Ministry for the Environment
Manatū Mō Te Taiao

Zero Carbon Bill Economic Analysis:

A synthesis of economic impacts

Produced to support the

***Our Climate, Your Say* discussion document**

New Zealand Government

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It is uncertain how the future will unfold. So we have looked at a series of economic analyses, models and other studies to assess the implications for the New Zealand economy. These studies can help us look ahead, but each has different strengths and weaknesses.

The models used are complex and so it is useful to understand – in broad terms – how they work. While modelling gives us a reasonable view through to 2030, looking forwards to 2050 is unusual for this kind of modelling, and means we are stretching the models we have to their limits.

No single model can give a complete picture of all challenges and benefits that a new target might create, and not a single report comparing all the costs and benefits in an easy way is available. Instead, each of the underlying reports tell a different part of the overall story.

This report attempts to synthesise all our economic analyses. The economic analysis is just one input into choices regarding targets. It should best be considered alongside other important considerations, such as our international standing and aspirations for leadership globally, and the brand our businesses are able to project internationally.

What will actually happen will depend on the actions of individual businesses and households, and policy choices by future governments. Overall, the economic analysis has looked broadly at the following areas.

- **Modelled challenges for the economy – growth, households and sectors**: Two different modelling approaches have been used – a 'top-down' New Zealand Institute of Economic Research (NZIER) model and a 'bottom-up linked sector' model developed by Concept Consulting, Motu Economic and Public Policy Research and Vivid Economics (Vivid).
- **The competitiveness challenges businesses may face and the potential for others to innovate faster:** Climate action to meet the new 2050 targets could have competitiveness impacts on our businesses, but could also drive faster innovation.
- **The wider co-benefits to climate action**: There are potential co-benefits of policies designed to achieve lower emissions (eg, health outcomes), or the emissions benefits of other policies like transport policy to reduce congestion.

This synthesis report mirrors the above analytical framework and explains the key findings across the economic reports.

Key findings

This report tells us our economy can continue to grow under any of the 2050 target options, just not as quickly as it might have done without any further climate action. It is, of course, highly unlikely we would take no further action on climate change in the period to 2050, given our current domestic target and our international commitment to the Paris Agreement.

To keep our economy growing, we would need to substantially expand our forest estate while continuing to innovate. Unless the Government takes action to ensure a just and fair transition, which it intends to do, some households and sectors could face higher costs and more disruption than others. Table 1 summarises the economic challenges and opportunities with strong climate action to reach new 2050 targets.

Table 1: Summary of the opportunities and challenges

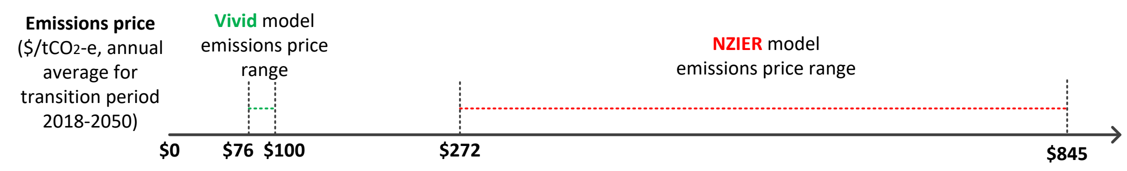
Opportunities	Challenges
We could see: • higher rates of innovation in sectors exposed to a higher emissions price, leading to an up-lift in productivity • new business opportunities in lower emissions sectors • less time wasted in traffic congestion and improved health from switches to public and active transport • health benefits from warmer and drier homes • if the rest of the world acts as well, reduced impact on our economy from climate change.	We could face: • slower rates of economic growth as a result of higher emissions prices and other transition policies • competitiveness issues in trade-exposed emissions-intensive industries • decline in output and jobs for higher emissions sectors • slower rates of growth in household incomes.

Key findings from the economic analyses presented are:

Modelled challenges for the economy – growth, households and sectors	The economic modelling suggests meeting a new 2050 target while growing our economy is achievable, but it will not come for free and it won't be without challenges. Our economy can continue to grow under any of the 2050 target options, but not as quickly as it might have done without any further climate action. The modelled rate of economic growth depends on the target we aim for, and how innovation in key emitting sectors develops. A strong economy will require innovation and a lot of trees. Emissions prices could be higher and growth rates lower if we do not plant enough trees or continue to innovate, or the impacts could be milder if we plant more trees or innovate faster. By 2050, per household national income would still have increased by 40 per cent, instead of 55 per cent if no further climate action is taken. The more ambitious the target, the higher the emissions price will be to incentivise the behavioural changes necessary to meet the target.
Some businesses will face competitiveness challenges, others will innovate faster	With strong climate action, businesses exporting to overseas markets may become less competitive if the climate actions lead to higher costs than their overseas competitors. Yet international evidence suggests a close link between strong climate action and increased rates of innovation. Areas that New Zealand is already leading the research and development in (eg, agricultural research and development) could benefit from first-mover advantage. New sectors may emerge and new business opportunities could arise.
Emissions reductions policies can have substantial upsides, or policies targeting other objectives; for example, reducing congestion, can also reduce emissions	While the benefits stronger climate action could deliver are often more difficult to quantify than the economic costs, many studies have calculated substantial wider benefits of transitioning to a low-emissions economy or estimated the scale of the problem. Significant wider co-benefits of stronger climate action include reduced congestion, health benefits, cleaner air, cleaner water and improved biodiversity. Further, policies designed to address other objectives (eg, congestion), could have flow-on emissions-reducing effects.
There are upsides if the whole of the world acts	Avoiding the costs of damage caused by a changing climate is likely to represent a substantial benefit of climate action. The whole world needs to act to avoid the damages from climate change Recent modelling analysis published in the *Nature* journal (Burke et al, 2018) suggests limiting global warming from climate change to 1.5 degrees Celsius by mid-century could lead to an increase in global gross domestic product (GDP) of 1.5 to 2 per cent and avoid damages from climate change globally of approximately NZ $11 trillion to $16 trillion.

Given the difference in modelling approaches across the Vivid and NZIER studies, and the range of scenarios considered, we think it is plausible that the relative costs and benefits of transition may fall somewhere in between the Vivid and NZIER results. Vivid suggest annual average emissions prices for the period 2018-2050 in the range \$76-\$100 per tonne of CO_2-e and the NZIER modelling suggests, for given innovation scenarios, a range of \$272-\$845 per tonne of CO_2-e (see figure 1).

Figure 1: A range of modelling results on emissions prices



The analytical results infer potentially challenging impacts of climate action, but in the absence of additional government policy to drive and support the transition. Yet as highlighted in the discussion document, the Government is committed to an approach that includes policies to support a fair and inclusive transition - and so the modelled challenges reported need not eventuate as we go through the transition to lower emissions.

Note that the models omit any wider co-benefits from policies to reduce emissions, and they omit the potential benefit, if the rest of the world also acts, in avoiding damage to the economy caused by a changing climate.

What this may mean for choice of a new emissions target

Modelling and economic analysis gives us a general sense of the trends and the impacts of target options. It shows planting substantial new areas of trees to sequester carbon, supporting innovation and being deliberate about the journey to support economic prosperity and our communities will be important.

Moving to Net Zero Emissions could, under certain modelling assumptions, slow the annual GDP growth rate by about 0.2 per cent from the current domestic target. But if we have assumptions about different levels of innovation, or afforestation, then there could be larger differences in growth rates.

Also doing nothing comes with its own risks, as does delaying embarking on the transition. There may be potential benefits of a planned and well-signalled approach to a transition that could avoid the economic and social impacts of a more abrupt change later.

Reading the economic reports with care

The work informs our choice of a new emissions target, and supports the future transition. The economic analysis undertaken *can* give us a sense of what *could* happen under different scenarios. It can help inform choices to guide actions that could allow us to maximise the benefits and upsides, and minimise or mitigate the risks. Yet the results must be read with care.

1. Introduction: the framework for assessing economic impacts

Summary

A suite of economic analyses and reports have been developed to support consultation on the options for a new 2050 target. This synthesis report presents the key findings across separate underlying reports.

The economic analysis undertaken can give us a sense of what could happen under different scenarios. Overall, the economic analysis has looked broadly at three areas: the potential challenges for the economy, households and industries (and the differing impacts on emissions-intensive and on low-emissions sectors); how taking action to meet climate targets could both have implications for industry competitiveness and serve to drive faster innovation; and the potential upsides to climate action.

The results must be read with care; the models are not perfect predictions or forecasts. What will actually happen will depend on the actions of individual businesses and households, and future policy choices by governments.

The analysis supports the current consultation

The Zero Carbon Bill proposes a new long-term emissions reductions target. The *Our Climate, Your Say* discussion document (Ministry for the Environment, 2018) seeks views on proposals including a new emissions target that could replace our current target of 50 per cent reduction below 1990 levels by 2050.

Recent analysis suggests limiting global warming to 1.5 degrees Celsius instead of 2 degrees Celsius by mid-century could lead to an increase in global GDP of 1.5 to 2 per cent and avoids damages from climate change globally of around $11 trillion to $16 trillion (Burke et al, 2018).[1]

There are plenty of ways New Zealand can take action. We can increase renewable energy generation, plant more trees, invest in new technologies, shift our cars and trucks to electric and invest in public transport. We can also continue our world-leading research exploring how to reduce emissions on farms.

It is uncertain how the future will unfold. So we have looked at a series of economic analyses: models and other studies to assess the implications for the New Zealand economy and to get a general sense of the range of economic impacts of our target options. This includes how they might affect different sectors, regions and households. These studies have been carried out by several experts, including independent external experts and officials.

These studies can help us look ahead, but each has different strengths and weaknesses. The models used are complex and so it is useful to understand how they work. This document provides a synthesis of the separate economic analyses.

The economic analysis should best be considered alongside other important considerations, such as our international standing and aspirations for leadership globally, and the brand our

[1] Note the avoided damages are calculated using a three per cent discount rate, and mid-century refers to the period between years 2046 to 2065.

businesses are able to project internationally. We also want to consider how actions we take to reduce domestic emissions support other outcomes, such as improved housing, health and cleaner waterways.

The *Our Carbon, Your Say* discussion document (Ministry for the Environment, 2018) contains consideration of these other policy objectives and analyses that is wider than the economic analysis outlined in this synthesis report.

You can have your say by providing feedback through the *Our Climate, Your Say* consultation process on our website.

Analytical structure of the synthesis and economic reports

The *Our Climate, Your Say* discussion document seeks views on new policy proposals to address climate change, including a new emissions target to replace our current target of 50 per cent reduction below 1990 levels by 2050. The three target options explored are listed below.

- **Net Zero Carbon dioxide**: reducing net carbon dioxide emissions to zero by 2050
- **Net Zero Long-lived Gases and Stabilised Short-lived Gases**: reduce emissions of long-lived gases to net zero by 2050, while also stabilising emissions of short-lived gases
- **Net Zero Emissions**: net zero emissions across all greenhouse gases by 2050.

This document provides a synthesis of the separate economic analyses

No single model can give a complete picture of all challenges and benefits that a new target might create, and not a single report comparing all the costs and benefits in an easy way is available. Instead, each of the underlying reports tells a different part of the overall story.

Overall the economic analysis has looked broadly at three areas.

- **Challenges for the economy – growth, households and sectors:** Two different modelling approaches have been used – 'top-down' NZIER model and 'bottom-up linked sector' Vivid model:
  - whole-of-economy computable general equilibrium (CGE) modelling to determine emissions prices and GDP impact of different targets (NZIER, 2018). The assumptions on emissions reductions options are, where possible, aligned with the modelling by Vivid
  - bottom-up and linked sector modelling linking rural land use and energy sector models to investigate transition pathways and emissions prices from 2030–2050 to meet different target options (Vivid Economics, 2018).
- **The competitiveness challenges businesses may face and the potential for others to innovate faster:** climate action to meet the new 2050 targets could have competitiveness impacts on our businesses, but could also drive faster innovation.
- **The wider co-benefits to climate action**: there are potential co-benefits of policies designed to achieve lower emissions (eg, health outcomes), or the emissions benefits of other policies like transport policy to reduce congestion.

This synthesis report mirrors the above analytical framework and explains the key findings across the economic reports. Table 2 shows the impacts assessed, provides the references to each full economic analysis or modelling report and explains where to find an overview of the analysis in this report.

Table 2: The analytical approach to assessing the economic impact of climate action

Synthesis Report Part #	Part 2		Part 3		Part 4	Part 5
	CHALLENGES			OPPORTUNITIES		
What did we assess?	Emissions prices	Economic growth and other macro-economic impacts	Competitive-ness challenges	Innovation opportunities	Wider co-benefits	Avoiding damages caused by climate change
How did we assess the economic impact?	Bottom-up modelling and whole-of-economy modelling	Whole-of-economy modelling	Economic analysis of EITE sectors	Economic analysis and review of the international literature	Economic analysis and review of relevant literature	Short review of literature on economic impacts
Where can you find the full report?	NZIER, 2018 Vivid Economics (including Motu & Concept), 2018	NZIER, 2018	Sense Partners, 2018	Ministry for the Environment, 2018 Sense Partners, 2018	Ministry for the Environment, 2018	*No report published*

There are still significant uncertainties about the impacts

The work informs our choice of a new 2050 target, and supports the future transition. The economic analysis undertaken *can* give us a sense of what *could* happen under different scenarios. It can help inform choices to guide actions that could allow us to maximise the benefits and upsides, and minimise or mitigate the risks.

Yet the results must be read with care because of uncertainties and limitations in the analyses we have done. The following points apply across each of the background reports.

- The models are not perfect predictions or forecasts:
  - the economy, technologies, and land uses will evolve and change in the next 32 years, sometimes in ways difficult to understand now. The models cannot capture unforeseen technologies developing or new sectors emerging in response to higher emissions prices as we do not know today what these are likely to be.
  - what will *actually* happen will depend on the actions of individual businesses, consumers and households, and policy choices by future governments.
- Looking back at the changes in technology and shifts in our economy over the past three decades shows we can expect huge changes between now and 2050. While modelling gives us a reasonable view through to 2030, looking forwards to 2050 is unusual for this kind of modelling, and means we are stretching the models we have to their limits.
- Competitiveness risks depend on what action our international competitors take in future, which is uncertain. And innovation is an uncertain and risky process. Our economy is part of the wider global economy, susceptible to global challenges and opportunities. How our trade and international relationships evolve, and the direction of international climate policies will shape our economy and responses.

- Impacts considered in our other research, such as the wider benefits from emissions reduction policies are uncertain. Estimates of these impacts are often illustrative because they are context-specific or based on assumptions due to uncertainties. For example, the nature and scale of any wider benefits can only be determined once specific emissions reduction policies are considered.

All models are designed to simplify reality. Of the models we have used, the Vivid study estimates emissions prices at the lower end of the range, while the NZIER model estimates are at the upper end of the range.

Both models focus on the impact of targets on emissions prices and do not attempt to quantify some potential benefits. For example, the models omit any wider co-benefits from policies to reduce emissions, and they omit the potential benefit, if the rest of the world also acts, in avoiding damage to the economy caused by a changing climate.

So the findings should be read as indicative

The results presented should be treated as indicative only and not predictions of the future, given the uncertainties. Despite this, the results are still helpful as they provide a picture of future trends and the relative differences in impacts from setting different targets.

The reports need to be read as a package. This is because none of these reports in isolation is a complete and full representation of the costs and benefits from a wide transition.

2. Modelling challenges for the economy

Summary

The modelling approaches across Vivid and NZIER differ fundamentally, so the models present a range of results for the impact of targets. This is due to model design, limitations and omitted impacts.

After considering the differences in modelling across Vivid and NZIER and the various scenarios, we think it is plausible the relative costs and benefits of transition may fall somewhere in between the Vivid and NZIER results.

Under any of the 2050 target options, our economy can continue to grow but not as quickly as it might have without any further climate action. Emissions prices will rise and economic growth rates fall if we do not plant enough trees or continue to innovate. On the other hand, the impacts could be milder if we plant more trees or innovate faster.

Some households and sectors are likely to face higher costs and more disruption than others. The Government is committed to an approach that includes policies to support a just and fair transition.

Models provide insights into economic impacts

We have used two different economic models developed by Vivid and the NZIER to gain insights into the economy-wide impacts of reaching different emissions reductions targets.

This part first details the modelling approaches, the limitations and assumptions of both economic models, and explains the proxies applied in the models to represent different 2050 targets. It then presents modelled results of emissions prices to reach different targets. Finally, it presents the macroeconomic impacts of these emissions prices, including on households and sectors.

Key technical reports supporting this part of the analysis are:

- **New Zealand Institute of Economic Research**, 2018. *Economic impact analysis of 2050 emissions targets: A dynamic computable general equilibrium analysis*. NZIER report to the Ministry for the Environment.
- **Vivid Economics**, 2018. *Modelling the transition to a lower net emissions New Zealand: Interim results*. Report in conjunction with Concept Consulting and Motu Economic and Public Policy Research.

Further relevant work includes:

- work currently underway within and for the Biological Emissions Reference Group (BERG). BERG was established in 2016 to bring together agriculture sector stakeholders to collaborate with the Government. The BERG is building the evidence on what can be done now to reduce biological emissions, and the costs and opportunities of doing so. It will publicly release a final report of its findings in mid-2018.

We use two different complementary models

Using two different approaches allows for a richer understanding of economy-wide and sector-level impacts. Metrics considered include emissions prices, GDP growth rates and household income (as measured by gross national disposable income or GNDI)[2] and impacts on specific sectors.

The models Vivid use look at the energy and transport sectors and land use, without modelling most of the interactions between them,[3] and tells us the impact of meeting targets on emissions prices. The Vivid study is made up of two separate sector models: a partial equilibrium land-use sector model and an energy, industry and transport sector model. By linking these two sector models together, Vivid is, in effect, able to model much of New Zealand's emitting sectors.

The NZIER model examines how emissions prices and economic growth might change for different emissions targets. The NZIER model contains information on 111 industries and 201 commodities, covering the economy-wide impact of emissions prices between *all* sectors and markets of the New Zealand economy.

What does an 'emissions price' mean?

The emissions prices we modelled reflect the full cost of transitional policies rather than the price that industry and households will face. For example, if the Government invests in public transport, the prices industry will face could decrease.

Policies such as free allocation of New Zealand units under the New Zealand Emissions Trading Scheme (NZ ETS) for emissions-intensive, trade-exposed industries, and potential future ETS market design decisions, such as price ceilings or floors, can further influence the actual prices faced by emitting businesses.

Each modelling approach has limitations and omissions

There are known limitations specific to each model and omissions of relevant impacts occurring across both models.

The Vivid study provides a detailed sector-level analysis compared to computable general equilibrium modelling (CGE) as applied by NZIER. This detail is important as it captures more low-cost abatement technologies that would be adopted as the emissions price increases.

However, this bottom-up approach does not capture as many of the interactions in an economy and as many of the flow-on impacts across sectors. This risks under-estimating the challenges to the economy of meeting a specific target. By design, the Vivid analysis does not report macroeconomic impacts and so the key economic comparison between the two models is emissions prices.

An advantage of the NZIER CGE model is it can assess the macroeconomic impacts of different targets, such as GDP growth. However, the CGE model is less equipped to represent detailed energy and land-use sector changes than the Vivid study. This is particularly the case for the forestry sector because the costs of increasing afforestation are not included.[4] However, the

[2] Per household GNDI reflects the gross national disposable income divided by number of households as an annual average over the period 2018 to 2050. Note, per household GNDI in 2018 is $187,000. Note also that GNDI is a measure of the total income of New Zealand residents from domestic production and from net income flows with the rest of the world.

[3] The models Vivid use do capture some interactions between energy/land use, through biofuels/biomass availability.

[4] These costs include the opportunity costs of forestry taking over potentially more productive land uses.

model design also does not account for the fact that with higher emissions prices the forestry sector would respond by planting more trees if there was suitable land available.

Both studies build on current economic data making it difficult to accurately predict the responses to higher emissions prices. People and businesses in the future are assumed to behave in a similar way to how we behave today, which is not realistic. We don't know how people and businesses will behave if faced with large increases in emissions prices.

The models assume some technological innovations resulting in emission reductions. The assumed innovations might be viewed as optimistic, and if these fail to occur the transition would be more challenging.

Neither model includes perfect foresight into everything that might happen in the future and do not allow for unforeseen technologies. For example, going back to 1988 and trying to predict what the world would be like in 2018 without any knowledge of the internet seems impossible. Also neither model accounts for some known low-emissions technologies (eg, carbon storage, hydrogen) not currently economic, but could become so with higher emissions prices.

Both models also contain some omissions and fail to include potential upsides of taking action on climate change including the wider co-benefits. Further, neither model includes the economic benefits that can occur with innovation when knowledge spillovers[5] occur.

In summary, these limitations and omissions mean:

- the models Vivid apply could be under-estimating the challenges of transitioning because it does not capture all of the interactions in an economy
- both models could be over-estimating the challenges of transitioning because they under-estimate how people and businesses may adapt and respond to higher emissions prices.

The models also do not consider that New Zealand could reap a potential benefit of avoiding damage to the economy caused by a changing climate if the rest of the world acts too.

Matching proposed new targets with targets it has been feasible to model

The suite of economic analyses has been designed to estimate the impact of a range of 2050 targets proposed in the *Our Climate, Your Say* discussion document: Net Zero Carbon, Net Zero Long-Lived Gases and Stable Short-Lived Gases and Net Zero Emissions.

Given limitations in data availability, it has not been possible to exactly model each of these targets. Due to differences in research questions across the Vivid and NZIER models[6], the targets modelled differ across the models, and for the NZIER model, some are proxies for the actual targets proposed by the Government: it has not been possible to explore, within the same model, the impacts of achieving separate limits for long-lived and short-lived gases.

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[5] Knowledge spillovers reflect benefits to other sectors from innovation in low-emissions technologies. Examples include innovations in biofuels that have provided benefits to the chemicals industry (see European Commission, 2017).

[6] The Vivid study was co-commissioned by the Productivity Commission and Ministry for the Environment, in the context of the Productivity Commission's Inquiry. The Vivid modelling initially sought to answer the more general research question of exploring transition pathways to lower emissions in the second half of the century. This scope was later amended to include achieving net zero emissions at 2050, but did not include explicit consideration of the other targets. However, the Vivid study did also model the target of reducing domestic emissions to 25 Mt of CO_2-e by 2050, which is approximately 60 per cent below 1990 levels.

Table 3 explains how the 2050 targets proposed in the *Our Climate, Your Say* discussion document align with the targets modelled by Vivid and NZIER. The NZIER 2050 target of 50 per cent reduction of emissions accurately represents the current domestic target, and also acts as a proxy for reaching Net Zero Carbon by 2050.

A Net Zero Carbon target is likely to be more challenging to achieve than the current domestic target. That is because it constrains the economy to reduce overall emissions to a similar level of the current target, but with all mitigation coming solely from carbon dioxide emitting sources. In other words, if emissions reductions are shared across all types of gases, achieving the target could have less impact on the economy than if we only target carbon dioxide.

Table 3: Comparison of proposed 2050 targets and those modelled by Vivid and NZIER

<table>
<tr><th>2050 targets</th><th>Current domestic target</th><th colspan="2">Net Zero Carbon</th><th>Net Zero Long-lived Gases /Stable Short-lived Gases</th><th>Net Zero Emissions</th></tr>
<tr><td>**2050 target description**</td><td>Reduce all emissions by 50% of 1990 levels</td><td colspan="2">Reduce CO_2 emissions to net zero</td><td>Reduce long-lived gas emissions to net zero and stabilise short-lived gases</td><td>Reduce all emissions to net zero</td></tr>
<tr><td>**Modelled 2050 targets**</td><td colspan="2">50% reduction on 1990 levels</td><td>25 Mt CO_2-e in 2050 (about 60% reduction in 1990 levels)</td><td>75% reduction on 1990 levels</td><td>100% reduction on 1990 levels</td></tr>
<tr><td>**Model(s) using this target**</td><td colspan="2">NZIER</td><td>Vivid</td><td>NZIER</td><td>NZIER and Vivid</td></tr>
<tr><td>**Relationship between modelled and actual 2050 target option**</td><td>Consistent with the current domestic target</td><td colspan="2">Proxy measure of Net Zero Carbon target as the models do not distinguish between different greenhouse gases. However, 50% reduction of emissions on 1990 levels is similar to the emissions reduction expected for net zero carbon by 2050</td><td>Proxy measure of actual 2050 target as the NZIER model does not distinguish between long- and short-lived gases. However, 75% reduction of emissions on 1990 levels by 2050 is similar to the emissions reductions expected for net zero long-lived gases and stable short-lived gases by 2050</td><td>Consistent with Net Zero Emissions target</td></tr>
</table>

Models apply different scenarios for reaching a given target

Both modelling studies develop scenarios to estimate emissions prices for a given target (eg, the NZIER model develops the Energy Innovation scenario). Scenarios are useful in modelling to provide alternative pathways as to how specific sectors and the wider economy may respond to stronger climate action.

Each scenario is defined by a range of underlying assumptions as summarised in table 4 below.[7] These assumptions define the scenarios of mitigations deemed possible, and so, after assuming these things happen, the models then calculate the emissions prices (and other economic metrics) necessary to meet a given target.

[7] For more details of the scenarios and assumptions used in the models see table 2 of the Vivid (2018) report and table 7 of the NZIER (2018) report.

Assumptions for possible mitigations in agriculture across both Vivid and NZIER build on work currently underway (which will be published shortly) by the Biological Emissions Reference Group (BERG).[8]

Table 4: Assumptions behind the NZIER model

NZIER model assumptions build on assumptions and results from the Vivid and include scenarios where:

- a NZIER baseline assumes current policy settings remain, it sets: energy efficiency and technological change assumptions based on today's rates; electric vehicles increase to make up 65 per cent of the light vehicle fleet by 2050 based on pricing considerations alone; other countries act consistently with the Paris Agreement, which they also signed; agricultural emissions remain unpriced and no international units are used
- faster energy innovation occurs, driven by higher emissions prices and transitional policies that double the baseline energy efficiency trends across all industries and provide a shift to 98 per cent renewable electricity by 2035 with the remaining 2 per cent used being gas-fired generation in dry years only
- faster transport innovation occurs, driven by higher emissions prices and transitional policies that increase electric vehicle uptake to 95 per cent of the light vehicle fleet and 50 per cent of the heavy vehicle fleet by 2050
- faster agricultural innovation occurs, this sees a methane vaccine introduced in 2030 being adopted across all farms, which reduces dairy emissions by 30 per cent and sheep and beef emissions by 20 per cent. A reduction in global demand for dairy (11 per cent fall in 2050 output from 2015 levels) and sheep and beef (15 per cent fall) is experienced as consumer preferences shift towards lower emissions intensive foodstuffs, such as synthetic meats.

Table 5 indicates the range of scenarios applied in each model and the underlying assumptions behind each scenario.

Table 5: Comparison of scenarios and key assumptions made across NZIER and Vivid

Model	NZIER model			Vivid model		
Scenario	Agriculture innovation	Energy innovation	Wide innovation	Policy driven decarbonisation	Disruptive decarbonisation	Techno-optimist
Assump-tions specific to each scenario	Reduction in global demand for dairy (of 11%), and sheep and beef meat (of 15%) by 2050 due to shift in consumer preferences Methane vaccine introduced from 2030, reducing dairy emissions by 30% and sheep and beef emissions by 20%; 100% adoption over 5 years Forestry sequestration by 2050 of 25Mt (for 50% target), 35Mt (for 75% target), and 50Mt (for 100% target)[9]	Doubling of energy efficiency trends across all industries Electric vehicles uptake to 95% of light vehicle fleet and 50% of heavy vehicle fleet[10] 98% renewables by 2035; rest from gas No additional net forestry sequestration above the baseline	Agriculture innovation and energy innovation scenarios combined	50% increase in the proportion of trips by public transport, walking and cycling	75% increase in the proportion of trips by public transport, walking, cycling Closure of iron, steel and aluminium production in 2025	25% increase in the proportion of trips by public transport, walking, and cycling Methane vaccine introduced from 2030, reducing dairy emissions by 30% and sheep and beef emissions by 20%; 100% adoption

[8] For BERG terms of reference see https://www.mpi.govt.nz/dmsdocument/15196.

[9] These assumptions are based on forestry sequestration levels estimated by Vivid's model.

[10] These assumptions are higher than the electric vehicle uptake estimated by Vivid's model.

Assump-tions common across scenarios	Climate change action by the rest of the world is consistent with action taken by New Zealand (terms of trade unchanged)	No new dairy conversions from 2025 Residential and commercial energy efficiency trends Agriculture commodity and fossil fuel prices
Assump-tions common across models	Emissions from agriculture face an emissions price (except NZIER baseline scenario) Free allocation to emissions-intensive, trade-exposed industries (with differences in phase-out rates across models and scenarios)	

This demonstrates some alignment between scenarios across both models. For example:

- agricultural emissions face an emissions price and the development and use of a methane vaccine
- capacity for more renewable electricity generation
- free allocation for emissions-intensive, trade-exposed (EITE) industries is provided
- increasing forestry as emissions prices rise.

Differences include phase-out rates for free allocation and the level of electric vehicle uptake. The NZIER model allows for a decreasing global demand for dairy and meat in all scenarios, whereas in the Vivid study this only occurs in their more disruptive scenario.

Results for all targets – the economy grows, just less quickly

Modelling results suggest emissions prices will rise

The price of emissions is the common economic metric reported in both models. Expressing accurately the definition of an emissions price in both of the models is not straightforward.

The emissions price estimated represents the economy-wide average cost of climate action to reduce a tonne of CO_2-e to meet a given target when that cost is lower than the cost of abating those emissions. Importantly, the emissions price estimated is not necessarily the price industry will face, and therefore does not necessarily reflect the price of New Zealand Units in the New Zealand Emission Trading Scheme (NZ ETS).

Various conclusions can be drawn from both studies when assessing the emissions prices estimated. These conclusions are that emissions prices:

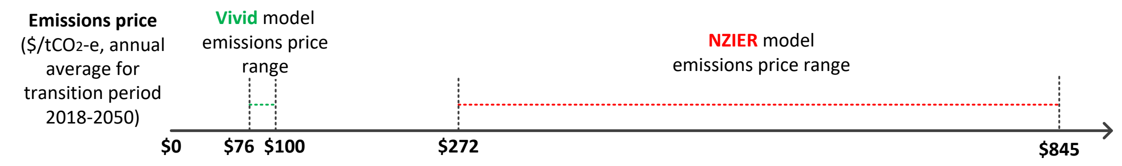
- vary significantly across each model to reach the same target
- are expected to rise, in some cases substantially, from current levels of around $21 per tonne of CO_2-e to reach a given target
- would be lower where greater levels of innovation and/or afforestation are assumed to reach a given target.

To meet Net Zero Emissions, the Vivid study estimates the annual average emissions price over 2018–2050 would be between $76 to $100 per tonne of CO_2-e. The emissions prices in 2050 range from $157 to $250 per tonne of CO_2-e.

The NZIER model results are substantially higher. The NZIER model emissions prices span a wide range, due to varying assumptions about forestry and future innovation across energy, transport and agriculture sectors. For example, to meet Net Zero Emissions, the NZIER model estimates an annual average emissions price for the transition period in the range of $272 per tonne of CO_2-e if we see further afforestation and innovation across energy, transport and agriculture, to $845 per tonne of CO_2-e if we see innovation only in energy and transport, and no additional net forestry sequestration.[11] An annual average emissions price of $272 per tonne of CO_2-e represents a scenario where the price would rise to $652 per tonne of CO_2-e at 2050.

Figure 2 illustrates a wide range of modelling results for emissions prices across the Vivid and NZIER models. The NZIER results reflect the Wide Innovation scenario ($272/t$CO_2$-e) and the Energy Innovation scenario ($845/t$CO_2$-e) that assumes innovation in only energy and transport.

Figure 2: A range of modelling results on emissions prices



This wide range in emissions prices between the models reflect the differences in their structure and the underlying assumptions as outlined previously. However, this wide price range is not unexpected and has been observed elsewhere. Economists Stiglitz and Stern (2017, p. 32) write that:

> *While there is a consensus across models on the technical changes that are needed to maintain climate change below 2°C, models fail to agree on the … [emissions] price required to trigger those changes. Based on the assessment provided in IPCC, scenarios that limit warming to below 2°C with a greater than 66 per cent probability imply carbon prices increasing throughout the 21st century, but with prices ranging from* […] *US$45 to US$1000 per tCO_2-e in 2050.*

As this illustrates, such modelling of economic impacts from stronger climate action out to 2050 is speculative.

Economy continues to grow but less quickly compared to no further action

An important result from the NZIER modelling is that the economy will continue to grow for every target and under every scenario.

In all scenarios modelled by NZIER, the average growth rates remains at 1.5 per cent or higher. If we change assumptions about innovation or afforestation, we would see differences in economic growth rates.

Economic growth, however, is modelled to be slower than if no further climate action were taken (ie, 'Do nothing' baseline). It is, of course, highly unlikely we would take no further action on climate change in the period to 2050, given our current domestic target and our international commitment to the Paris Agreement. Table 6 shows a range of results for meeting the current 2050 target, and other more ambitious targets under varying assumptions of innovation and afforestation.

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[11] Emissions prices at $272 and $845 per tonne of CO_2-e were calculated across 2020–2050, as 2018 and 2019 data points were unavailable.

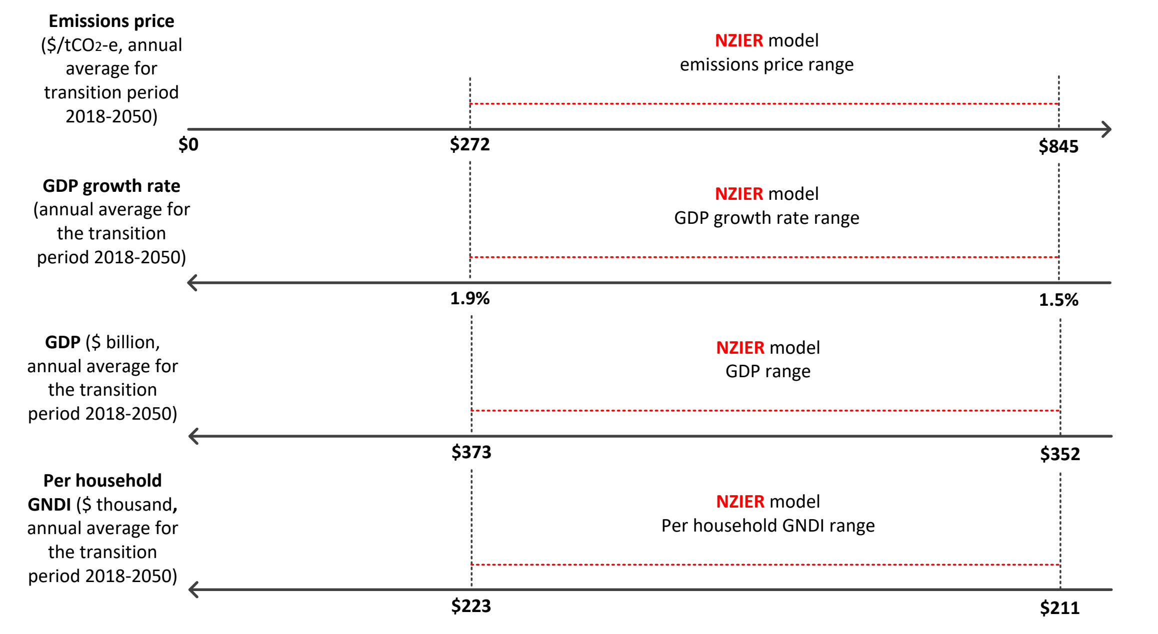
Table 6: Economic growth across scenarios and targets[12]

Target (at 2050)	'Do nothing baseline'	Agriculture innovation			Energy innovation		Wide innovation		
	–	Current target 50%	75%	Net Zero	Current target 50%	Net Zero	Current target 50%	75%	Net Zero
Average annual GDP growth rate over 2017–50	2.2%	1.8%	1.6%	1.6%	1.7%	1.5%	2.1%	1.9%	1.9%
Average GDP per year over 2017–50, $ billion	$386	$367	$359	$357	$359	$349	$377	$371	$370

Source: NZIER

Figure 3 illustrates the range of results from the NZIER modelling to reach Net Zero Emissions, and presents emissions prices, GDP levels, GDP growth rates, and per household income (in terms of gross national disposable income or GNDI[13]). The results shown in all figures are annual averages across the transition period 2018–2050. We can infer that, at the emissions prices the Vivid study suggests necessary to meet the same target, the impact on economic growth would be milder than the NZIER modelling results indicate.

Figure 3: Range of economic impacts to reach the Net Zero Emissions target – NZIER results



12 '50%' represents both Net Zero Carbon and the current 2050 domestic target; '75%' is a proxy for Net Zero Long-lived Gases and Stabilised Short-lived Gases. A 75% reduction on 1990 levels by 2050 has been used as it approximates an outcome where long-lived gases have been reduced to net zero in 2050 and short-lived gases from agriculture have been reduced by 45% from 1990 levels by 2050; Net Zero is Net Zero Emissions.

13 Per household GNDI reflects the gross national disposable income divided by number of households as an annual average over the period 2018 to 2050. Note, per household GNDI in 2018 is $187,000. Note also that GNDI is a measure of the total income of New Zealand residents from domestic production and from net income flows with the rest of the world.

Under a Net Zero Emissions target, the NZIER model indicates that GDP might be in the range of 10 to 21 per cent less by 2050, compared with what it might have been in that year if we had taken no further action on climate change. However, it is highly unlikely we would take no further action on climate change in the period to 2050, given our current domestic target and our international commitment to the Paris Agreement.

If we compare the GDP impact at 2050 of a Net Zero Emissions target to the impact of the current domestic target, the comparable GDP reduction is lower, at 5 to 17 per cent. In dollar terms, the GDP impact in 2050 represents a fall of $25 billion under the Wide Innovation scenario and $85 billion where innovation only occurs in the energy and transport sectors.

In line with GDP impacts, employment grows to reach the new 2050 targets under all scenarios, just not as quickly as if no further climate action was taken.

International market access could lower the economic impacts

The NZIER scenarios assume all reductions in emissions to meet 2050 targets occurs domestically. An illustrative international units scenario was also carried out, which assumed New Zealand has unlimited access to international units at emissions prices in the range of $100–$150 per tonne of CO_2-e by 2050.

In this scenario the economic costs of meeting our climate change targets fall sharply because these prices are low compared to the domestic price, and businesses choose to buy international units rather than reduce their own emissions. However, this scenario assumes access to a substantial volume of high-integrity international units at particular emissions prices which are not guaranteed.

The Government is keeping options open at this point, and has not made decisions about the use of international units in the future.

Plausible impacts may lie between the two economic models

Given the difference in modelling approaches across the Vivid and NZIER models, and the range of scenarios considered, we think it is plausible that the relative costs and benefits of transition may fall somewhere in between the Vivid and NZIER results.

The results presented in table 7 reflect a sample of modelling results indicating key economic metrics that assume more innovation across agriculture, energy and transport, and substantial forest planting – driven by climate change policies.

Table 7: A sample of modelling results on economic growth and emissions prices under 2050 target options, Wide Innovation scenario

		Net Zero Carbon	Net Zero Long-lived Gases and Stabilised Short-lived Gases	Net Zero Emissions
	Assumed forestry sequestration	25 Mt	35 Mt	50 Mt
Economy-wide impact	GDP growth rate[14] (%)	2.1%	1.9%	1.9%
	Absolute change compared with current domestic target	–	↓0.1%	↓0.2%
	Absolute change compared with 'do nothing' baseline[15]	↓0.2%	↓0.3%	↓0.3%
	GDP[16] ($ billion)	$381	$374	$373
	Percentage change compared with current domestic target	–	↓1.7%	↓2.1%
	Percentage change compared with 'do nothing' baseline[17]	↓2.3%	↓4.0%	↓4.4%
Household impact	Per household GNDI[17] ($ thousand)	$228	$224	$223
	Percentage change compared with 2018 GNDI	↑21.8%	↑19.7%	↑19.3%
	Percentage change compared with current domestic target	–	↓1.7%	↓2.1%
	Percentage change compared with 'do nothing' baseline[18]	↓2.3%	↓4.0%	↓4.3%
Strength of climate action	Transition cost ('emissions prices') [18] ($ per tCO_2-e)	$109	$243	$272
	Absolute change compared with current domestic target	–	↑$134	↑$163

Source: Based on work by NZIER, 2018.
Note: GDP = gross domestic product; GNDI = gross national disposable income; Mt = megatonnes; N/A = not applicable; tCO_2-e = tonnes carbon dioxide equivalent.

14 GDP growth rate reflects the annual average GDP growth rate over the period 2018 to 2050.

15 The 'do nothing' baseline has been constructed by NZIER based on Treasury's economic projections and emissions information provided by government agencies. This baseline's emissions projections are higher than those published in the most recent government projections, and this difference means the model could be over-stating the emissions reductions needed to meet each target, and so the impacts on the economy could be milder than modelled. The most recent government emissions projections were not finalised in time to feed into this modelling study but will provide the basis for continued modelling of the transition to low emissions.

16 GDP reflects gross domestic product as an annual average over the period 2018 to 2050. Note, GDP in 2018 is approximately $269 billion.

17 Per household GNDI reflects the gross national disposable income divided by number of households as an annual average over the period 2018 to 2050. Note, per household GNDI in 2018 is $187,000. Note also that GNDI is a measure of the total income of New Zealand residents from domestic production and from net income flows with the rest of the world.

18 Emissions prices are annual averages over the period 2018 to 2050. The emissions price reflects the economy-wide average cost to reduce a tonne of CO_2-e to meet a given target. They do not necessarily represent a forecast for the price of New Zealand Units in the NZ ETS. Note emissions prices were calculated for 2020–2050 as prices were unavailable for 2018 and 2019.

Economic impacts may disproportionately affect lower income households

The NZIER modelling indicates that with Net Zero Emissions, per household national income would still increase by 40 per cent by 2050, compared to 55 per cent if we took no further climate action.

Modelling shows the impact of domestic climate action would be felt more strongly by lower income households, if the Government does not take action to mitigate the impacts, because a higher proportion of their spending is on products and services that are likely to increase in cost as we reduce emissions across the economy. Modelling by Infometrics for the NZIER study suggests the households in the lowest 20 per cent bracket for income may be more than twice as affected, on a relative basis, than those households with an average income.

The uneven distribution of costs across different households is an important part of the reason for taking a planned approach to ensure a just and fair transition.

Emissions-intensive sectors most affected

Some sectors may face a greater challenge, unless there are technical breakthroughs or support, particularly those with high emissions and those competing in international markets and/or that have limited opportunities to reduce their emissions.

Both the Vivid and the NZIER model find that as emission prices increase to meet more ambitious 2050 targets, the sectors likely to face harder choices will be those which have high emissions, compete in international markets, and/or have limited opportunities to reduce their emissions.

Without government policy to support the transition, emissions-intensive sectors (eg, sheep and beef farming, dairy processing, and petrochemical processing) could be more negatively affected than less emissions-intensive sectors (eg, retail services). For example, in some modelling scenarios some sectors could see their output drop by 50 per cent from current levels by 2050. As a consequence of these impacts to these emissions-intensive sectors, modelling results from both NZIER and Vivid also support the conclusion that to reach the 2050 targets the overall economic structure of New Zealand will be very different in 2050 than it is today.

Our transition will raise choices for landowners around what is the most profitable use of their land. For example, some land uses such as horticulture or planting trees on marginal land could become more profitable, so land owners may choose different land-use options.

What this may mean for choice of a new emissions target

The modelling results gives us only a general sense of the economic impacts of target options. It shows that, in all cases, planting substantial new areas of trees to sequester carbon, supporting innovation, and being deliberate about the journey to support economic prosperity and our communities will be important. We should also not lose sight of the fact that doing nothing comes with its own risks, as does delaying embarking on the transition.

An important result from the NZIER modelling is that, for the scenarios modelled, the difference to the economy of moving from the current domestic target to a Net Zero Emissions target could slow the annual growth rate by about 0.2 per cent. But if we have assumptions about different levels of innovation, or afforestation, then there would be larger or smaller differences in growth rates.

The economic analysis should best be considered alongside other important considerations, such as our international standing and aspirations for leadership globally, and the brand our businesses are able to project internationally. We will also want to consider how actions we take to reduce domestic emissions also support other outcomes, such as improved housing, health or waterways.

Many of the economic effects of the transition to 2050 will be felt slowly over time. The Government wants to plan well, to avoid unexpected shocks.

3. Competitiveness challenges and the opportunities for innovation

Summary

Strong climate action could bring competitiveness challenges, especially for emissions-intensive and trade-exposed (EITE) businesses. Competitiveness challenges reflect differences in costs businesses face compared to their overseas competitors.

Evidence indicates climate action stimulates faster innovation rates in low-emissions technologies that are of high economic value. This innovation provides the ability for some businesses to reduce the competitiveness impacts they face.

International evidence suggests competitiveness challenges may be overstated at current emissions prices. However, economic analysis indicates that with higher emissions prices some EITE sectors in New Zealand could be susceptible to competitiveness challenges.

On the other hand, some New Zealand businesses may obtain benefits from increased innovation. For example, businesses in sectors where we are world-leading in our research and development may be able to innovate and so thrive as increased rates of innovation will soften competitiveness impacts from strong climate action. Furthermore, climate policies, such as free allocation, could be applied to also protect from competitiveness impacts.

Strong climate action may bring competitiveness challenges

A new 2050 target will require strong climate action to reach it. The modelling results indicated that emissions-intensive sectors will be the sectors most impacted. These impacts lead to concerns about competitiveness within emissions-intensive and trade-exposed (EITE) sectors. These competitiveness challenges reflect differences in costs that New Zealand businesses face from climate action compared to their overseas competitors. In time, these differences in costs could result in businesses at the margin ceasing operation or shifting their production offshore to countries with weaker climate action causing emissions leakage[19] where global emissions are not reduced (Levinson & Taylor, 2008).

We have already seen from the modelling that there could be significant negative economic impacts on some EITE sectors (eg, sheep and beef farming, dairy processing, and petrochemical processing) with strong climate action. This indicates that challenges regarding competitiveness may be substantial and need to be considered carefully especially with emissions prices much larger than we see today.

EITE sectors can be shielded through free allocation and other supporting policies, but this results in other sectors having to step up their mitigation efforts. Modelling by NZIER indicates that if free allocation were continued at current rates, EITE sectors would be shielded against competitiveness impacts if the rest of the world does not take stronger climate action (NZIER, 2018).

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[19] Emissions leakage is where businesses and economic activity moves overseas and the reduction of emissions in New Zealand is offset by an increase elsewhere. If this happens, global emissions may not fall at all.

Models that produce ex-ante (forward-looking)[20] analysis tend to indicate larger economic impacts from climate action than are observed in ex-post (backward-looking)[21] studies (Sense Partners, 2018). So it is useful to moderate the modelling results observed with the available ex-post evidence of the competitiveness impacts from climate action. While there is limited ex-post evidence of the New Zealand context, there is a growing international literature.

Key technical reports supporting this part of the analysis are:

- **Ministry for the Environment**, 2018. *Emissions pricing impact on innovation and competitiveness: A review of the international literature*. Wellington: Ministry for the Environment.
- **Sense Partners,** 2018. *Countervailing forces*: *Emissions targets and implications for competitiveness, leakage and innovation.*

This part first summarises international ex-post evidence of the impacts of emissions pricing on industry competitiveness. It then details economic analysis undertaken by Sense Partners on the current impacts on competitiveness in New Zealand. Finally, this part investigates potential future competitiveness impacts with stronger climate action in the future.

Evidence suggests competitiveness challenges may be overstated

The evidence in the international literature suggests challenges to be addressed regarding industry competitiveness may be overstated. For example, Arlinghaus (2015, p. 23) when reviewing climate policies concluded that "*most studies reviewed … fail to measure any economically meaningful competitiveness effects as a consequence of these policies*." But the emissions prices investigated in this study are relatively modest. The international literature also indicates evidence that climate action results in small, but significant effects on trade, in some EITE sectors (eg, Chan et al, 2013; Sato & Dechezlepretre, 2015).

On the other hand, some recent studies indicate more remarkable findings (eg, Klemetsen et al, 2016; Dechezlepretre, 2018). For example, Dechezlepretre (2018) when investigating the economic impact of the European Union emission trading scheme (EU ETS) on regulated businesses found that the EU ETS led to emissions reductions, but also to an *increase* in revenues of between seven to 18 per cent.

Strong climate action may stimulate faster innovation

A key question is what factors could counter impacts regarding industry competitiveness. The most obvious explanation is that strong climate action promotes cost-cutting resource efficiency improvements including switching to alternative lower-emissions technologies and fosters innovation in new low-emissions technologies.

The international evidence indicates that climate action stimulates faster innovation rates. For example, Dechezlepretre et al (2016) find evidence that innovation closely correlates with stronger climate action (figure 4). Despite relatively low emissions prices worldwide, much innovation has occurred including wind and solar power, green supply chains, and electric vehicles (Productivity Commission, 2018).

International evidence also indicates low-emissions technologies are of high economic value, and provide knowledge spillovers (eg, biofuels providing spillovers innovations to the chemical

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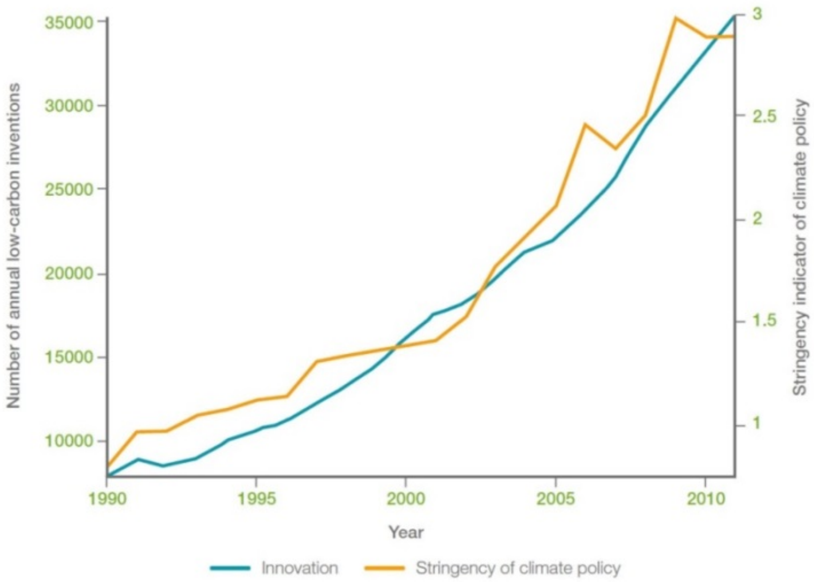
[20] Ex-ante means we look at future events based on possible projections.

[21] Ex-post means we look at events that have actually occurred.

industry[22]) to other supporting sectors (Dechezlepretre et al, 2013). In fact, these spillovers are similar in economic value to those in high-technology industries (eg, robotics), and are mainly received by surrounding local businesses providing a "*potential channel for positive home country effects from unilateral emission pricing* (Dechezlepretre et al, 2016, p. 15)."

The conclusion that businesses respond to a higher emissions price by innovating in new, high value, low-emissions technologies is important. This is because this evidence provides justification for the assumed innovation with stronger climate action as modelled previously, and provides the ability of businesses to reduce competitiveness impacts as faster innovation provides wider options for businesses to lower emissions. Furthermore, many studies identify technological leadership as the core source of first-mover advantage (Lieberman & Montgomery, 1988).

Figure 4: Innovation in low-emissions technologies and strength of climate action



Source: Dechezlepretre et al (2016)

Future innovation potential in low-emissions technologies

Many low-emissions technologies exist today, but are not currently economically viable at current emissions prices. However, many of these technologies are expected to be viable at emissions prices of about \$100/tCO_2-e to \$200/tCO_2-e. For example, using wood or electricity to replace coal in industrial process heat systems such as when milk is processed into dairy products. Not only can we expect new low-emissions technologies to become economically viable with higher emissions prices, but we can also expect the costs of some of these technologies to reduce. Battery technology in electric vehicles is a good example of this in practice.

[22] A significant discussion of knowledge spillovers from low-emissions technologies has been recently reported by the European Commission (2017).

There has been no perceptible impact on competitiveness from the NZ ETS

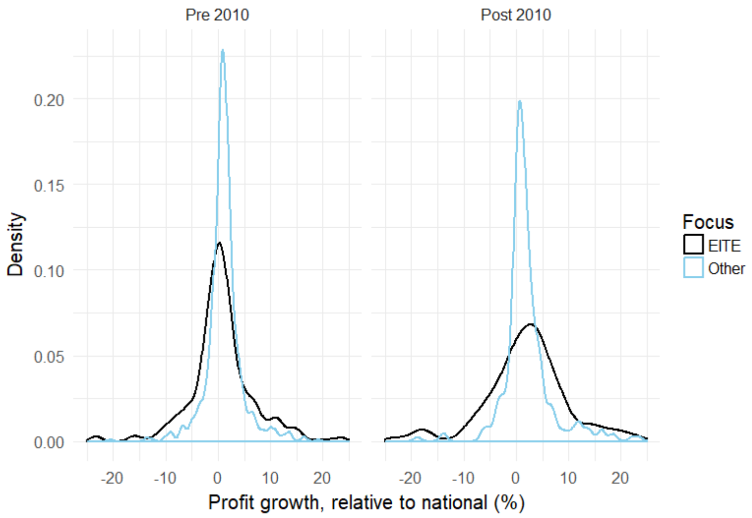
So far we have considered the international evidence regarding competitiveness concerns and the potential of innovation from stronger climate action. But what about New Zealand, where many of our sectors are trade-exposed?

Sense Partners (2018) undertook economic analysis on the impact of current emission prices and found no perceptible impact of the NZ ETS on the competitiveness of New Zealand EITE sectors (figure 5). They also found EITE sectors in New Zealand have experienced growth rates in profit not dissimilar from other businesses. This result could be for many reasons including the relatively modest emissions price currently under the NZ ETS and the availability of free allocation.

But New Zealand may be susceptible to *future* competitiveness challenges

While emissions prices in the NZ ETS are not high by international standards, they are higher currently than most of the countries in Asia Pacific that New Zealand trades with. So competitiveness challenges remain valid especially when we consider that much higher emissions prices with stronger climate action will be required to meet new 2050 targets and we acknowledge the uncertainty of future action from other countries.

Figure 5: No perceptible impacts from the NZ ETS on profit growth of EITE sectors



Source: Sense Partners (2018)

These competitiveness challenges for EITE sectors amplify when it is considered that there is evidence that to meet New Zealand's Nationally Determined Contribution in 2030 could result in a domestic emissions price that is more than three times the emissions price in Australia (Vandyck et al, 2016). That is, based on this evidence the reduction of emissions in New Zealand is likely to be comparatively expensive compared with some, but not all, of our trading partners. For example, the European Union has ambitious emissions reduction targets and under the Paris Agreement all countries are obliged to reduce their emissions.

Sense Partners (2018) analysed the impacts on profits in various EITE sectors of significantly higher emission prices (up to $200/tCO_2$-e) and under a reformed NZ ETS. They found that some EITE sectors can bear quite large changes in emissions prices. But, some industries could become unprofitable even with relatively small increases to emissions prices and therefore risk emissions leakage (eg, petrochemicals). Sense Partners also indicate that risk of emissions leakage to the agricultural sector is more subtle than in some other sectors.

However, Sense Partners (2018, p. 2) caveat their work, noting conclusions regarding competitiveness impacts are highly speculative. They state that their work:

> *… should be taken as cautionary notes, not predictions. In any case, competitiveness is a two-side coin and competitiveness effects depend to a large extent on policy developments overseas. Actual impacts will depend on how fast and how stringently climate policy is applied, both here and overseas.*

Sense Partners (2018, p. 106) also note in relation to their conclusions on the relative levels of New Zealand's possible emissions prices:

> *However, it is not a fait accompli: rather, it is an indication of what might happen and perhaps a cautionary note that climate policy needs to include an adjustment mechanism or monitoring process to ensure that carbon prices do not grow significantly out of step with developments elsewhere in the world and amongst major trading partners.*

Two further points also need to be raised to caveat competitiveness impacts on EITE sectors.

- The Productivity Commission (2018) note that the emissions prices indicated by the Vivid model to reach Net Zero Emissions are within the bounds of emissions prices that the rest of the developed world would need to face to limit global warming to under 2°C, consistent with the Paris Agreement. Hence, at emissions prices reported by Vivid, there may not be large differences in emissions prices amongst New Zealand's developed country trading partners.
- The key factor ignored from the economic analysis of future competitiveness impacts is innovation and the ability of businesses to adapt in response to higher emission prices. This is critical as the international evidence indicates that innovation closely correlates with strong climate action. This innovation, in turn, can soften competitiveness impacts and the potential for emissions leakage.

Will faster innovation rates happen in New Zealand?

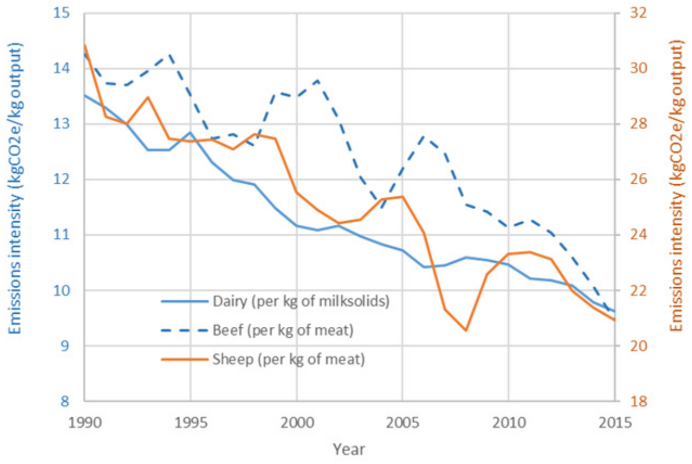
The crux question is whether or not faster innovation rates will happen in New Zealand to soften or offset competitiveness impacts. Especially given the evidence that New Zealand businesses have struggled to innovate in the past in many sectors, and that New Zealand's economy is not a world-leader in economic productivity (Conway, 2016).

New Zealand's productivity levels are likely to be the result of low investment in research and development (R&D) amongst businesses, as well as New Zealand's small market size and distance to overseas markets (Productivity Commission, 2018). These factors provide reasons for Sense Partners to conclude that innovation may not occur fast enough to reduce competitiveness concerns for many EITE sectors with higher emissions prices.

New Zealand, on the other hand, is world-leading in research and development in some EITE sectors (eg, agriculture) that investigates on-farm emissions reductions. In fact, the OECD (2017) has indicated that New Zealand's environment-related R&D accounts for nearly 10 per cent of government research outlays in New Zealand, which is the highest share amongst OECD countries.

Productivity gains and R&D have already contributed to material reductions in emissions intensity over recent decades on sheep, beef and dairy farms. These reductions have been achieved, in part, through improved farm management and stock selection. This has resulted in more than a one per cent per year reduction in emissions intensity, as seen in figure 6 below, even in the absence of an emissions price.

Figure 6: Agriculture emissions intensity between 1990–2015



Source: MPI data

The significance of environment-related R&D is critical to support innovation in low-emissions technologies, especially because there are typically insufficient incentives for businesses to invest in R&D (Acemoglu et al, 2012). The Productivity Commission (2018) conclude that to speed up innovation in low-emissions technologies in New Zealand, there is a need to combine an effective emissions price with R&D support. Hence, Government may need to support our businesses, farmers, entrepreneurs and science and innovation institutions to realise these benefits from innovation.

New Zealand businesses in certain sectors may obtain benefits from increased innovation with higher emissions pricing. For example, businesses in sectors where we are world-leading in our R&D may be able to innovate and so thrive, especially if they are first movers. This innovation could lead to the emergence of more low-emissions technologies and businesses that can provide opportunities for employment and productivity gains. We would expect to see these new business opportunities arise.

The increased rate of innovation could also soften competitiveness impacts from strong climate action. However, it is possible that not all New Zealand businesses exposed to a higher emissions price will benefit. Businesses slow to respond and innovate could be exposed to competitiveness challenges. Importantly, climate policies, like free allocation, could be applied to also protect from competitiveness impacts.

4. Stronger climate action can create substantial upsides

Summary

Stronger action to reduce emissions can create substantial upsides. First, there may be wider benefits from taking stronger climate action besides reducing emissions.

The wider benefits could include reduced congestion, health benefits, cleaner air, cleaner water, and improved biodiversity. They will depend on which measures are taken to reduce emissions, for example, measures which encourage the use of public transport will have different benefits than measures that improve home insulation.

Co-benefits can strengthen the case for reducing emissions and could alter the mix of emissions reductions policies pursued. Careful policy design should aim to maximise the potential co-benefits, and minimise the potential co-costs of a transition to a low-emissions economy.

This part of our economic analysis explores the opportunities stemming from stronger climate action to deliver positive impacts. Many studies have calculated substantial benefits from transitioning to a low-emissions economy. Our analysis relies on a broad scan of this relevant literature, and recent studies quantifying the wider co-benefits from strong climate action.

This part details five key areas where wider co-benefits are foreseen to be substantial with action to reduce emissions and where there is sufficient evidence to support such claims. Recognising the wider co-benefits is important as both the Vivid and NZIER studies are limited in that they do not account for the potential co-benefits from climate action.

Key technical report supporting this part of the analysis is:

- **Ministry for the Environment**, 2018. *The co-benefits of emissions reduction: An analysis*. Wellington: Ministry for the Environment.

Co-benefits from reducing emissions may be substantial

New 2050 targets could lead to specific actions (eg, investment in public transport) to reduce emissions that also bring substantial co-benefits, such as reduced congestion, health benefits, cleaner air, cleaner water, and improved biodiversity.

The Intergovernmental Panel on Climate Change (2014) has noted that in some cases the co-benefits can be as large as, or even larger than, the emissions reductions benefits. So assessing the co-benefits from climate action can strengthen the case for reducing emissions and could alter the mix of policies pursued.

The estimates of co-benefits reported below should be used with care. Co-benefits are difficult to quantify and are even more difficult to compare. Some estimates are context-specific so may not be directly applicable to other situations. Other estimates are an upper bound of the potential scale of the benefit. Whether all of this benefit is captured will depend on the specific policies for emissions reductions implemented. Achieving these impacts may not directly link to target choices – they relate more broadly to the additional benefits to taking actions in New Zealand.

As such, the co-benefits reported are illustrative only. The Government has not yet made decisions on many of the policy options discussed.

Better home insulation could improve health

The potential health co-benefits of improved home insulation are large. Home insulation can increase energy efficiency, reducing demand on electricity generation from fossil fuels. New Zealand has one of the highest rates of asthma in the world, with one in six adults affected. This is likely to be linked to our poor standard of housing; one third of New Zealand homes remain uninsulated (Holt & Beasley, 2001; Gillespie et al, 2013).

Exposure to extreme heat, cold, damp and mould are risk factors in many non-communicable diseases such as respiratory problems and cardiovascular disease (World Health Organization, 2012). Insulation can improve temperatures and reduce dampness and mould, particularly reducing exposure to extremely low temperatures in winter.

The benefit-cost ratio of insulating houses in New Zealand is estimated at 4:1. Retrofitting insulation can help deliver particularly strong health cost savings for at-risk groups (eg, children and the elderly). The bulk of this benefit comes from the health gains rather than emissions reductions as most people choose to keep their energy use high and have a warmer house (Grimes et al, 2012). As a result the relative health co-benefits are far higher than the emissions reductions benefits. The evidence of health co-benefits from improved home insulation is strong.

Shifting road freight to rail could reduce congestion and maintenance costs

Rail can be a more environmentally sound way to move large volumes of freight over frequently used routes. Putting more freight onto the rail network would reduce the number of trucks on the road, leaving greater space for other road users. This would be particularly valuable in congested areas of the network such as peak travel times in cities. Carrying freight by road also increases accident rates. Trucks are generally safer than passenger vehicles, but those accidents involving trucks have far higher rates of death and serious injury (Ernst & Young, 2016).

Ernst & Young (2016) gives an idea of the relative scale of co-benefits based on the current levels of freight use in the rail network. The largest benefit from the current rail freight service comes from reduced congestion on the roads, valued at about $200 million per year. Other benefits are savings of about $80 million per year in maintenance spend, and improvement in safety of about $60 million per year. The total emissions reduction benefit is around $6 million, less than two per cent of the total benefit from the current rail network. However, the potential costs of increased rail maintenance and rail accidents have not been estimated.

The strength of the evidence of reduced traffic congestion is moderate. While it is clear that the co-benefits are large compared with the emissions reductions, it is not well understood what the scope is to switch road freight to rail across the wider New Zealand network.

Shifting to public transport could reduce congestion and improve road safety

The increased use of public transport reduces congestion. Traffic congestion costs households and businesses in Auckland an estimated $0.9 billion to $1.3 billion every year in lost time and economic activity (NZIER, 2017).

Public transport is safer than a private vehicle. The risk of being killed or injured as a passenger in a bus is seven times lower than for driving a car, and four times lower for being a passenger in a car per kilometre travelled (Ministry of Transport, 2015). The road toll in 2017 was 378 deaths and injury numbers have ranged from 11,000 to 13,000 per year over the past few years. The social cost per life saved is $4.14 million (Ministry of Transport, 2017).

Public transport is more fuel efficient than private transport, which reduces air pollution. Around 570 premature deaths occur every year as a result of air pollution (Ministry for the Environment, 2015; Ministry of Health, 2016). Vehicle emissions are likely to be the secondary cause of this, although that will depend on location. For example, in Auckland vehicle emissions are likely to be the key driver of air pollution deaths (Kuschel et al, 2012).

Ernst & Young (2016) estimate that the total value of benefits from the existing passenger rail network in Auckland and Wellington are around $1.15 billion. Of these benefits, almost all are from reduced congestion. The safety benefits are small and account for less than one per cent of the total benefits. The climate benefits of emissions reductions were also less than one per cent of the total. This suggests that for the increased use of public transport, the congestion co-benefits will outweigh climate benefits by a substantial order of magnitude. Ernst & Young (2016) did not investigate air pollution benefits.

The strength of the evidence of the co-benefits of increased public transport use is moderate.

More walking and cycling could reduce congestion and improve health

Increased walking and cycling (ie, active transport) increases the level of exercise overall. Insufficient exercise is associated with higher levels of type 2 diabetes, heart disease, some forms of cancer, and mental health problems (World Health Organization, 2012). Increased active transport also means fewer vehicle kilometres travelled in private cars. This reduces congestion and improves air quality.

However, there is a co-cost associated with a shift to cycling because it is a riskier form of transport per kilometre travelled, which may lead to more transport accidents.

While $630 million in infrastructure investment would be needed to increase the modal share of cycling to 40 per cent, the net benefits are considerable, estimated at over $13 billion by 2050, and give a benefit-cost ratio of 24 to 1 (MacMillan, 2014). Most of the benefits ($12.1 billion) are from reduced mortality as a result of improved exercise levels. Reductions in air pollution are worth another $78 million over that time. However, higher levels of cyclist injuries and fatalities result in an additional cost of $1.45 billion. The health benefits outweigh the climate benefits from reduced emissions by a factor of almost 12 to 1.

We have not found any studies that look at the benefits of active transport on reduced congestion. The evidence of the co-benefits from increased active transport is strong.

More forestry could improve water quality and biodiversity

Land-use change to forestry could reduce nitrogen leaching and soil erosion into waterways. Land used for forestry has lower levels of nitrogen leaching than sheep and beef farming, dairy farming, and some forms of horticulture. New Zealand has relatively high levels of soil erosion. In the South Island erosion is largely due to natural processes, but in the North Island it is the result of human processes, usually the clearing of forest from hill country, and triggered by heavy rainfall (Ministry for the Environment, 2015).

Land-use change to forestry could also help protect the many indigenous species that face extinction, including 81 per cent of resident bird species and 72 per cent of freshwater fish.

These species are at risk in part because of reduced habitat (Ministry for the Environment, 2015).

The value of the co-benefits will depend on where the trees are planted and the type of trees planted. For example, planting trees on riverbanks can prevent more nutrients and soil ending up in waterways. As a result co-benefits are difficult to generalise at a national level.

One study estimates that the ecosystem value of each hectare of plantation forestry was $5600 per year for one catchment (Ohiwa) (Yao & Verlarde, 2014). More than half of this total is made up by benefits related to water quality. Recreation also produced notable benefits. Biodiversity benefits came next, valued at $257 per hectare, and pollination at $206 per hectare. Erosion control was valued at $121 per hectare.

The evidence of the co-benefits from land-use change to forestry is moderate. While there are clearly strong co-benefits, the scale and mix of those benefits will vary greatly depending on where the trees are planted.

5. The global challenge of climate impacts and the timing of taking action

This final part summarises the key economic analysis available on the expected damages from a changing climate, and so the costs that could potentially be avoided if the rest of the world acts to reduce emissions.

While this part explains issues that may not be specific to the choices of one target option over another, it acknowledges the global context within which we are making decisions, and our role as a developed country expected to take a lead on limiting a changing climate.

It also considers the timing of taking action to reduce emissions in New Zealand, and the potential benefits of acting sooner rather than later.

Global leadership to avoid the damage caused by a changing climate

A new policy framework for New Zealand's contribution to address climate change is proposed. The intention is that strong global action will slow temperature rises and avoid further damage to our economies caused by a changing climate. Climate change is already having an impact on New Zealand and the rest of the world. While we have a good understanding of these biophysical damages, valuing the economic costs of these damages is less well understood.

Recent modelling analysis published in the *Nature* journal suggests that limiting global warming from climate change to 1.5 degrees Celsius instead of two degrees Celsius by mid-century could have a significantly beneficial impact globally: an increase in global GDP of 1.5 to 2 per cent and avoided damages from climate change globally of approximately $11 trillion to $16 trillion (Burke et al, 2018).[23]

The full costs from climate change on New Zealand and its economy specifically are difficult to estimate. In many areas there is little economic evidence available as to the impacts from climate change including on migration, water resources, conflict, energy supply, labour productivity, and tourism. While some uncertainties will always remain when analysing impacts of climate change into the future, attempting to get a better understanding of these impacts from climate change on New Zealand will be important as negative surprises are much more likely than similar magnitude positive ones (Tol, 2018). Despite the limited economic evidence on the impact of climate damage on New Zealand, some studies do exist. For example, the OECD (2015) has estimated the economic impact of climate change on New Zealand and Australia (combined) as a one per cent reduction in GDP levels by 2060, maybe up to two per cent.

We also know our exposure to climate change impacts are higher in certain areas, such as our coastal floodplains where most of our population centres are located (Climate Change Adaptation Technical Working Group, 2017). The Intergovernmental Panel on Climate Change (2014) identified key climate risks to New Zealand being continuing sea-level rise and the increased frequency and intensity of flood damage on our low-lying and coastal infrastructure.

[23] The avoided damages is calculated using a three per cent discount rate, and mid-century refers to the period between years 2046 to 2065. The authors report the discounted avoided damages in US dollars as between US$7.7 trillion to US$11.1 trillion.

The Climate Change Adaptation Technical Working Group (2017) also note the example that costs of weather events on New Zealand's land transport network have increased from $20 million per year to $90 million per year in the last 10 years.

In addition to sea-level rise and flooding events, the projected changes to the frequency and intensity of storms will increase the reach of storm surges and king tides and the extent of rising groundwater (White et al, 2017). The Parliamentary Commissioner for the Environment (2015) indicates that the cost of replacing every building within half a metre[24] of the average high tide mark[25] could be $3 billion and within 1.5 metres, as much as $19 to $20 billion[26].

Furthermore, Frame et al (2017) estimated for the period 2007 to 2017 that flood costs attributable to climate change are around $11 million per year. This study also notes that these costs are likely to be underestimates as at least $279 million in weather-related losses were ignored in their analysis.

Costs associated with the 2012–2013 drought have been estimated at $NZ1.5 billion by the New Zealand Treasury based on reduced growth in GDP, compared to a hypothetical year without drought. Harrington et al (2016) estimates that 20 per cent of the risk of weather events is attributable to climate change. Applying this estimate to the costs associated with the 2012–2013 drought yields costs due to climate change to be NZ$300 million (Frame et al, 2017).

It could be beneficial for New Zealand to act sooner rather than later

The Vivid study and the Productivity Commission both commented on the timing of action toward a transition to a lower emissions economy. The Productivity Commission noted that the pace of this transition matters a great deal, and that delaying action risks exacerbating the economic and social costs, since future reductions would need to be much more dramatic and abrupt to compensate. Vivid indicated their results provide general findings that greater technological change and early action through higher emissions prices may help to constrain long-term costs.

The speed at which we reduce our emissions will vary sector by sector, but some areas have long lead times so signalling the benefits of investing in lower-emissions technologies sooner rather than later may avoid locking in emissions for the lifetime of assets. This may matter most in the electricity, transport and forestry sectors.

In some areas it may make sense to allow for new technologies or prices to fall. There is also the need to consider the competitiveness impacts for some businesses of moving more quickly than international partners.

In summary, though again not linked specifically to 2050 target choices, a wider consideration is the potential benefits of a planned and well-signalled approach to a transition that could avoid the economic and social impacts of a more abrupt change later.

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[24] The mid-range projected sea-level rise over the next 50 years is about 30 cm, and could vary between 20 and 50 cm. Note in the past 100 years seas have risen around 14–22 cm in New Zealand ports.

[25] Defined as the Mean High Water Springs.

[26] "The RiskScape analysis (NIWA, 2015) shows that the replacement value of buildings within 50 centimetres of the spring high tide mark is $3 billion and that of buildings within 150 centimetres of the spring high tide mark is $20 billion." *Preparing New Zealand for Rising Seas: Certainty and Uncertainty*: Office of the Parliamentary Commissioner for the Environment, New Zealand. 2015.

Acting sooner rather than later

A recent study from Westpac NZ (2018) found that taking early and planned action on climate change could be less economically challenging, compared with taking delayed, then abrupt action later. The private sector and civil society must be able to plan and take long-term decisions with confidence. Businesses, households and consumers will be better able to manage the risks of moving to a low-emissions economy and plan for the behavioural and structural changes required in a stable and credible policy environment.

Vivid Economics (2018) reports that:

> "*Choices made now will have long term consequences, for instance assets, such as cars and industrial process heat boilers may remain in operation for several decades. Likewise, a land-owner's decision to convert land may have implications for land-use over an extended period. Given these dynamics, it is important to influence these decisions sooner rather than later, to avoid locking-in higher emissions for decades.*"

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