France's energy mix away from fossil fuels and nuclear energy towards renewable energy (PRI, 2016). Legislation can also be supported by strategies and plans, such as the recently updated Energy Efficiency and Conservation Strategy (2017-2022).

Q28 **Is New Zealand's current statutory framework to deal with climate change adequate? What other types of legislation might be needed to effectively transition towards a low-emissions economy?**

Q29 **Does New Zealand need an independent body to oversee New Zealand's domestic and international climate change commitments? What overseas examples offer useful models for New Zealand to consider?**

An adaptive system

In transitioning to a low-emissions economy, it seems likely that an adaptive system will be necessary – one that recognises and responds to changes in technological availability, cost or capacity, as well as to policies enacted by other countries that impact New Zealand. For example, lithium-ion battery costs have reduced by 73% over the last seven years, making electric vehicles cost-competitive with internal combustion engines far earlier than most predictions (Carbon Tracker, 2017). Changes such as these could dramatically alter what New Zealand's low-emissions economy looks like and the speed with which change happens.

An adaptive system could discourage irreversible investments in large, expensive fixed assets that lock-in the use of a technology with a higher level of emissions, when a possibility exists down the track of new technologies that would significantly reduce emissions. This would require designing pathways that are adaptive and dynamic, not predetermined. Alternatively, given that decisions will always need to be made that have long-term emissions implications, designing a system that explicitly *aims* to lock-in low-emissions pathways, even if they might not be optimal given future uncertainties, is also a possibility.

As outlined in Chapter 4, the weak settings of the NZ ETS means that it is having little effect on the level of New Zealand's emissions. Box 12 describes a recent proposal to enable the NZ ETS to remain adaptive, yet provide more certainty and stability to participants.

Box 12 **Motu's proposal to enable a flexible but certain NZ ETS**

Suzi Kerr et al. (2017) from Motu propose reforms to help the NZ ETS strike a balance between giving certainty to firms and being flexible in the face of changing information. Authorities would set the cap to achieve a steadily declining path of total emissions for the participant sectors, over the next five years, with the path announced in advance. The market would determine permit prices. But to limit price uncertainty, the announcement would also stipulate a price floor and a price ceiling, and there would be indicative guidance on future prices for a further 10 years beyond the five-year period.

Similar to the UK CCC model, Motu suggests an expert, independent Committee to re-set the numbers for successive five year windows in the light of new information on prices, abatement costs, technological developments, levels of disruption and trends in emissions. Further efforts could enhance liquidity and enhance the ability of firms to hedge against short-term price volatility – for example banking and borrowing provisions for permits, the development of futures and derivatives markets, and linking different permit schemes.

Q30 **How can adaptability best be incorporated into the system supporting New Zealand's low-emissions transition?**

Designing the best combination of policies

New Zealand is very likely to need a mix of policies as it transitions to a low-emissions economy. In order to choose between policy approaches, a number of relevant tools are available and which emphasise different factors. Table 5-1 highlights some tools that may be useful:

Table 5-1 Tools for evaluating policies

Tool	Description
Cost-benefit analysis (CBA)	CBA weighs up the costs and benefits of each option in a short list of options so that the option that offers the highest net benefit can be found. If an adequately high carbon price exists and is internalised in decision-making, investment options that result in lower emissions will have comparatively lower costs and higher benefits (all else being equal). An adequately high carbon price would also serve to align private CBA with social CBA – ie, decisions made by private economic agents would not counteract the public good.

Tool	Description
	CBA also requires the application of a "discount rate" to weigh the relative importance of costs and benefits occurring in different time periods. The choice of discount rate is critical as great care is needed to treat generations fairly and not discount benefits to future generations simply because they will live only in the distant future (Stern, 2007). However, incorporating assessments of wider social costs and benefits, including co-benefits, in CBA is complex and requires a lot of skill to do well.
Real options analysis (ROA)	ROA is a form of CBA but which includes a temporal element. It values being able to preserve or create options that enable decisions to be made in the future with the benefit of information not currently available. An example would be a decision in the present to focus on sequestering carbon in forestry to reduce net emissions and meet New Zealand's targets. This strategy would afford time for other solutions, such as agricultural technologies, to emerge. Another example is making investment decisions about electricity or transport infrastructure – expensive fixed assets with long lives. ROA takes account of the risk of building them and then being stranded with outdated, commercially expensive technology – either because new technology emerges or future carbon prices are higher than expected. Ways to hold off on committing to these investments would be awarded high "real option values".
Modelling	Models are often needed to conduct a CBA or ROA. As models predict within a margin of error what might eventuate from given policy intervention, they are an essential step towards estimating the costs and benefits of each choice. Models used in New Zealand include computable general equilibrium models to estimate impacts on incomes from different types of emissions targets (MfE, 2009), and scenario modelling in order to identify plausible descriptions of how the future may turn out (BusinessNZ Energy Council, 2015; Vivid Economics, 2017). Models have limits, such as difficulties in incorporating technological change, but used well they can cut through complexity and aid understanding (Pindyck, 2017). Their quality is largely dependent on the quality of data fed into the model and assumptions about values of model parameters.
Applied forward reasoning	Applied forward reasoning places greater weight on identifying and enabling policy decisions that adequately value long-term interests. Rather than attempting to avoid path dependency, it instead aims to focus on actively "nurturing countervailing policies that might trigger path-dependent "low carbon" trajectories" (Levin et al., 2012, p. 124). It specifically aims to identify how policy decisions may "lock-in" pathways that lead to transformative change over time by promoting policy irreversibility, entrenchment over time, and expansion to a greater population of interest.

The tools in Table 5-1 require good data, as well as a deep understanding of the interactions between policy choices and likely outcomes. A wealth of data exists in New Zealand but there are gaps. Data sources and analysis include:

- the national GHG inventory - the full New Zealand inventory is available at the Ministry for the Environment (MfE) (2017d) and a snapshot at MfE (2017c);

- the forthcoming inaugural report on atmosphere and climate by Statistics NZ and MfE; and
- energy generation and use data statistics compiled by Statistics NZ, the Ministry for Business Innovation and Employment, and the Energy Efficiency and Conservation Authority (EECA); and
- data on transport volumes, infrastructure and emissions by the Ministry of Transport.

Gaps include data and analysis on:

- the marginal abatement costs of different ways of reducing emissions in New Zealand (at a national and sectoral level);
- demand and supply "elasticities" that estimate the extent to which households and firms make emission choices in response to carbon prices;
- emissions at the level of individual firms, farms and households;
- co-benefits arising from different abatement activities and the size of those benefits; and
- the values and norms that are relevant to understanding whether specific emissions-related policies are likely to achieve acceptance.

Q31 **What types of analysis and underlying data would add the greatest value to this inquiry?**

Despite these analytical gaps, and based on the literature and other countries' experiences, there are arguments for emphasising, particularly in the short-term, two particular sorts of policies, both described in detail in Chapter 4:

- using a market-based instrument to put a financial cost on GHG emissions to reflect their true social cost; and
- supporting innovation and the development and diffusion of low-emissions technologies (Acemoglu et al., 2012).

Each directly addresses well-understood weaknesses in market economies and hence go to the root economic cause of unabated GHG emissions (OECD, 2008; Stiglitz & Stern, 2017).

Both policies already exist in New Zealand. However, it is difficult to say how far these two approaches alone, enacted at levels sufficient to effect strong behavioural change, will successfully transition New Zealand to a low-emissions economy. The Commission's view at this early stage is that they are important and necessary forms of intervention, but not sufficient. Evidence suggests that other supporting measures – direct regulations, certain infrastructure investments, education, information provision, and others – should also be part of the mix.

The timing of interventions is another factor to consider. The World Bank (2015) notes that focusing in the early stages of a transition on policies that do not hurt owners of existing capital may be more effective in the long-term because they reduce resistance to change, even though they may be less economically efficient. This is consistent with applied forward reasoning which argues that in order to successfully prioritise the long-term, policies must entrench support over time while expanding the populations they cover (Levin et al., 2012).

Finally, research shows that coherence across policy approaches is critical (Rogge & Reichardt, 2016). A poorly-designed or uncoordinated policy package can result in confusing signals and higher costs. For example, pricing emissions without R&D support could mean that some currently cost-effective technologies (such as wind energy) are "locked-in" and other promising, but currently more expensive technologies at an earlier stage in their development are not adequately pursued (such as some types of battery technologies) (Baranzini et al., 2017).

Q32 **What should be the mix, and relative importance of, different policy approaches (such as emissions pricing, R&D support, or direct regulation) in order to transition to a low-emissions economy?**

Co-benefits

When thinking about a coherent strategy for New Zealand's low-emissions transition, it will be important to take account of co-benefits. Specific examples were discussed in Chapter 3, but it is also necessary to consider how a policy and institutional framework can best value these in decision-making processes, including addressing several challenging questions.

- What can or should be considered a co-benefit? For example, diversifying New Zealand's export mix may be beneficialr to protect the economy from climate-related shocks. But should this be actively considered to be a co-benefit?
- How can co-benefits be measured? It may be possible to use existing methods for some co-benefits (eg, reduced illness from better air quality), but others such as public valuations of clean waterways may be more challenging to assess, particularly in monetary terms.
- How should co-benefits be valued as compared to the core benefits of climate change mitigation? For example, how should the co-benefit of ecosystem services offered by a vibrant native forestry sector be compared to the core benefit of avoided climate losses that mitigation would achieve, such as reduced storm surges or sea-level rise?

Existing methods to explicitly include co-benefits in policy decision making include "multiple-objective-multiple-impact" frameworks, "no regrets" policy making, or conducting CBA or risk analysis (Pearce, 2001; Ürge-Vorsatz et al., 2014).

Q33 **What are the main co-benefits of policies to support a low-emissions transition in New Zealand? How should they be valued and incorporated into decision making?**

Who can and will make change happen?

Evidence from the decades-long effort to addressing climate change suggests that action at multiple levels and by multiple actors is needed to complement top-down global efforts. These actions may take place at national, regional or local levels including at the level of individual businesses and households. Nobel Laureate Elinor Ostrom (2012) argues that solely relying on a strategy to reduce emissions devised and implemented at a global level is risky and will lack effectiveness even though the climate is an instance of a global commons. Top-down solutions to collective-action problems without substantive stakeholder involvement typically founder.

Another important factor is that GHG emissions and their impact on the climate are complex processes with significant unknowns so that reliance on one scale and one model to solve these problems is naïve. On the contrary, multiple actions and approaches can generate valuable learning. Cities and local government are increasingly taking the lead in implementing climate change initiatives. In July 2017, a declaration was signed by 39 of New Zealand's mayors – representing the majority of New Zealand's population – committing to developing and implementing ambitious action plans to reduce GHG emissions at a local level (LGNZ, 2017).

City-level efforts can also be coordinated internationally. For instance, the C40 Cities Climate Leadership Group is a network of large cities, including Auckland, committed to addressing climate change. Another example is the work by cities such as Dunedin under the International Compact of Mayors to measure emissions, and set targets and report on progress towards reducing those emissions (Cull, 2017).

Implementation at the local or regional scale also appears to be particularly relevant given the ability to make tangible changes in terms of resource allocations, as well as highlighting the connection between everyday activities, climate change impacts and potential co-benefits of mitigation (Dolšak, 2009). For example, emissions from heating buildings or from waste disposal make only a minor direct contribution to New Zealand's total emissions. Yet both these sources have a direct interaction with everyday lives (eg, via heating sources, building design, or recycling or re-use). As a result, lowering emissions in these sectors could have spillover effects for wider public understanding of, and support for, a low-emissions transition.

Finally, experience in other countries shows that relevant agents are not confined to government – either central or local (T2gE, 2016). For instance, the courts play a key role in interpreting the practical application of laws and regulations, and business and civil-society organisations can play strong roles in protecting the environment. In New Zealand, the Sustainable Business Council provides support for member businesses to improve their sustainability practice "because businesses can only be successful in the long term when people live well and within the limits of the planet" (Sustainable Business Council, 2017).

Q34 **Who are the most important players in driving forward New Zealand's transition to a low-emissions economy?**

Managing impacts on vulnerable households and businesses

Achieving large emissions reductions in order to transition to a low-emissions economy will be disruptive to many businesses and households, and will affect some people more than others. The inquiry will examine these impacts, and measures to address them, since they have the potential "to affect broader economic objectives for increasing wellbeing and achieving higher living standards …[and] increasing equity, social cohesion, and resilience to risk" (Terms of Reference, p. 2).

Applying measures that effectively incentivise emissions reductions (such as a carbon price) raises questions about the need for, and scale and duration of compensation for significantly affected parties. The NZ ETS, for instance, allocated free NZUs to some businesses as various sectors entered the scheme, and continues to do so. The rationale for this free allocation is to give firms time to adjust and to retain international competitiveness.

Policies such as an emissions price could also raise household costs, such as for fuel and food. This is important because low-income households spend a greater proportion of household income on these items than better-off households (Insley & Meade, 2008). In New Zealand, income support through tax credits and welfare benefits are adjusted for consumer price inflation, and so this offers some protection for more vulnerable households. Yet the consumer price index may not accurately reflect the actual price increases faced by low-income households relative to higher-income households.

Impacts of climate change policies are also likely to be uneven across different parts of New Zealand society. For example, the Climate Change Iwi Leaders Group argues that:

> Māori households are much more vulnerable to downstream costs created by an ETS. They are less likely to be able to absorb these costs and are unable to easily invest in alternatives to reduce their own costs to offset the ETS (CCILG, 2016, p. 10).

Significant changes in land use and economic activity in different communities may occur during the transition to a low-emissions economy. This would have consequences for patterns of employment both on the land and in downstream processing, with the impact of such changes falling differently across diverse groups of land owners. For instance, Insley and Meade argue (in relation to the potential inclusion of agriculture in the NZ ETS) that

> [t]he risk for Māori is that free NZU allocations will favour [existing] intensive and high-emissions farming, constraining Māori moving out of less-intensive and low-emissions farming into higher-intensity farming, further exacerbating the relative under-development of Māori land (2008, p. 46).

Efforts to reduce emissions will likely make some technologies and associated capital and skills redundant. The speed of the transition is particularly relevant to this point. Policies that aim to reduce adjustment costs for firms and employees, such as via re-training, may therefore also be needed (Frey & Osborne, 2013; NZPC, 2014a).

Q35 **What measures should exist (and at what scale and duration) to support businesses and households who have limited ability to avoid serious losses as a result of New Zealand's transition to a low-emissions economy?**

A strategy and a vision for New Zealand's future

Many valuable processes are underway, within and across sectors, in New Zealand to address different aspects of climate change mitigation. However, a low-emissions strategy that has broad support and understanding across different groups and sectors does not yet exist.

New Zealand has made a commitment under Article 4, paragraph 19 of the Paris Agreement to develop a long-term low GHG emissions development strategy. This strategy, in essence, describes how New Zealand will achieve its Nationally Determined Contribution (NDC)[21] to the global climate change mitigation effort and must be lodged with the UNFCCC by 2020.

While under the Paris Agreement countries have the option to invest in emission reductions in other countries, enabling guidelines and mechanisms to do so are not yet in place. While this option may prove useful in the future, keeping global temperatures under the 2°C limit is very likely to mean most countries, particularly developed countries, having to substantially reduce their *domestic* net emissions. The central consideration therefore is what New Zealand's strategy should be towards achieving domestic emissions reductions.

Many different strategies and pathways for low-emissions transitions are possible. The key will be to choose the right elements that make the greatest sense for New Zealand's unique transition. It will also be important that the system focuses on most effectively reducing New Zealand's largest sources of emissions over the long-term, as well as those that will have the most impact in transitioning the economy as efficiently as possible towards a low-emissions future.

The IPCC (2014) argues that achieving carbon neutrality by 2100 will require action across four pillars including fuel shifting (ie, electrification) in transport, heating and industry; and greater efficiency and less waste in all sectors. In their 2015 report *Decarbonizing development*, the World Bank identifies three broad principles that should guide countries' low-emissions efforts:

- Planning ahead with an eye on the end goal: Implementing a mix of cheap, quick fixes that are sector-specific, as well as locking-in costlier, longer-term measures that support technology development and low-carbon infrastructure.
- Supplementing carbon pricing with other policies: Recognising that carbon pricing alone will be insufficient, so creating a policy package that triggers changes in patterns of investment, technologies and behaviours.
- Managing the political economy and smoothing the transition for those who are most affected: Ensuring that climate policy is attractive for the majority, and avoiding impacts appearing to be unfair or concentrated in a region, sector or community.

Motu's *Low emissions future dialogue* (Leining & Kerr, 2016) identified several necessary components for a low-emission development strategy, such as an economic (benefit-cost) case for accelerating mitigation action, long-term mitigation goals, and a list of agreed short- and medium-term mitigation policies and actions.

To highlight one aspect of these suggested pathways, making the economic case for accelerated mitigation action is particularly relevant given that most economic cost-benefit appraisals of the case for urgent mitigation action are overwhelming net positive compared with the alternative of mild or zero action. Yet many individual people, businesses, communities and industries will suffer disruption and loss from bold action. This is at the core of what makes devising an effective emissions-reduction strategy so hard.

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[21] New Zealand's NDC describes New Zealand's commitment to mitigating GHGs between 2021 and 2030 (New Zealand Government, 2017). NDCs for all countries must be submitted to the UNFCCC by 2020 and every five years thereafter.

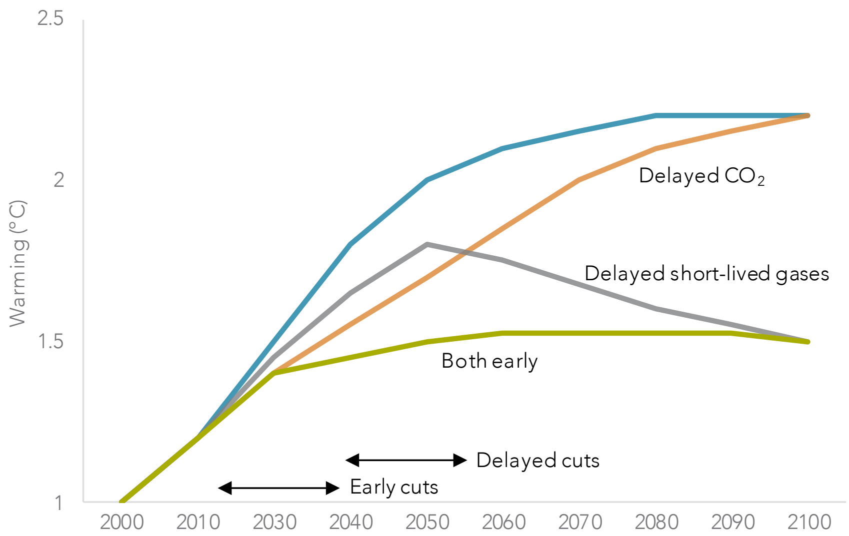
Q36 **What are the essential components of an effective emissions-mitigation strategy for New Zealand that will also be economically and politically sustainable?**

The "two baskets" approach

An important question feeding into New Zealand's strategy towards a low-emissions economy is whether the country should follow what is known as the "two baskets" approach. At the moment, all GHG emissions are treated in the same way for the purposes of emissions accounting – they are all converted into carbon dioxide equivalent, or CO_2e. As explained in Chapter 2, this means that a one tonne reduction of CO_2 can be substituted for an equivalent reduction of another gas, such as methane (CH_4). However, the two baskets approach, broadly speaking, treats long-lived gases such as CO_2 differently to short-lived gases such as CH_4. This is because of the length of time that CO_2 remains in the atmosphere – up to hundreds of years – which means that cumulative emissions of CO_2 are the main driver of global mean surface warming (IPCC, 2014).

It is vital to reduce CO_2 emissions to zero as soon as possible to have any chance of keeping global temperature increases to 2°C (Figueres et al., 2017). But, because short-lived gases have less influence on long-term warming, delays in reducing them, or even whether they should reach zero or can just be reduced to lower levels, is arguably less important (Figure 16).

Figure 16 Stylised depiction of the impact of delayed emission cuts



Source: Allen (2015)

Note: The graph depicts the possible impact of delayed emission cuts of CO_2 and short-lived gases, together and separately, on global temperatures. Grey line: short-lived gases cuts delayed, CO_2 cuts initiated now. Orange line: CO_2 cuts delayed, short-lived gases cuts initiated now.

One rationale for the two baskets approach therefore is to ensure a focus on reducing CO_2 emissions in the immediate term. Another implication is that emissions of short-lived gases "only have an impact on peak warming under circumstances in which CO_2 emissions are either already falling or about to fall rapidly" (Allen, 2015, pp. 15-16). Or, as the Parliamentary Commissioner for the Environment notes:

> If the flow of these [short-lived] gases into the atmosphere levelled off, and there were no other GHG emissions, the temperature of the atmosphere would stabilise in a few decades. But the higher the level, the higher the temperature would be (PCE, 2016, p. 78).

This is especially pertinent to New Zealand because of the substantial contribution of CH_4, a short-lived gas, from agriculture to New Zealand's emissions profile. Taking a two-baskets approach could mean setting separate emissions objectives and targets, or using separate pricing schemes, for long-lived and short-lived gases. There is increasing discussion of and support for such an approach in New Zealand and internationally (Allen, 2015; Generation Zero, 2017; Upton, 2016; World Bank, 2015). If it was followed, it would greatly influence what a low-emissions future for New Zealand would mean and look like.

Q37 **Should New Zealand adopt the two baskets approach? If so, how should it influence New Zealand's emissions reductions policies and long-term vision for the future?**

Emissions leakage

New Zealand is a world leader in agricultural production with relatively low emissions because of its long experience as an efficient export-oriented producer (Chapter 3). Because of its energy sources and efficiency, Tiwai Point claims to produce very low emissions aluminium compared to most international competitors (Bennett, 2007). If New Zealand businesses face a higher carbon price than international competitors, there is a risk that some production will move to "dirtier" producers overseas, with an increase in global emissions. In the case of agriculture, New Zealand's support for low-emissions agricultural R&D could also be put in jeopardy.

It makes sense for New Zealand to take account of other country's climate change policies, in deciding how to apply its own policies domestically. As Vivid Economics (2017, p. 19) states, "there is a growing body of evidence on how to design emission mitigation policies in a way that can help alleviate such concerns". Currently New Zealand provides free allocations to trade-exposed and emissions-intensive industries under the NZ ETS (Chapter 2).

Q38 **How should the issue of emissions leakage influence New Zealand's strategy in transitioning to a low-emissions economy?**

Benefits from a decarbonised economy

The specific benefits to New Zealand from transitioning to a low-emissions economy are varied. They may include potentially transformative breakthroughs in agricultural emissions reductions technologies that could revolutionise local and global food production, through to the development of more liveable and resilient cities that would benefit the majority of New Zealand's population who live in urban areas. New Zealand's international reputation could also be improved by taking decisive action on climate change as it would serve to back up the "clean and green" reputation that underpins much of the export economy (Chapman, 2015).

The benefits of transitioning to a low-emissions economy can also be thought of as the avoided costs of *not* transitioning. Much of the discussion around climate action suggests that it will be costly. For example, a common theme is that incomes will rise, but just not as quickly as they would do otherwise. More recently, a better understanding of what the impacts of climate change will mean has led to estimates that GDP *losses* arising from a *lack* of climate action could be as high as 10-12% annually on a global scale by 2100 (OECD, 2017b).

Regardless of whether the two baskets approach is adopted, the Commission understands that the implication of the commitments made under the Paris Agreement to limiting temperature increase to 2°C is a transition to a zero net CO_2 emissions economy[22] domestically over this century. Given New Zealand's position as a developed economy, it is also likely that this goal should be achieved closer to 2050 than 2100 (OECD, 2017b). While this is a very ambitious and challenging goal, it offers many opportunities for the New Zealand economy, overall, to benefit. Specifically, the gains from investing in low emission, climate-resilient infrastructure or green innovation and technology deployment will

> more than offset the impact of higher energy prices, tighter regulatory settings, and high-carbon assets that may become economically stranded before the end of their economic life (OECD, 2017b, p. 21).

Finally, decoupling economic growth from carbon emissions is not only possible, but already underway for many countries, including major economies such as the US, France and Germany. For example, the UK reduced CO_2 emissions by 24% during the 2000-2014 period, while GDP rose 27% - meaning a reduction in carbon intensity of 40% (Carbon Brief, 2016). Even taking into account New Zealand's unusual emissions profile, this shows that it is possible to transition to a low-emissions economy while at the same time continuing to grow incomes and wellbeing.

Q39 **What do you see as the main benefits and opportunities to New Zealand from a transition to a low-emissions economy?**

A shared vision

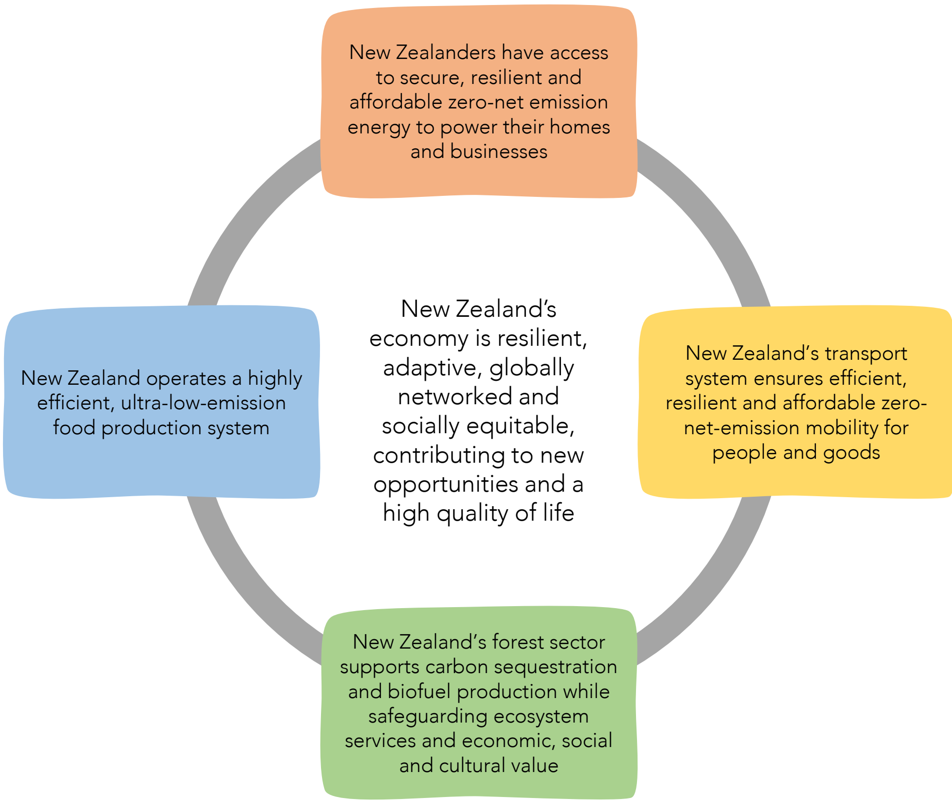
What is also increasingly evident, both from international examples as well as existing work in New Zealand, is the importance of creating a shared vision for the future. This does not imply agreement on every detail of what New Zealand's low-emissions economy should look like. Rather, it is intended to provide a way of ensuring against uncoordinated decisions being made in the present that work against a cohesive, long-term goal. It can also provide a framework within which conversations can be held about relative areas of emphasis and direction that have sufficient buy-in to enable collective action.

A shared vision of the future could be as simple as stating a desire to achieve a zero net CO_2 emissions economy domestically over this century. It could also be more comprehensive. For example, as part of Motu's *Shaping New Zealand's low emissions future* programme (Leining &

[22] A zero net CO_2 emissions economy doesn't mean no CO_2 emissions at all. It means that any remaining CO_2 emissions that are produced are offset through other means such as carbon sinks (eg, forests) or carbon capture and storage (CCS).

Kerr, 2016), the vision in Figure 17 was offered as a starting point for discussion about what a successful zero-net emission economy would look like for New Zealand.

Figure 17 A zero-net emission vision for New Zealand



Source: Leining and Kerr (2016)

A shared vision contributes towards enabling political action to implement ambitious policies (such as occurred with the passing of the UK's Climate Change Act), and helps to ensure that policy and institutional decisions are made that are consistent with and committed to this vision and are not side-tracked by vested interests or short-term priorities. As the World Bank (2015) notes, a strategy that lacks substantial buy-in by affected groups is unlikely to be successful.

The idea of creating a shared vision can also apply across multiple scales. At the global scale, the Paris Agreement represents a "vision of a low-emission, climate-resilient future; a climate-neutral world in the second half of the century" (Espinosa, 2016). Local Government New Zealand, in the context of future-proofing New Zealand communities towards 2050, also highlights the imperative of having a shared vision for the future to plan in the best interests of future generations at a local scale (LGNZ, 2016). This is not to say that this vision can or should not change over time. Indeed, it should be able to be adaptive and responsive to changing circumstances, particularly as the physical impacts of climate change become increasingly apparent and which may provide the impetus for more decisive action.

Q40 **What does your long-term vision for a low-emissions economy look like? Could a shared vision for New Zealand be created, and if so, how?**

Summary of questions

Q1	How can the Commission add the most value in this inquiry?
Q2	Chapter 3 of this issues paper mostly looks at ways to reduce emissions directly at their source. What other approaches would help identify opportunities to effectively reduce emissions?
Q3	To what extent is it technically and economically feasible to reliably measure biological emissions at a farm level?
Q4	What are the main opportunities and barriers to reducing emissions in agriculture?
Q5	What are the issues for government to consider in encouraging alternative low-emissions land uses?
Q6	What are the main barriers to sequestering carbon in forests in New Zealand?
Q7	What policies, including adjustments to the New Zealand Emissions Trading Scheme, will encourage more sequestering of carbon in forests?
Q8	What are the main barriers to the uptake of electric vehicles in New Zealand?
Q9	What policies would best encourage the uptake of electric vehicles in New Zealand?
Q10	In addition to encouraging the use of electric vehicles, what are the main opportunities and barriers to reducing emissions in transport?

Q11 What are the main opportunities and barriers to reducing emissions from the use of fossil fuels to generate energy in manufacturing?

Q12 What changes will be required to New Zealand's regulatory, institutional and infrastructural arrangements for the electricity market, to facilitate greater reliance on renewable sources of energy across the economy?

Q13 What evidence is there on the possible physical effects of future climate change on sources of renewable energy in New Zealand, such as wind, solar and hydro power?

Q14 Apart from the regulation and operation of the electricity market, what are the main opportunities and barriers to reducing emissions in electricity generation?

Q15 What are the main opportunities and barriers to reducing emissions in industrial processes (such as the production of steel, aluminium and cement) and in product use (such as the use of hydrofluorocarbons in refrigeration and air conditioning equipment)?

Q16 What policies and initiatives would best promote the design and use of buildings that produce low greenhouse gas emissions?

Q17 What are the main opportunities and barriers to reducing emissions in waste?

Q18 Policies to lower emissions from particular sources, technologies and processes can have interactions with emission sources in other parts of the economy. What are the most important interactions to consider for a transition to a low emission economy?

Q19 What type of direct regulation would best help New Zealand transition to a low-emissions economy?

Q20 Acknowledging the current review, what changes to the New Zealand Emissions Trading Scheme are needed if it is to play an important part of New Zealand's transition to a low-emissions future?

Q21 What type of market-based instruments would best help New Zealand transition to a low-emissions economy?

Q22 What type of support for innovation and technology would best help New Zealand transition to a low-emissions economy?

Q23 How can New Zealand harness the power of financial institutions to support a low-emissions transition?

Q24 What type of alternative approaches (such as voluntary agreements or support for green infrastructure) would best help New Zealand transition to a low-emissions economy?

Q25 In addition to "core" climate policies and institutions, what other changes to policy settings or institutional frameworks are required to effectively transition New Zealand to a low-emissions economy?

Q26 What are the main uncertainties affecting New Zealand businesses and households in considering investments relevant to a low-emissions future? What policies and institutions would provide greater confidence for investors?

Q27 What approaches, such as regulatory frameworks or policy settings, would help embed wide support among New Zealanders for effective reduction of domestic greenhouse gas emissions?

Q28 Is New Zealand's current statutory framework to deal with climate change adequate? What other types of legislation might be needed to effectively transition towards a low-emissions economy?

Q29 Does New Zealand need an independent body to oversee New Zealand's domestic and international climate change commitments? What overseas examples offer useful models for New Zealand to consider?

Q30 How can adaptability best be incorporated into the system supporting New Zealand's low-emissions transition?

Q31	**What types of analysis and underlying data would add the greatest value to this inquiry?**
Q32	**What should be the mix, and relative importance of, different policy approaches (such as emissions pricing, R&D support, or direct regulation) in order to transition to a low-emissions economy?**
Q33	**What are the main co-benefits of policies to support a low-emissions transition in New Zealand? How should they be valued and incorporated into decision making?**
Q34	**Who are the most important players in driving forward New Zealand's transition to a low-emissions economy?**
Q35	**What measures should exist (and at what scale and duration) to support businesses and households who have limited ability to avoid serious losses as a result of New Zealand's transition to a low-emissions economy?**
Q36	**What are the essential components of an effective emissions-mitigation strategy for New Zealand that will also be economically and politically sustainable?**
Q37	**Should New Zealand adopt the two baskets approach? If so, how should it influence New Zealand's emissions reductions policies and long-term vision for the future?**
Q38	**How should the issue of emissions leakage influence New Zealand's strategy in transitioning to a low-emissions economy?**
Q39	**What do you see as the main benefits and opportunities to New Zealand from a transition to a low-emissions economy?**
Q40	**What does your long-term vision for a low-emissions economy look like? Could a shared vision for New Zealand be created, and if so, how?**

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Terms of reference

New Zealand Productivity Commission Inquiry into the Opportunities and Challenges of a Transition to a Lower Net Emissions Economy for New Zealand

Issued by the Minister for Climate Change Issues, the Minister of Finance, and the Minister for Economic Development (the "referring Ministers").

Pursuant to sections 9 and 11 of the New Zealand Productivity Commission Act 2010, we hereby request that the New Zealand Productivity Commission ("the Commission") undertake an inquiry into how New Zealand can maximise the opportunities and minimise the risks of transitioning to a lower net-emissions economy.

Context

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

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

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

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

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

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

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

Scope and Aims

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

Two broad questions should guide the inquiry:

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

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

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

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

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

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

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

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

In particular the inquiry should include the following:

- the role of the NZ ETS in supporting New Zealand to transition to a lower net emissions economy, building on the Ministry for the Environment's Stage II review

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

Report and Recommendations

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

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

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

Exclusions

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

Consultation

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

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

Timeframes

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

HON PAULA BENNETT, MINISTER FOR CLIMATE CHANGE ISSUES
HON STEVEN JOYCE, MINISTER OF FINANCE
HON SIMON BRIDGES, MINISTER FOR ECONOMIC DEVELOPMENT

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