BEC 2050:
A deep dive into the New Zealand energy and transport sector emissions

This deep dive builds on a framework developed as an aid to policy makers and businesses. The insights of this detailed analysis will help focus future effort to shape New Zealand's energy agenda and establish balanced energy policy settings.

Why a deep dive into energy and transport sector emissions?

In 2015 the BusinessNZ Energy Council launched BEC2050: two New Zealand-specific energy scenarios – Kayak and Waka. Based on the work of the World Energy Council (WEC), these scenarios provided two cohesive narratives about New Zealand's energy future to 2050 and quantified the outcomes expected under each scenario.

On 4 November 2016 the United Nations' Framework Convention on Climate Change "Paris Agreement" came into force. This agreement was a major turning point for the global collective effort to minimise temperature rises by limiting greenhouse gas (GHG) emissions. Under the Paris Agreement New Zealand's "Nationally Determined Contribution" (NDC) is a reduction target of 30% in total GHG emissions, below the 2005 level, by 2030 (equivalent to 11% below 1990 levels).

New Zealand's NDC (as well as the global target of zero net emissions by the second half of the century) is clear and unambiguous. Indeed, these targets are almost certain to tighten in the future. However, the future is clouded with uncertainty, as our scenarios illustrate.

This raises the crucial question of how we, as a country, will plan – through our policies and investments – to meet the target.

The BEC2050 modelling allows us to go back and ask more detailed questions about how the energy sector might evolve, in this case investigating the prospects for energy and transport sector emissions. This deep dive sets out the potential contribution the energy and transport sector will make to the total 2030 emissions' target under the Paris Agreement and sheds light on where additional emissions reductions may come from.

The Paris commitment was a total greenhouse gas target; no specific targets have been developed for subsectors (e.g., agriculture, waste, energy and transport). The BEC2050 scenarios only cover the energy and transport sector. Even so, the detail this deep dive provides on the source of emissions in energy and transport and the potential for reductions under each scenario will assist policy setting in the sector and inform the size of the task in other sectors.

BEC2050 at a glance

The 2030 carbon price in NZ	Population grows by	GDP grows by	Energy productivity increases by
NZD18/tCO_2	0.9% per annum	2.1% per annum	1.8% per annum
NZD60/tCO_2	0.6% per annum	1.6% per annum	1.95% per annum

Kayak (blue) Waka (orange)

Find all assumptions at **www.bec.org.nz/projects/bec2050**

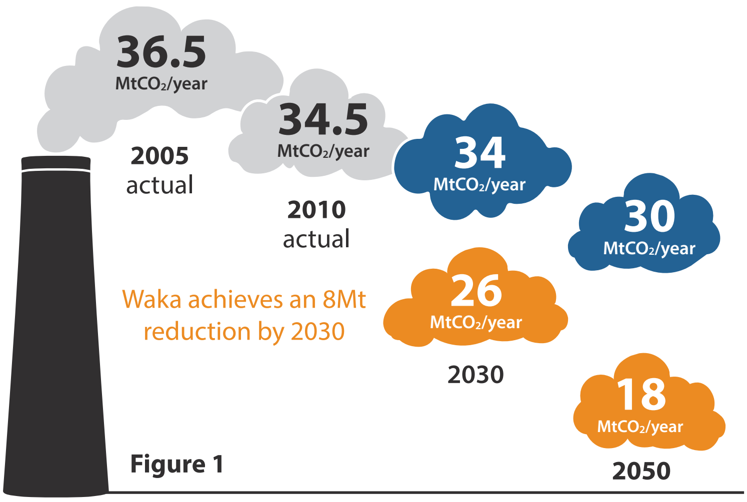


Figure 1

As this deep dive is focused on the energy sector's contribution to our overall NDC under the Paris Agreement, we are consider emissions to 2030. Compared with 2010, Waka, by 2030, will have achieved an 8Mt reduction while Kayak will see little change.[1]

Figure 1 shows projected energy sector CO_2 emissions to 2050 relative to the sector's actual emissions in 2005 and 2010. Over the full time horizon of the Kayak and Waka scenarios (2010-2050), energy and transport emissions reduce by 4Mt in Kayak (to 30Mt in 2050) and by 16Mt in Waka (to 18Mt in 2050).

Emissions in the BEC2050 scenarios are expressed as millions of tonnes of carbon dioxide emitted per annum (MtCO_2/year) by the energy sector. Note that these are CO_2 emissions alone (not CO_2-e). Non-CO_2 emissions (CH_4, N_2O etc) account for about 5% of total energy sector GHGs (mainly from transport and gas usage) but are not included in our results.

[1]The BEC2050 modelling includes emissions from international transport (aviation and marine). These emissions are not covered by New Zealand's NDC, hence the absolute level of energy and transport emissions in Figure 1 (and the 2005 reference level) overstates those covered by the NDC. However, since international transport emissions behave somewhat similarly in both scenarios removing these emissions doesn't change the narrative as the difference between Kayak and Waka emissions in 2030 is still approximately 8Mt. Hence analysing Kayak and Waka outcomes still illuminates the potential drivers of greater emissions reductions.

Context for carbon emission analysis

New Zealand's actual carbon emissions by sector

Figure 2

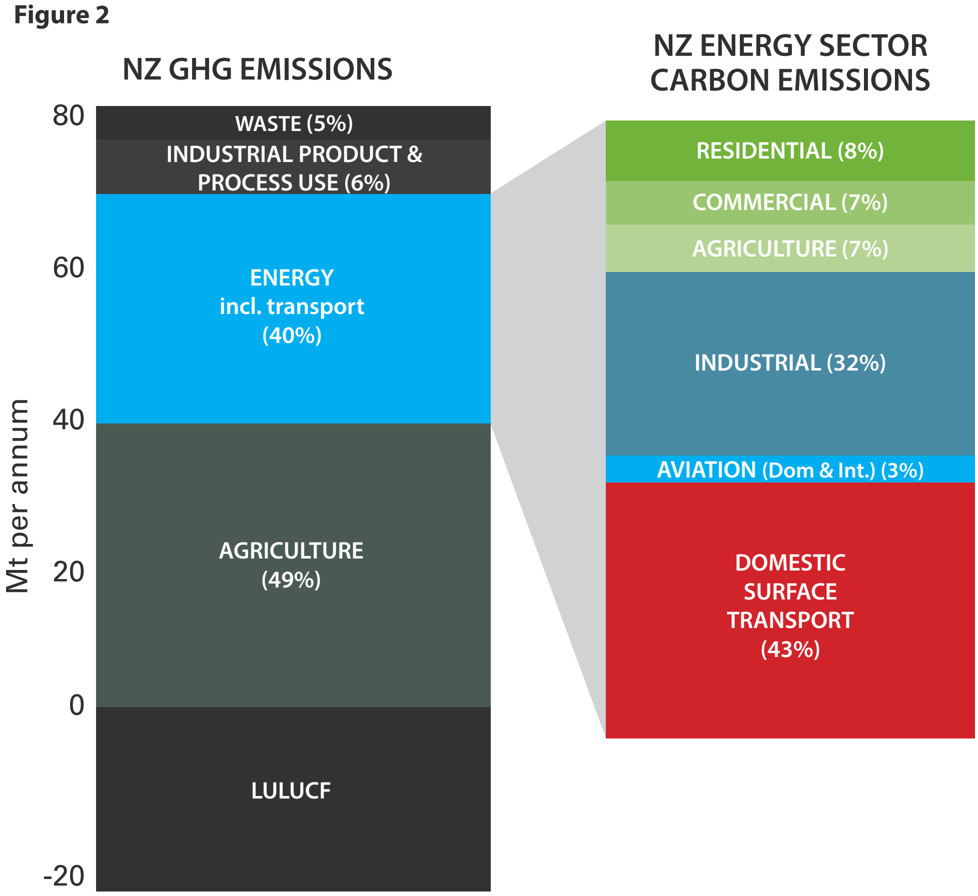


Figure 2 shows New Zealand's total greenhouse gas (GHG) emissions including carbon emissions from the energy and transport sector. Energy (incl. transport) emits 40% of New Zealand's greenhouse gases, mainly in the form of CO_2. On the right hand side of the chart is a current breakdown of energy sector CO_2 emissions by end use sector.[2] The breakdown illustrates how significant emissions from transport are to the energy sector.

Modeled carbon emissions by sector 2010-2030

Figure 3

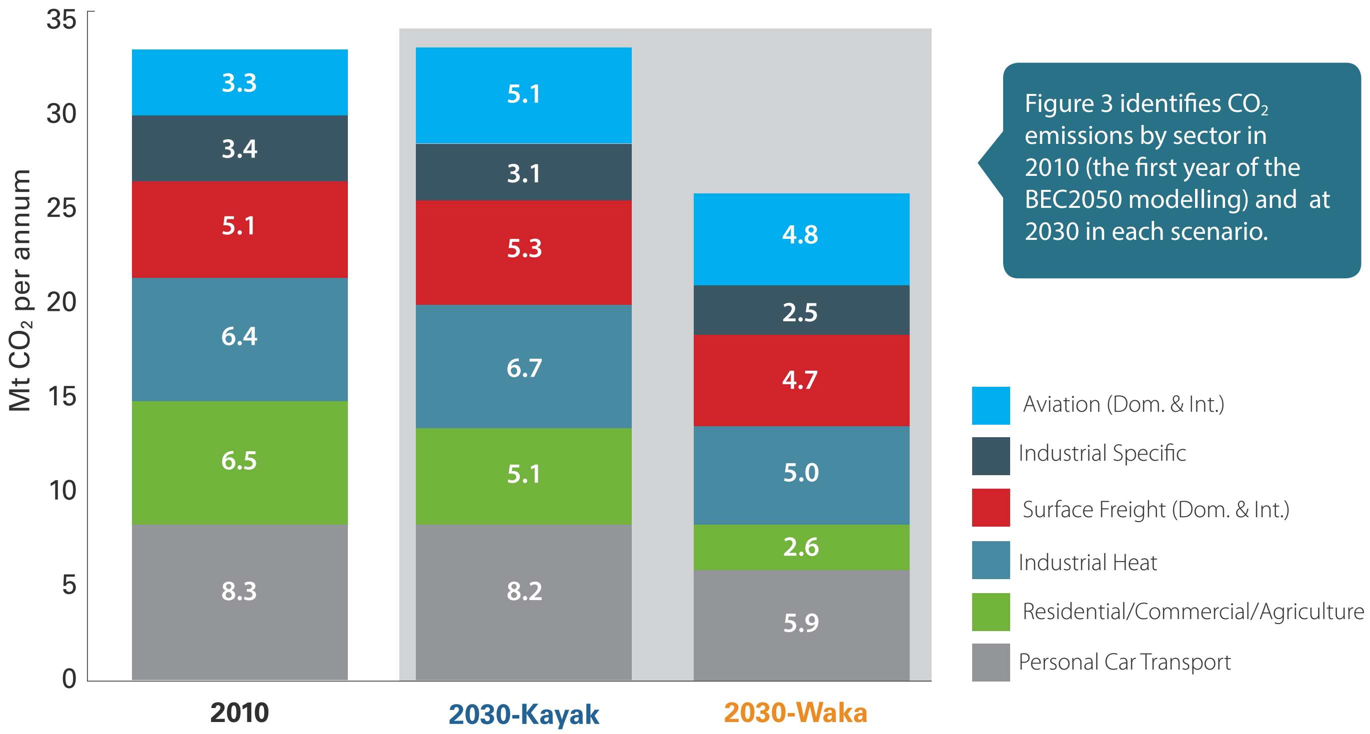


Figure 3 identifies CO_2 emissions by sector in 2010 (the first year of the BEC2050 modelling) and at 2030 in each scenario.

[2]The Ministry of Business Innovation and Employment (MBIE) provides similar information expressed in a different way. See http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-greenhouse-gas-emissions. For BEC2050 we include electricity production within its end use sector in order to provide a more demand-side perspective.

In which sectors do Kayak and Waka differ most?

Figure 4

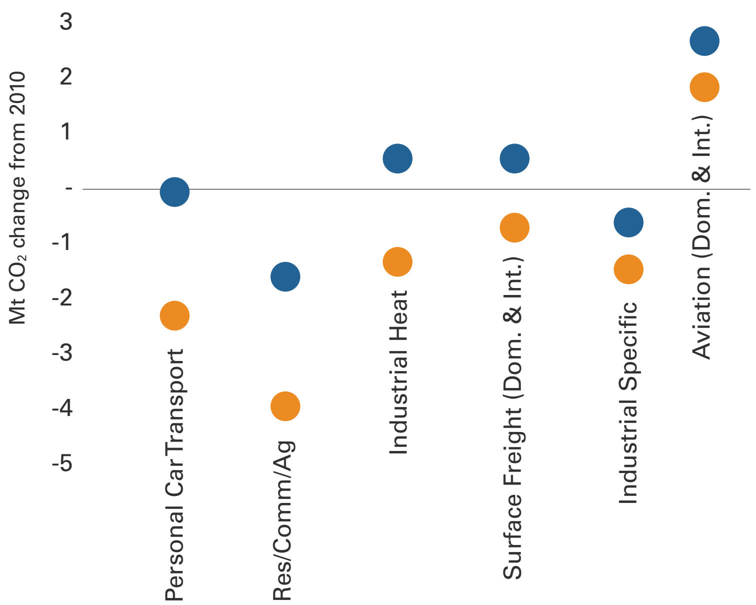


Figure 4 shows that the Residential, Commercial and Agriculture sectors offer the most significant avenues for emissions reductions in each scenario. Personal Car Transport and Industrial Heat also see 1.0Mt and 2.5Mt of additional reductions in the Waka scenario.

Since our focus is on the range of emissions reductions the energy sector can achieve, in Figure 4 we present the change in emissions compared with today, for each energy subsector, under both Kayak and Waka in 2030.

Underlying growth and structural change has a large influence on emissions

Figure 5

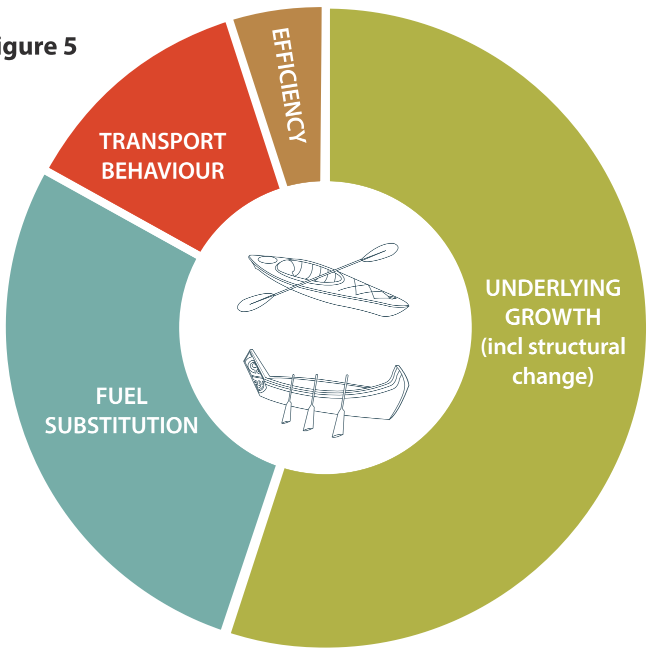


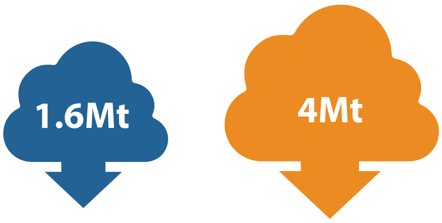
Figure 5 highlights how the difference in emissions reductions between the two scenarios is made up.

Over 50% of Waka's additional emissions reductions are due to lower underlying growth – i.e., lower population growth, lower economic growth, and a structural shift in the economy away from energy intensive industries.

The differences between these underlying growth factors can be seen in the two scenarios' emission intensity (CO_2/\$GDP) and emissions per capita. While these measures decline in both, Kayak's decreasing intensity is largely offset by absolute growth in GDP and population (hence total emissions remain relatively constant at 34Mt). Waka achieves an absolute reduction of emissions due to its more aggressive decarbonisation: a faster decline in intensity and per capita emissions is only partly offset by its own (lower) economic and population growth assumptions.

Differences in the degree of substitution between fuels (especially towards Waka's heavily decarbonised electricity sector) is the second largest component, and (along with a small difference in efficiency gains) is mostly driven by Waka's higher carbon price. Private individuals' changes to their transport behaviour generates 1Mt of additional emissions reductions in Waka, around 12% of the total.

The leverage effect from renewable electricity generation



Total electricity emissions reduce 1.6Mt in Kayak and 4Mt in Waka.

While we consider specific sectors below, an important context is the powerful leverage effect of increasing low-carbon electricity generation across a number of sectors. Total electricity emissions reduce 1.6Mt in Kayak and 4Mt in Waka.

The leverage effect of large supply-side investment decisions in the electricity sector is significant. It would take many tens of thousands of individual decisions regarding, for example, electric vehicles to achieve the same effect on emissions as a single renewable energy power station.

Both scenarios see 1.3Mt of emissions reductions as a result of the modelled decommissioning of the Huntly Power station and, as a result, the elimination of coal generation at some point prior to 2030.

Otherwise both scenarios reflect a differing degree of substitution between gas and renewables: As shown below in Figure 6, both scenarios see similar (and significant) investment in renewables but the lower demand in Waka allows it to dramatically reduce its use of gas generation.

Figure 6

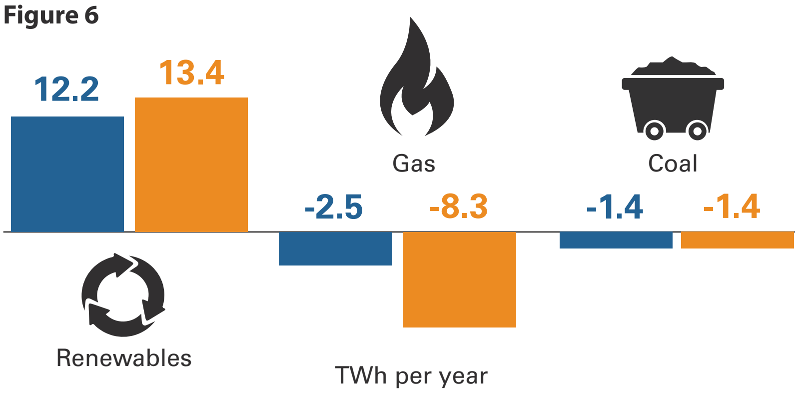


Figure 6 shows the changes in electricity generation fuel in 2030 for Kayak and Waka.

Note that modelling is based on mean years so dry years may require more fossil fuel generation although the commercial arrangements to achieve that are not considered here. Also, fugitive emissions of CO_2 from geothermal energy rise in both scenarios, proportional to the degree of geothermal investment.

Nearly two-thirds of the emissions reductions in residential, commercial and agriculture sectors come from their use of electricity.

Personal car transport offers opportunities via technology and behaviour change

Emissions from personal car transport decline in both scenarios but by 2.3Mt more in Waka than in Kayak, reflecting the fact that total fuel consumption in the personal car fleet falls 2% in Kayak and 27% in Waka.

Two key drivers for Waka emerge: electrification and behaviour change.

Figure 7

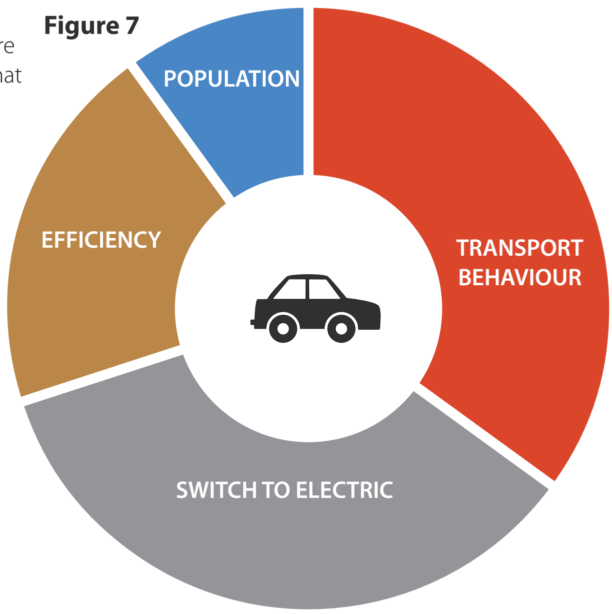


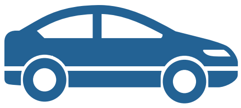
Figure 7 illustrates the source of the differences in emissions for personal car transport under Kayak and Waka. These effects are discussed over the page.

The emissions reductions in the personal car transport sector are result of:

UNDERLYING GROWTH

As a result of higher population growth, there are more private cars on the road in Kayak compared with Waka. However, this increase in population has a relatively small impact on emissions, as it represents only 6% of emissions in the personal car fleet.

277,000
more private cars on the road in Kayak compared to Waka



SUBSTITUTION

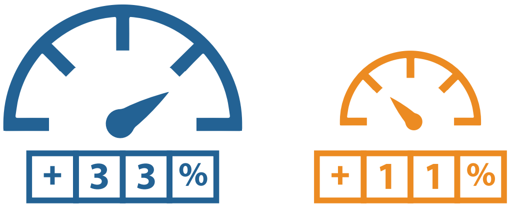
In Kayak 33,000 vehicles have switched to highly efficient electric cars[3] while in Waka the light electric vehicle fleet would reach 475,000 in 2030. The switch to electric vehicles reduces liquid fuel consumption commensurately. That, combined with more renewable electricity in the fleet, reduces emissions by a small amount - 0.05Mt - in Kayak, but by a more substantial 0.8Mt in Waka.

33,000 **475,000**

Total electric vehicles on the road

BEHAVIOUR CHANGE

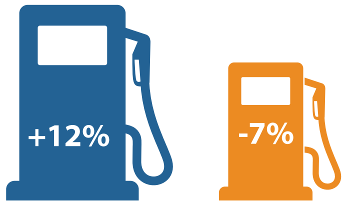
The distance we drive (vehicle kilometres travelled, VKT) per capita increases 8% in Kayak, while dropping 9% in Waka as urban intensification sees people locate closer to work and choose public transport or other options (walking, biking). Once combined with population growth in the respective scenarios, we observe an increase in total VKT of 33% in Kayak but only 11% in Waka, accounting for around 1.0Mt of the difference between scenarios. Thus 12% of Waka's additional emissions reductions are enabled through changing the way we travel and live.



Increase in total VKT (vehicle kilometres travelled)

EFFICIENCY

Waka sees reductions in fossil fuel consumption due to the combined effect of fuel efficiency and substitution. Improved efficiency in the liquid-fuelled internal combustion engine (ICE), as a result of more efficient cars (including hybrids) being absorbed into the fleet through turnover and growth is achieved under both scenarios. However, due to the higher carbon price, we observe greater efficiency improvements in the ICE in Waka, leading to around 0.5Mt of additional emissions reductions.



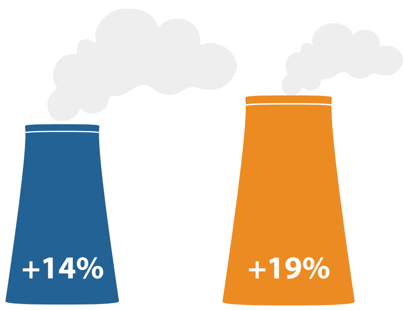
Change in transport fuel consumption

Opportunities to reduce industrial heat emissions

There is some substitution from coal to gas for heat in both scenarios, especially in Waka, and a modest uptake of geothermal energy for process heat (with some associated emissions).

The ability to switch from coal to gas for process heat in the South Island is limited, however, by the lack of availability of a local supply and distribution network. That said, the majority of coal consumption for process heat occurs in the North Island. But neither of our scenarios suggests that there is any substantial switch to renewable fuels (biofuels or electricity) for process heat.

Increased energy efficiency in the industrial heat sector



The model does not see these options as economic by 2030 but if technology improves it may be another avenue for further reductions in carbon emissions.

This highlights the challenge for the industrial heat sector. Since there are few alternatives to fossil fuels (and few alternatives to coal in the South Island) seen by the model as commercially viable, the only other options open to businesses facing Waka's increasing carbon price are either greater efficiency or, ultimately, exit.

We see a mixture of both, in Waka there are higher energy efficiency improvements than Kayak (a greater rate of boiler replacement), but also a 14% contraction in the industrial heat sector. Hence, as highlighted earlier, the Waka scenario is somewhat predicated on a more aggressive transition to a low energy intensity economy and that is achieved (to some degree) by a wider economic transition.

[3] A pure battery operated electric vehicle has two impacts on emissions: (i) it is more efficient at converting energy into motion and (ii) it can use highly renewable electricity to do so. For simplicity, we account for both effects under "substitution" here.

Key messages

While the future is inherently uncertain, our two distinct but plausible stories allow us to explore some of the underlying drivers of energy and transport sector CO_2 emissions. By focusing on the differences between the scenarios we are able to quantify the range of uncertainty that exists as it relates to technology, economic transformation, the pursuit of higher renewables penetration and transport behaviour change. Deeper interrogation of our modelling then allows us to ask 'what-if' questions. This reveals:

1. Making significant emissions reductions in any part of the energy and transport sector has its challenges. BEC2050 shows CO_2 emissions from the energy and transport sector are strongly tied to economic, energy productivity and population growth. Achieving both a high growth economy and significant emission reductions will require a significant reduction in energy intensity and carbon intensity. It is not clear from the modelling that this will occur in a high growth scenario.
2. Substantial emissions reductions can be achieved as a result of a high CO_2 price in a Waka world (NZD60/t by 2030), which would incentivise fuel substitution away from higher carbon content fuels (e.g., coal and oil) to lower carbon fuel (natural gas and renewables). The most significant reductions would be achieved by:
    a. Transport sector transformation through a significant uptake of EVs (0.5m cars by 2030) in the light fleet. Supporting consumer choice towards EVs is important here; and
    b. Increasing the percentage of renewable electricity generation as this impacts on all parts of the economy. One option for significant emissions reductions under strong economic growth is to target >95% renewable electricity generation. However, such a target needs to be paired with realistic commercial frameworks underpin security of supply.
3. Beyond the impact of the carbon price on emissions, further emissions reductions could be possible if transport system and urban design evolve so as to change how we travel, away from private car usage, increasing the use of public transport, walking and biking.
4. Some efficiency gains are expected to reduce industrial process heat emissions but greater reductions would be challenging without economic transformation and/or substantial technology advances.
5. To the extent that New Zealand doesn't meet emission reduction goals there are other options not explored in the BEC2050 modelling. For example, achieving more emissions reductions from the energy and transport sector than indicated would be helped by greater investment in R&D in emissions-related opportunities. Failing that, further reductions would have to come from other sectors. If reductions are still insufficient to meet international obligations offsetting could become part of the solution.

However we respond as a country, one thing is increasingly clear – resilience is critical. The more predictable the policy framework for achieving emissions reductions, the clearer the investment signals will be. Predictability and clarity will deliver the greatest resilience as we navigate the uncertainties we face.

Potential for further investigation

We identified several areas of potential carbon emission reductions that the model did not detect. Future emissions reduction may come from efficiencies, innovation and technology not yet at commercial scale or even invented.

SURFACE FREIGHT

The model suggests there are few opportunities for emissions reductions in Surface Freight in either scenario. Changes in emissions from Surface Freight (domestic & international) primarily reflect differences in underlying growth. Both scenarios see similar degrees of efficiency, as the difference in the carbon price between the two scenarios has little effect (NZD60/t in Waka equates to ~5c/l on diesel costs). Further, the uptake of electricity into the surface freight sector (electric rail and buses) is also relatively similar in both scenarios, offsetting 10PJ of diesel consumption (0.7Mt of emissions). But our current modelling does not consider the economics of switching freight between sea, rail, road and air, which warrants consideration from a policy perspective. Domestic and international non-road transport (aviation and sea) is a significant component of energy demand totalling 17% of total national energy consumption by 2030.

BIOENERGY

Bioenergy, especially liquid biofuels in freight and solid biofuels for industrial heat, offers some hope in the quest for greater sustainability and lower carbon emissions. Biofuels need to be investigated from an overall supply chain perspective, especially the source of the feedstock and the quantum of biofuels (and thus reduced fossil fuels) it can support.

INDUSTRY SPECIFIC

Emissions from Industrial Specific (all non-heat related industrial energy consumption) do not change significantly. While the underlying demand for energy from industry grows +16% in Kayak and +13% in Waka, in emissions terms, this is offset by the emissions reductions in electricity rather than any reduction in liquid fuels use. There is no fuel substitution taking place for liquid fuels, hence any emissions reductions are largely the result of significant emissions reductions in electricity.

AVIATION

Aviation, under both scenarios, increases its emissions.[4] The Aviation figures indicate that, as a country, the opportunity for New Zealand to substitute away from flying is relatively limited domestically and - given our remote location as a country, and our tourism aspirations - almost zero internationally.

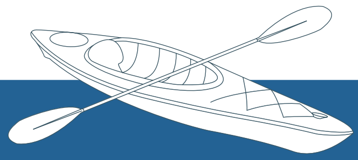
But BEC2050's aviation figures do not factor in possible improvements in fuel efficiency. The historically observed improvements in fuel efficiency in the domestic aviation sector may continue at similar, or potentially greater, rates.

[4] These include international emissions which would not be included when energy sector emissions are accounted for in the countrywide NDC targets.

BEC2050 – Kayak and Waka

The Kayak and Waka scenarios are two divergent but equally plausible scenarios that include alternative macroeconomic, policy, and consumer behaviour assumptions to those observed today. The modelling of the two scenarios has provided – for the first time in many years – plausible, integrated, energy sector futures developed by a broad cross-section of New Zealanders from both within and outside the energy sector. In doing so, it provides a common platform and vocabulary for an ongoing national discussion about energy, and a quantification of the future, vital to policy and investment decisions.

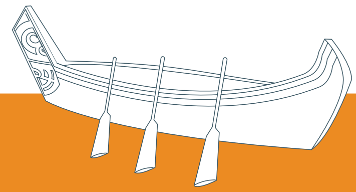
The modelling for Kayak and Waka places New Zealand in WEC's two international scenarios. WEC's global scenario assumptions include the status of an agreement on climate change, and related global economic and demographic assumptions. With the international situation as an input, the Kayak and Waka scenarios develop the New Zealand response, consistent with the outcomes of the other critical uncertainties dealt with in the scenarios.



KAYAK

In a Kayak world a global deal on climate change is agreed but international commitments on reducing emissions are weak. Carbon markets develop but are fragmented across ad-hoc regional and national schemes.

New Zealand governments turn towards the market to drive the uptake of new low-carbon and energy-efficient technology. There are no direct or indirect support mechanisms for these technologies apart from a modest carbon price



WAKA

In the Waka scenario global leaders unanimously agree that climate change is the defining problem of our time and a comprehensive global deal on climate change is agreed based on strong emissions reduction commitments.

In New Zealand, governance and decision-making become more hands-on with climate change mitigation strategies prioritised to meet New Zealand's international obligations. Emissions from the energy sector are reduced accordingly.

For more information, go to **http://www.bec.org.nz/projects/bec2050**

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