

Chapter 7

Te Tahua Tukunga Hauwaro – Te Porotutuki Demonstrating emissions budgets are achievable

Summary

The Commission's analysis shows that while our recommended emissions budgets are ambitious, they are also achievable.

To establish this, we have developed a series of possible paths outlining different rates of technology and behaviour change to 2035 to test the budgets are resilient and ensure uncertainty about the future does not stall or delay climate action. These scenarios follow different paths of technology and behaviour changes to 2035, and include the critical actions identified through our analysis that must be carried out over the next 15 years. These actions are outlined in *Chapter 6: Long term scenarios to 2050*. We have also developed detailed assumptions that support those actions.

This chapter provides detail on our analysis to show the emissions budgets can be met. This includes:

- Detail on the demonstration path, including assumptions that underpin that path over the next 15 years.
- Detail on two alternative paths that show the recommended emissions budgets could be met under a different mix of actions. These are 'less technological change, more behaviour change' and 'more technological change, less behaviour change'.
- Sensitivity analysis to test how further uncertainties could impact on the ability to meet the budgets. The analysis gives us confidence that these uncertainties are manageable.

It is important that we set budgets that have enough flexibility to respond to unanticipated change. Aotearoa may need to adjust its course as the low emissions transition proceeds. This will mean government, industry, businesses and individuals will be able to adapt as new information, technologies and approaches to lowering emissions are developed.

Changes in our final advice

During consultation, we received feedback from submitters about our models and assumptions. This has been fed into our analysis and changed some of our underlying assumptions. We have presented more paths for achieving the budgets. We have rerun our models and carried out sensitivity analysis.

The key areas where we received feedback from submitters and made changes to our modelling in response to new evidence are detailed sector by sector in the chapter.

Introduction

- 1 Our work shows that there are multiple paths for Aotearoa to achieve our recommended emissions budget levels. We have looked at multiple scenarios that follow different paths of technology and behaviour changes to 2035. We have also undertaken sensitivity analysis of our assumptions. All of this analysis tells us that the recommended emissions budgets are achievable despite uncertainty around how fast technology will develop and how behaviours could change in the next 15 years.
- 2 Figure 7.1 below shows the process we have gone through to test that our recommended emissions budgets are achievable and will put us on track to meet the 2050 emissions reduction targets (2050 targets). We constructed a demonstration path that includes a portfolio of actions across the economy. We used the demonstration path to calculate the level of the first three emissions budgets which are set out in *Chapter 5: Recommended emissions budgets*.
- 3 The demonstration path includes the actions from the long-term scenarios (outlined in *Chapter 6: Long term scenarios to 2050*) that were identified as being critical for meeting the 2050 targets. The portfolio of actions in the demonstration path are also consistent with the judgements described in *Chapter 5: Recommended emissions budgets*.
- 4 The evidence base underpinning the assumptions for each action is outlined in detail in *Chapters 5-9 of the 2021 Supporting Evidence*. The detailed lists of assumptions for all the path runs are available on our website www.climatecommission.govt.nz/modelling.

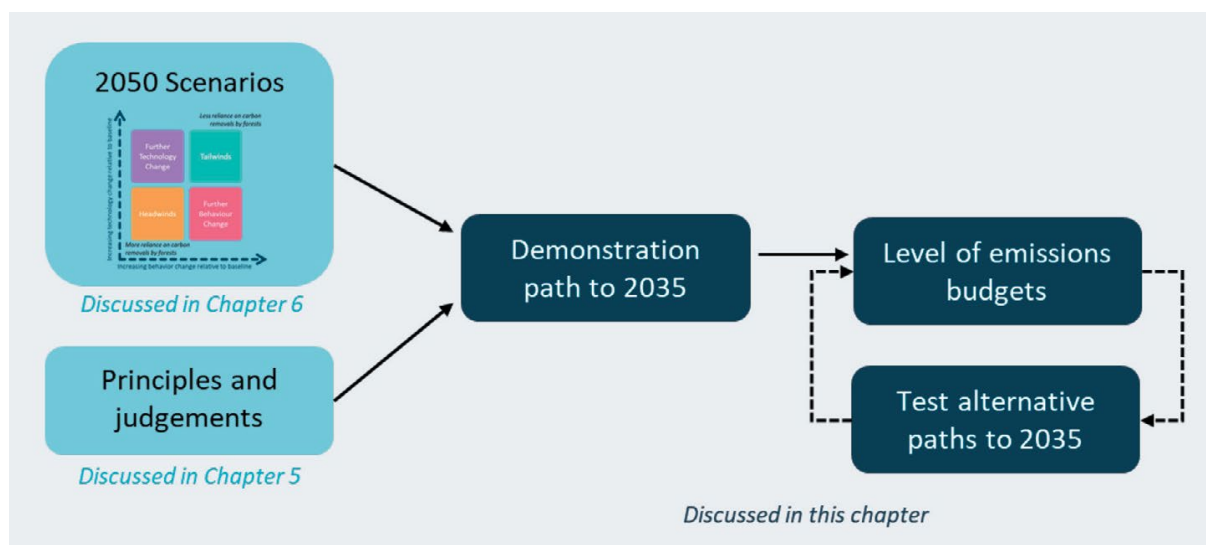


Figure 7.1: Our process to determine the levels at which to set the first three emissions budgets

- 5 We also checked to see whether these emissions budget levels were still achievable if some technology or behaviour changes happened faster or slower than in the demonstration path. To do this we designed two alternative paths which are variations on the demonstration path, and carried out sensitivity analysis.

- 6 The alternative paths include the same emissions reduction options as the demonstration path but vary the speed with which the options are taken up. These paths are:
- **Alternative path A** – this includes less technological change and more behaviour change than the demonstration path.
 - **Alternative path B** – this includes more technological change and less behaviour change than the demonstration path.
- 7 The purpose of these paths is not to prescribe the exact mix of technologies that Aotearoa should use, but to show that our recommended emissions budgets are achievable in light of uncertainty about the future. Some technologies or behaviour changes not included in these paths could end up eventuating, depending on the relative economics and people’s preferences.
- 8 We have recommended emissions budgets that are ambitious, but also achievable. For this reason, the demonstration path focuses on technologies that are commercially available now. Recommending emissions budgets that are so ambitious they could only be met if new technologies were developed and deployed would undermine the purpose of emissions budgets – to set a credible course for medium-term emissions reductions.
- 9 In response to submissions, we have made a number of amendments to our modelling and assumptions. The changes we have made are detailed in Box 7.3 at the end of this chapter.

Box 7.1: Emissions values

All the paths to 2035 we set out in this chapter include the same future emissions values, which increase over time (Figure 7.2). These emissions values apply to the energy and transport sectors only in our modelling. These values should not be directly interpreted as New Zealand Emissions Trading Scheme (NZ ETS) prices, as that will depend on the mix of policies Government chooses to implement in meeting the emissions budgets.

We have arrived at the emissions values by looking at the abatement costs that would be required in 2050 to eliminate fossil fuel emissions from those sectors where there are low-emissions alternatives. Our modelling suggests that a price of around \$250/tonne would be required to achieve this.

A more detailed description of how we arrived at the emissions values and how they are used in our modelling is set out in *Chapter 12: Long-term scenarios to meet the 2050 target in the 2021 Supporting Evidence*.

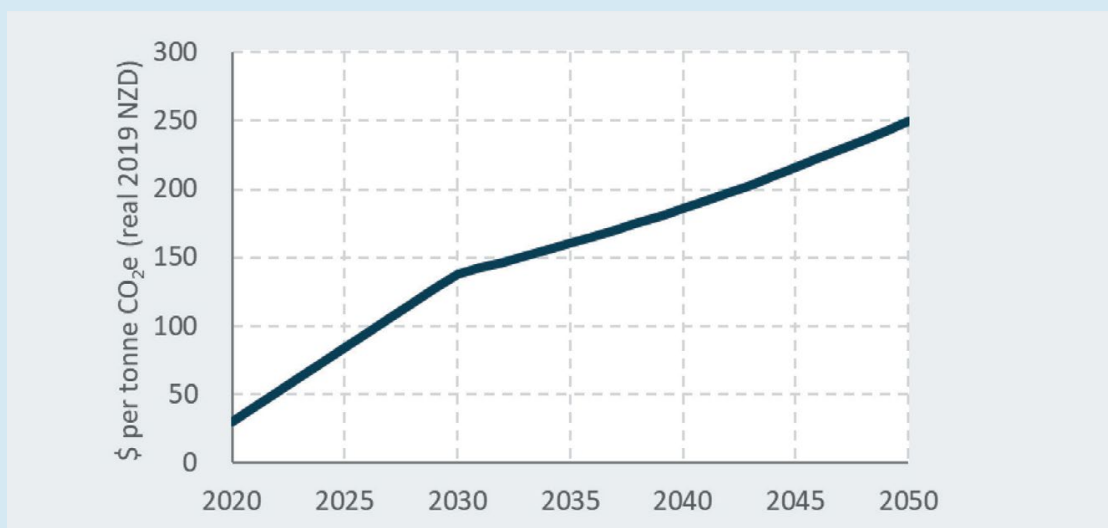


Figure 7.2: Emissions values for the energy and transport sectors applied in the paths

7.1 Summary of the demonstration path

- ¹⁰ This section outlines a demonstration path – one set of measures and actions within each sector that would deliver our recommended emissions budgets. The final assumptions that sit behind the demonstration path are outlined throughout this section.
- ¹¹ Table 7.1 below provides a summary of key actions in the demonstration path across the first three budget periods. In the following sections we give a more detailed description of the changes that would happen within each sector.
- ¹² In relation to the long-term scenarios described in *Chapter 6: Long-term scenarios to 2050*, the demonstration path would see reductions in long-lived greenhouse gas emissions near the more ambitious end of the range (Figure 7.3). Net long-lived greenhouse gas emissions would fall by 15% by 2025, 38% by 2030, and 63% by 2035 compared to 2019. This path would set Aotearoa up to achieve net zero long-lived greenhouse gas emissions in the early 2040s.
- ¹³ These emissions reductions would mostly come from road transport and energy, industry and buildings (Figure 7.3). The demonstration path would see gross and net carbon dioxide emissions reduced by 27% and 47% respectively by 2030, compared to 2019.
- ¹⁴ For biogenic methane, in the demonstration path we have assumed no adoption of a biogenic methane inhibitor or other biogenic methane reducing technologies that are not already commercially available. Because of this, the demonstration path sees biogenic methane emissions reductions towards the less ambitious end of the scenario range (Figure 7.4). The demonstration path would see ambitious and sustained changes to low-emissions farm practices such as stock and pasture management, alongside strong action to reduce biogenic methane emissions from landfills (Figure 7.4).

Table 7.1: Key transitions along the demonstration path

		Budget 1	Budget 2	Budget 3
Transport	Lower-emissions vehicles	Accelerate uptake of electric and zero-emissions cars, buses and trucks Improve efficiency of vehicles and freight movement		Phase out imports of internal combustion engine light vehicles
	Reducing vehicle trips	Encourage switching to walking, cycling and public transport Reduce demand for travel, for example through smart urban development and increased working from home Increase use of rail and coastal shipping for freight		
	Aviation and shipping	Improve efficiency	Start electrifying ferries and coastal shipping	Start electrifying short-haul flights
	Low carbon liquid fuels		Increase use of biofuels	
Energy, industry and buildings	Buildings	No new fossil gas heating systems installed after 2025 Improve thermal efficiency		Start phasing out existing fossil gas use in buildings
	Electricity	Phase out fossil base-load generation	Transmission and distribution grid upgrades Expand renewable generation	Achieve ~95% renewable generation
	Industrial process heat	Replace coal with biomass and electricity		Replace fossil gas with biomass and electricity
Land	Agriculture	Adopt low-emissions practices on-farm	Adopt low-emissions breeding for sheep	Encourage new low biogenic methane technologies to be adopted when available
	Native forests	Ramp up establishing new native forests		Establish 25,000 ha per year
	Exotic forests	Average 25,000 ha per year of new exotic forests		Ramp down planting new exotic forests for carbon storage
Waste and F-gases	Waste	Divert organic waste from landfill Improve and extend landfill gas capture		
	F-gases	Increase end-of-life recovery of F-gases		

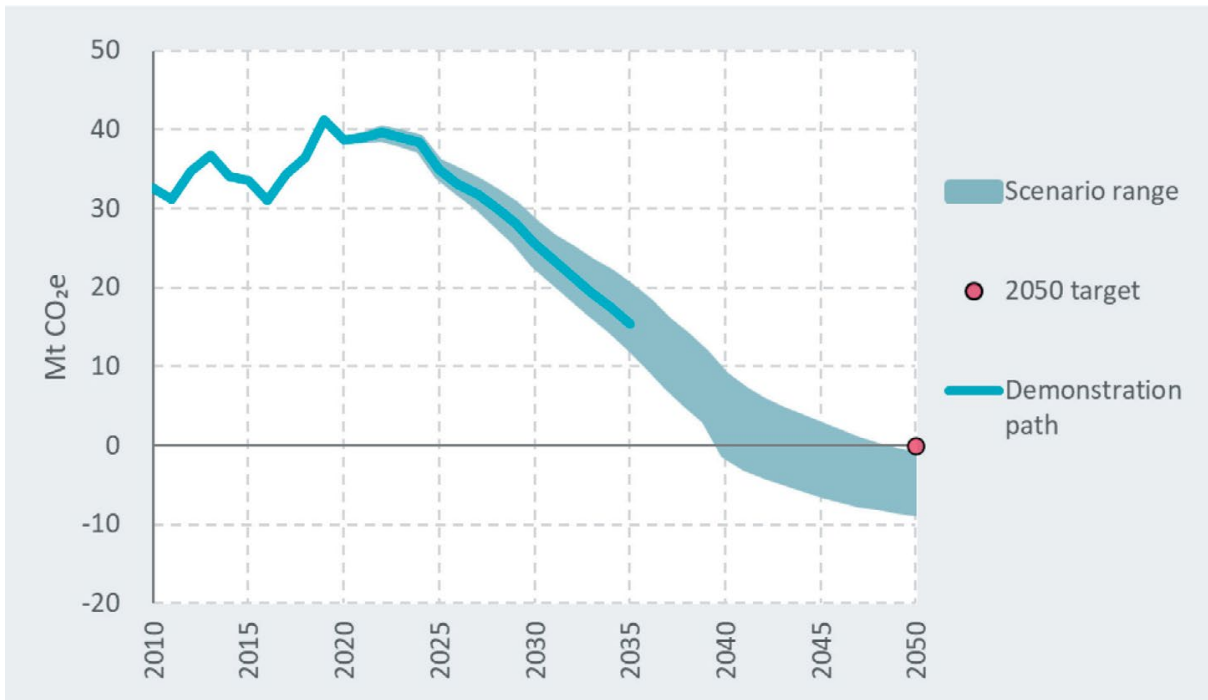


Figure 7.3: Long-lived greenhouse gas emissions in the demonstration path to 2035 compared with the long-term scenario range

Source: Commission analysis

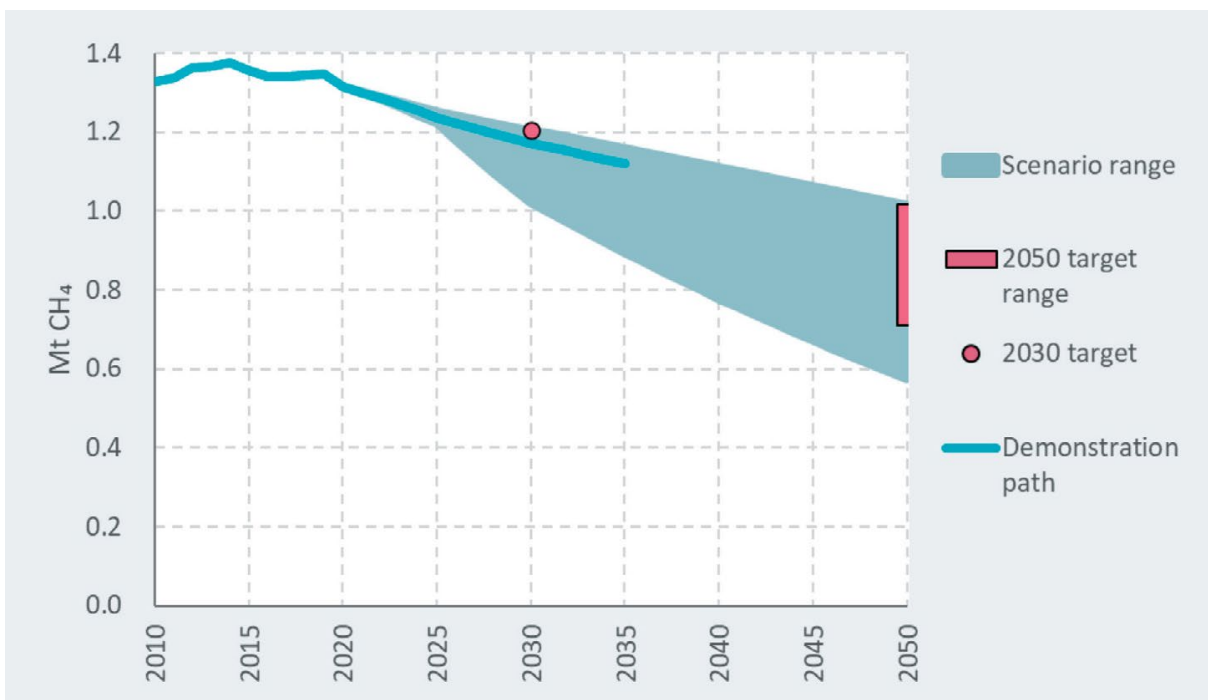


Figure 7.4: Biogenic methane emissions in the demonstration path to 2035 compared with the long-term scenario range

Source: Commission analysis



Figure 7.5: Snapshots of emissions in 2025, 2030 and 2035 in the demonstration path, compared with 2019

Source: Commission analysis

7.2 Transport in the demonstration path

15 Our approach to meeting the 2050 targets would see Aotearoa almost completely decarbonising the transport system. The demonstration path includes the necessary actions over the next 15 years to put Aotearoa on track for the 2050 targets while delivering immediate emissions reductions and co-benefits. This means travelling less, or shorter distances; using public transport, walking and cycling more; and changing how most vehicles are powered.

16 The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 6: Reducing emissions from transport, buildings and urban form* of the *2021 Supporting Evidence*.

7.2.1 Changes to how New Zealanders move

17 Changes to how and how much New Zealanders travel play an important role in the demonstration path.

18 We assume the average household travel distance per person can be reduced by around 3% by 2030, relative to our Current Policy Reference case in 2030. This could be achieved, for example, through more compact urban development and encouraging remote working for those who can.

19 We also assume that the mode share of total distance travelled by low-emissions options – walking, cycling, public transport, and emerging options such as e-scooters – can be increased, from around 6% nationally in 2019, to 11% by 2030 and 14% by 2035. Within this, we assume that cycling grows from around 0.6% of household travel distance in 2019 to 1.5% in 2030, and public transport grows from around 3.5% to 7.7%.

20 These figures are built up from regional-level assumptions. For example, we assume that share of travel distance by public transport nearly triples in Auckland by 2030, compared with growing by around 60% in Wellington and 20% in the rest of Aotearoa. We have considered the different circumstances and opportunities in urban, rural and provincial areas.

21 Overall, these assumed changes would see total household vehicle travel holding flat from 2023 and then declining, despite a growing population. We assume household light vehicle travel can be reduced by 9% by 2030, relative to our Current Policy Reference case in 2030 (Figure 7.6).

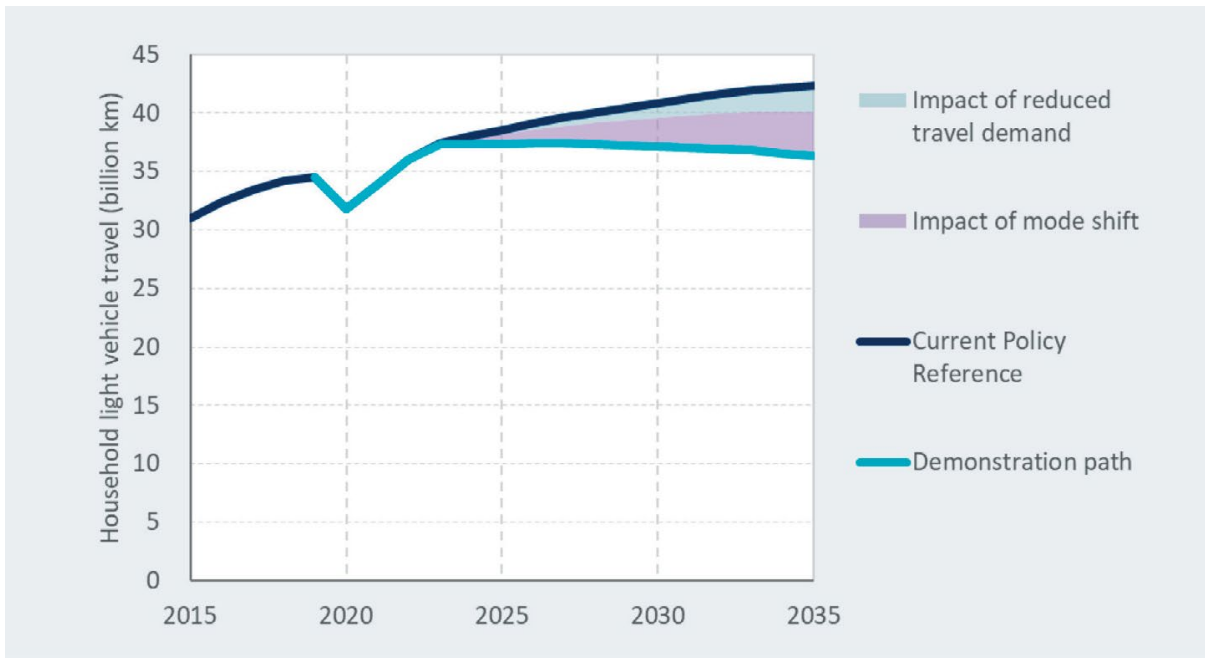


Figure 7.6: Household light vehicle travel in the demonstration path compared with under current policies

Source: Commission analysis

7.2.2 Switching to electric and zero-emissions vehicles

22 Electric vehicles (EVs) – that could include hydrogen fuel cell vehicles where battery electric is not feasible – have zero tailpipe emissions, and the electricity to power them can come from clean, renewable sources.

23 The long-term scenarios outlined in *Chapter 6: Long term scenarios to 2050* show that electrifying the vehicle fleet is a critical element of meeting the 2050 net zero target. Ending the import of internal combustion engine (ICE) light vehicles in the early 2030s is necessary in order to have most travel electrified by 2050 without forcing significant early scrappage of vehicles.

24 EVs are currently more expensive to purchase than ICE vehicles, with the additional cost partly offset by cheaper running costs. The upfront cost of EVs is expected to continue to fall through continued reductions in lithium ion battery costs and rapidly increasing global production.

25 In the demonstration path, we assume EVs reach purchase price parity with ICE vehicles on average by 2031.

26 For light vehicles – cars, SUVs, vans and utes – imports of new and used ICE vehicles are phased out by 2032 and 2035, respectively. This timeframe is consistent with phase out dates set by a growing number of countries and automakers. While we have modelled different phase-out dates for new and used ICE vehicles, our advice on the direction of policy does not distinguish between the two (see *Recommendation 17, Chapter 14: Policy direction for transport*).

27 Under the demonstration path, EVs would make up at least half of total light vehicle imports by 2029. By 2035, 46% of all light vehicle travel would be in EVs and 36% of light vehicles on our roads would be electric (Figure 7.7).

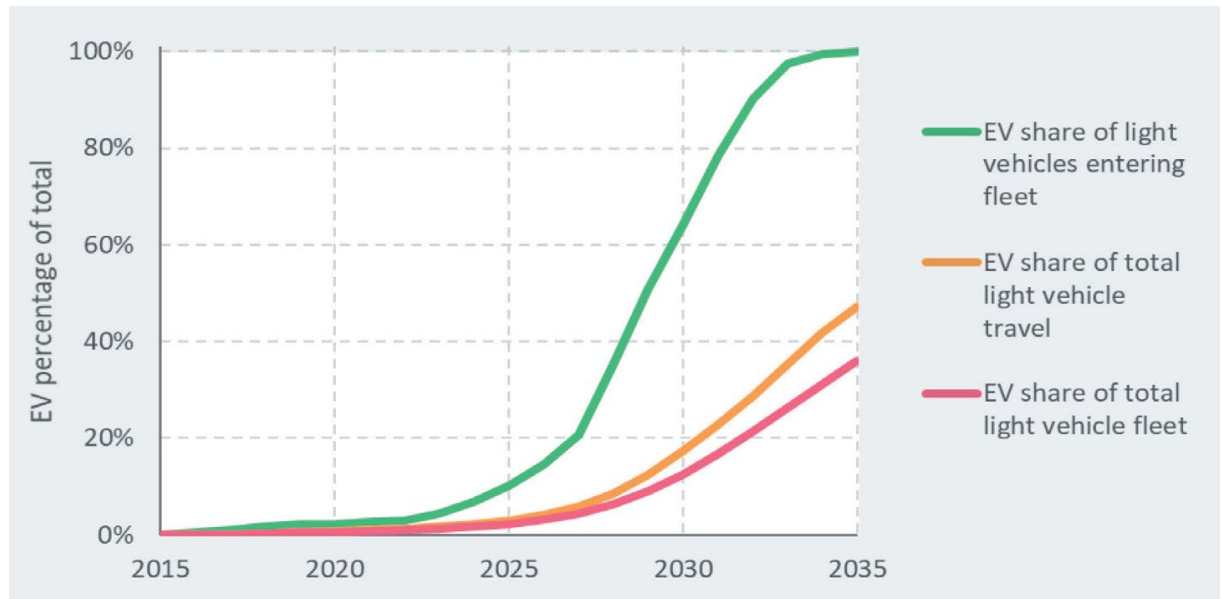


Figure 7.7: Uptake of light EVs in the demonstration path

Source: Commission analysis

28 The demonstration path also sees significant electrification of heavy transport. This includes a rapid switch to electric buses, led by favourable economics and in line with commitments from local councils and central government. Electrification of trucks, on the other hand, is slower to begin due to higher costs and technology barriers, such as current battery technology not allowing for the greater daily distances many trucks need to travel.

29 For heavy duty trucks in particular, the extent to which batteries or hydrogen fuel cells will provide a more viable and cost-effective solution is uncertain. Battery electric trucks are a more efficient use of energy, requiring roughly one-third as much input electricity as a fuel cell truck running on green hydrogen. However, hydrogen fuel cell trucks offer other advantages such as being faster to refuel, travelling longer distances, and not having heavy batteries that take the place of freight.

30 While we have modelled battery electric trucks as the electrification route, the resulting uptake could also represent fuel cell trucks powered with green hydrogen. In our consultation, we heard from councils and industry that there are multiple green hydrogen heavy transport projects underway.

31 Of the trucks imported in 2030, 42% of medium trucks and 18% of heavy trucks would be electric. By 2035, these would increase to 95% and 73% respectively.

Box 7.2: Costs of electric vehicles now and in the future

Electric vehicles (EVs) today cost more to purchase than a comparable internal combustion engine (ICE) vehicle. We estimate the additional upfront cost for a EV in Aotearoa is currently around \$16,000 excluding GST, of which about \$11,000 is the cost of the battery. However, the outlook is positive, with leading international analysts such as Bloomberg New Energy Finance forecasting that electric cars will be cheaper to make than petrol cars by 2030.

These expected cost reductions come through a combination of falling battery costs and other manufacturing cost reductions as automakers retool their production lines and scale up EV production. The cost of lithium ion batteries has already fallen 88% from 2010 to 2020 and is projected to more than halve again by 2030.

In the demonstration path, we assume that EVs reach purchase price parity with ICE vehicles on average by 2031. We have been conservative to reflect uncertainty around manufacturer pricing and other factors. We have tested faster and slower cost reductions in the alternative paths.

Because EVs are cheaper to fuel and run, they will have a lower total cost of ownership compared with an ICE vehicle several years ahead of reaching purchase price parity. We estimate this would occur by 2026 on average for a new car purchase, for a five-year ownership period. For vehicles driven more than average, the time when an electric car is cheaper will come sooner. For vehicles driven less than average, that time will come later.

Figure 7.8 shows the different components of the total cost of ownership for a new car purchase in 2021, 2025 and 2030. In addition to the falling capital costs, the operating cost for the battery electric car also falls. This is because we assume a shift to cost-reflective electricity pricing, with vehicles primarily charged overnight at a low rate.

Looking over the whole life of the vehicle, which for a new car entering Aotearoa is around 20 years on average, the time when an EV becomes cheaper arrives even sooner. We estimate the whole-of-life cost for a new battery electric car will be lower than a new petrol car from 2022 (Table 7.2). By 2030, we estimate this whole-of-life cost would be 20% lower.

For more information on how the numbers in Figure 7.8 and Table 7.2 have been calculated and on the underlying assumptions, see *Chapter 12: Long-term scenarios to meet the 2050 target* in the *2021 Supporting Evidence*. The *2021 Supporting Evidence* also contains cost assumptions for other vehicle types.

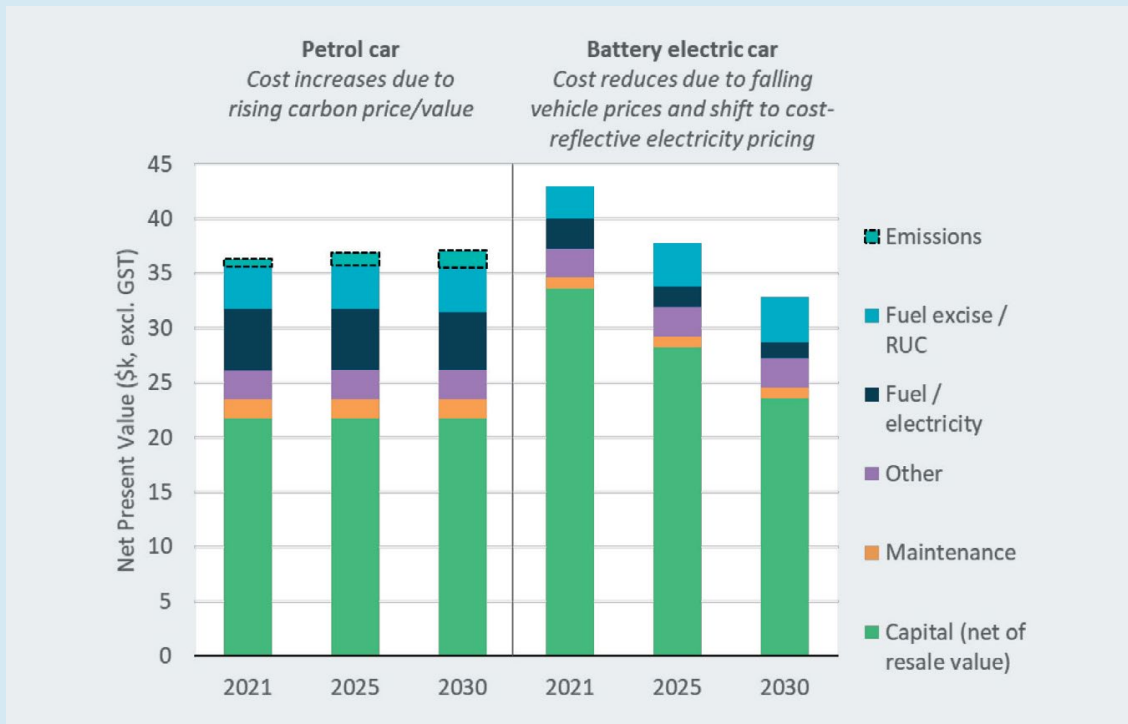


Figure 7.8: Projected five-year total cost of ownership for a new battery electric car compared with a new ICE engine car in 2021, 2025 and 2030 (private perspective)

Source: Commission analysis

Table 7.2: The year that a new electric car becomes cheaper than a new petrol car on whole-of-life cost, total cost of ownership and purchase price under the demonstration path assumptions

	Whole-of-life cost (societal perspective, 3% discount rate)	Five-year total cost of ownership (private perspective)	Purchase price
Year by which new battery electric car is cheaper than new petrol car on average	2022	2026	2031

Source: Commission analysis

7.2.3 Improving the efficiency of vehicles and freight movement

³² Even with the rapid switch to EVs, roughly 80% of the vehicles entering the fleet this decade would still be ICE vehicles. Improving their efficiency is therefore important for reducing emissions out to 2035 and beyond.

³³ The demonstration path assumes the efficiency of light ICE vehicles entering the fleet improves by around 1.3% per year on average, leading to a fleet-wide efficiency improvement of 11% by 2035. This is based on Ministry of Transport projections and includes the effect of a growing share of conventional hybrid vehicles.

³⁴ We assess there are fewer opportunities for improving the efficiency of trucks. However, further opportunities to reduce emissions from freight exist through operational efficiency (such as route optimisation and collaborative use) and switching some freight movements from road to rail and coastal shipping. The demonstration path assumes 5% operational efficiency gains in road freight and that 3% of total freight tonne-kilometres can switch by 2030, relative to the Current Policy Reference case. Further reductions in freight emissions could be achieved by completing the electrification of the Auckland to Wellington railway line and electrifying the Hamilton to Tauranga railway line.

7.2.4 Increasing use of low carbon liquid fuels

³⁵ Low carbon liquid fuels, such as biofuels, are another way to reduce emissions from ICE vehicles now. They may also have a long-term role in hard-to-electrify uses, particularly long-haul aviation and shipping.

³⁶ The demonstration path assumes the use of low carbon fuels increases to 5 petajoules per year by 2030 and 9.5 petajoules per year by 2035. This is equivalent to around 270 million litres of fuel or roughly 5% of total liquid fuel demand in 2035. For simplicity, we have modelled this as an equal share across all fuel types (petrol, diesel, jet fuel and marine fuel oil).

7.2.5 Reducing emissions from domestic aviation and shipping

³⁷ Aviation and shipping face more challenges for decarbonisation than land transport. Still, in addition to low carbon liquid fuels there are other proven and emerging opportunities.

³⁸ The demonstration path assumes further improvements in efficiency, which have played an important role in limiting emissions growth historically.

³⁹ Based on stakeholder feedback and our analysis, we assume that from 2030, short-haul aviation – such as a trip from Wellington to Nelson – begins to convert to new generation planes. We modelled this as electric planes, but biofuels or hydrogen could also be used to make sustainable aviation fuel for longer distance flights. Overall, we assume 5% of aviation fuel use can be displaced by 2035.

⁴⁰ We also assume that domestic shipping, including the Cook Strait ferries, switches to zero-emissions fuels at the same rate as heavy trucks. Use of batteries, hydrogen or ammonia fuel cells are all potential options.

7.3 Buildings in the demonstration path

- ⁴¹ The long-term scenarios show that actions to improve the energy efficiency of buildings, alongside decarbonising the energy used for heating, hot water and cooking, will be important for meeting the 2050 targets. Improving the energy efficiency of homes reduces emissions and can improve the occupants' health, particularly for low-income households. This is because homes in Aotearoa are typically underheated in winter. Households may choose to maintain a warmer home after improving energy efficiency, rather than reducing their energy use or emissions. A warmer drier home is also healthier (see *Chapter 8: Demonstrating emissions budgets can be fair, inclusive and equitable*).
- ⁴² In the demonstration path, we assume that the heat demand for existing homes reduces by 6% by 2035. We assume newly built homes require 35% less heating compared to today's performance.
- ⁴³ It is already possible to transition away from heating homes with coal and fossil gas. Heat pumps already offer a lower cost way to heat homes compared to fossil gas. For hot water, where possible, electric resistive hot water cylinders offer an alternative to fossil gas systems with comparable costs.
- ⁴⁴ Heat pumps will offer a lower cost option to heat most new commercial and public buildings. For existing buildings, renovations offer an opportunity to replace fossil fuel heating systems, such as fossil gas central heating, with lower emissions alternatives such as heat pumps or biomass.
- ⁴⁵ Commercial and public buildings offer large opportunities to improve energy efficiency through improved insulation and greater control of energy use. New commercial and public buildings can be built to higher standards with new technologies to monitor and control energy use, and existing buildings retrofitted to achieve these improvements.
- ⁴⁶ The demonstration path assumes a 30% reduction in new commercial and public buildings' heat demand is possible by 2035 compared to today's performance. We assume that existing commercial and public buildings' heat demand reduces by 25% by 2035.
- ⁴⁷ Commercial and public buildings can transition away from coal to alternatives such as biomass which could be used in existing boilers.
- ⁴⁸ The demonstration path assumes that by 2030 coal use in commercial and public buildings will be largely eliminated. The Government announcement in 2020 that all coal boilers in public sector buildings will be phased out is a step towards this.
- ⁴⁹ Fossil fuel heating systems will typically last for 20 years or longer. The demonstration path looks to avoid new heating systems having to be scrapped before the end of their useful lives to avoid unnecessary costs.
- ⁵⁰ This means that we assume all new space heating or hot water systems installed after 2025 in new buildings are electric, to put Aotearoa on track for nearly completely decarbonising building heating systems by 2050.
- ⁵¹ For existing buildings, to be consistent with the insights from our long-term scenarios, we assume the phase out begins in 2030 (Figure 7.9). We also assume that no further fossil gas connections to the grid, or bottled LPG connections, occur after 2025. This would allow time for a steady transition, to be on track for a complete transition away from using fossil gas in buildings by 2050.
- ⁵² While they have not been directly modelled, it is possible that low emissions gases, such as biogas or hydrogen, could be blended into the current fossil gas network. This would reduce its emissions.

- 53 There are also emissions from building construction, producing construction materials and from waste generated throughout the lifecycle of a building. We account for emissions from construction, building energy use and producing construction materials under industry.
- 54 The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 6: Reducing emissions from transport, buildings and urban form* of the 2021 Supporting Evidence.

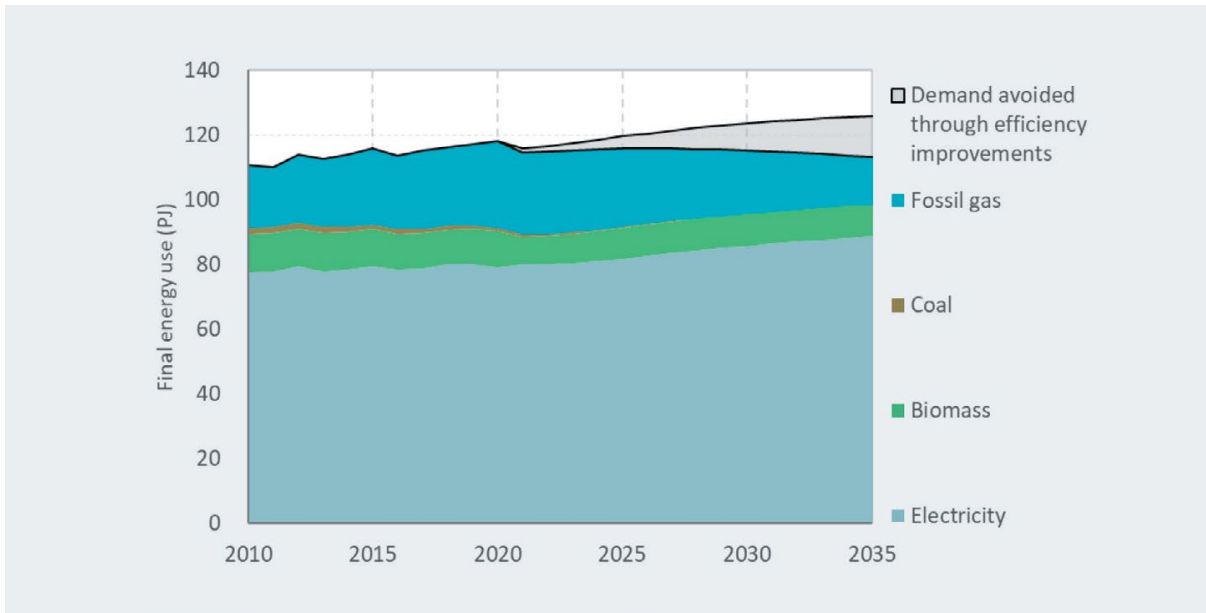


Figure 7.9: Energy use in buildings in the demonstration path

Source: Commission analysis

7.4 Electricity in the demonstration path

- 55 The use of low emissions electricity allows other sectors to reduce emissions. Electrifying transport and process heat will require significant expansion in electricity generation capacity. Demand for electricity will also increase as buildings and process heat switch away from fossil fuels. Increased generation and demand will need to be accompanied by expanding infrastructure for transmission and distribution.
- 56 The long-term scenarios showed that renewable wind and solar generation need to rapidly expand in the 2030s and beyond to meet increased electricity demand as electric vehicles (EVs) are widely adopted. This rapid expansion has been modelled in the demonstration path (Figure 7.10 and Figure 7.11).
- 57 However, in the short term, electricity generation companies may not commit to this expansion in capacity while there is uncertainty around the future of the New Zealand aluminium smelter at Tiwai Point.
- 58 The New Zealand aluminium smelter is the single largest consumer of electricity. Over the last five years it used on average around 13% per year of the country's electricity. During the course of the Commission preparing its advice, the future of the smelter was under review by its owner Rio Tinto. If Rio Tinto decides to close it, this electricity would be available for other uses, delaying the need for new generation. In January 2021 the New Zealand aluminium smelter reached a deal to extend its electricity contract through to December 2024, enabling it to continue operations until 2024.

- 59 In the demonstration path, as in the Current Policy Reference case, we assume the Tiwai Point aluminium smelter comes to a full close at 31 December 2024 and assume electricity becomes available for other uses in Aotearoa.
- 60 Wind, solar and geothermal offer low cost and low emissions ways of generating electricity. The demonstration path would see 3.8 TWh of currently committed generation projects built between 2020 and 2024. The building of further renewables pauses due to the New Zealand aluminium smelter closing and resumes in the late 2020s. Beyond 2030, our modelling shows increases in wind, solar and geothermal generation greater than 1 TWh per year. This is illustrated in Figure 7.10 and 7.11. The exact combination of renewable generation that is built in reality will depend on how the relative economics pan out.
- 61 Some geothermal fields have high emissions from their geothermal fluid, with an equivalent emissions intensity to fossil gas generation. In the demonstration path these high emitting geothermal fields would continue to operate. However, these high emitting fields have naturally degassed in recent years and we assume a continuation of their historic rate of reduction in emissions intensity. Geothermal power generation increases 23% while emissions increase 6% above 2019 levels by 2035.
- 62 Fossil gas generation provides flexibility to meet daily and seasonal peaks in demand and backs up renewable generation. While the demonstration path would see reductions in fossil gas generation, some fossil gas is still required to provide this flexibility until 2035 at least. In the demonstration path, coal fired generation at Huntly closes in the mid-2020s.
- 63 The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 5: Reducing emissions from energy and industry* of the 2021 Supporting Evidence.

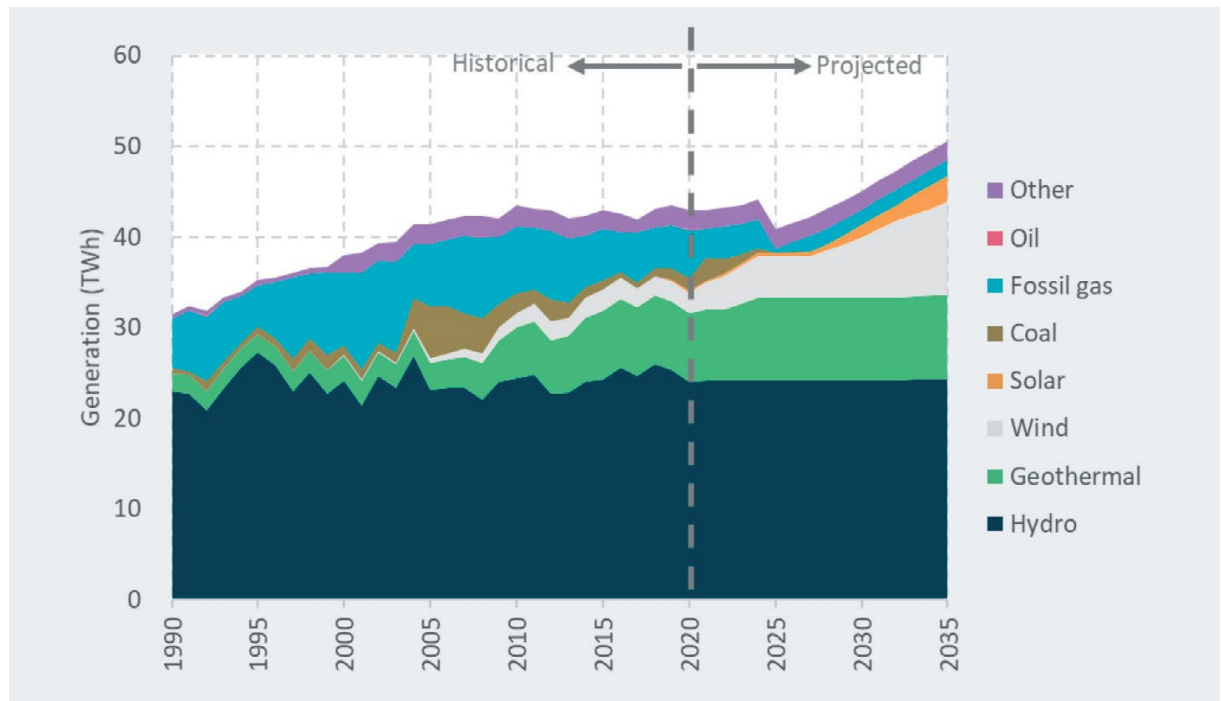


Figure 7.10: Electricity generation by fuel in the demonstration path

Source: Commission analysis

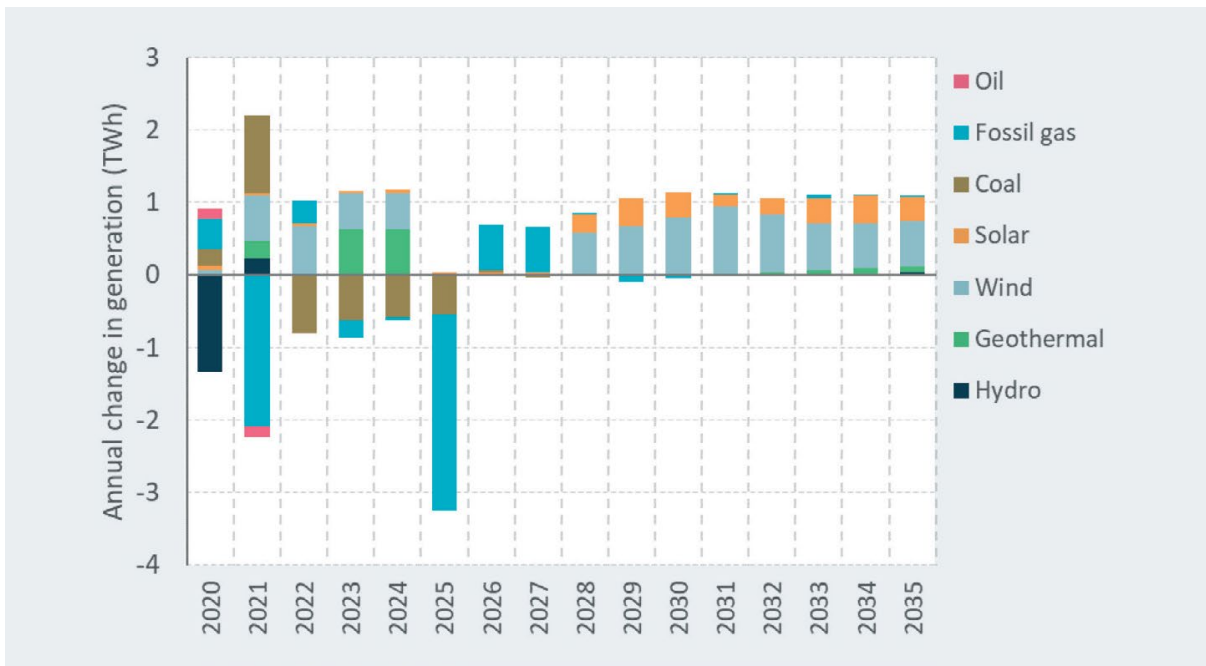


Figure 7.11: Annual increase (positive) or decrease (negative) in electricity generation in the demonstration path compared to the previous year. Note that 2020 was an historic dry year with low inflows into the hydro lakes, resulting in low hydro generation.

Source: Commission analysis

7.5 Industry and heat in the demonstration path

- ⁶⁴ There are proven options for decarbonising low- and medium-temperature process heat. These include switching fuel use from coal and fossil gas to biomass and electricity. There are also opportunities to improve energy efficiency.
- ⁶⁵ Some coal boilers in the food processing sector are already being replaced with biomass or electricity.
- ⁶⁶ The demonstration path would see a steady, but reasonably rapid, rate of conversion to be on track to eliminate coal use for food processing before 2040 (Figure 7.12). Coal use would decline at around 1.4 PJ per year to 2030 - the equivalent of converting one to two very large dairy processing plants away from coal each year or converting a larger number of smaller plants.
- ⁶⁷ Along with boiler conversion, the demonstration path assumes significant improvements in energy efficiency across the food processing sector, averaging 1.1% per year.

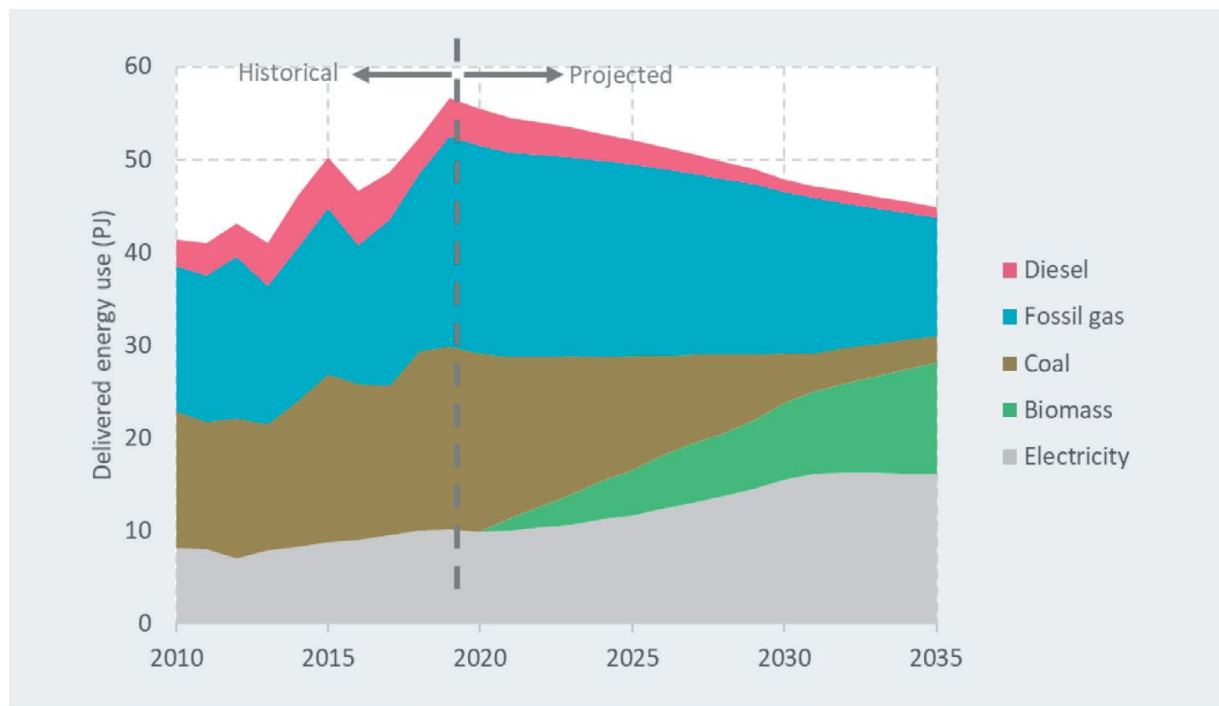


Figure 7.12: Food processing energy use in the demonstration path

Source: Commission analysis

- 68 Where available, biomass from forestry and wood processing residues are a low-cost fuel switching opportunity. There may be constraints on biomass supply in some regions where there is not significant forestry. In these regions, electric boilers will be needed, however they will have a higher operational cost than fossil fuel boilers at current carbon prices. Electrifying process heat will also require expanding the electricity transmission and distribution grids. This will add to the total cost.
- 69 In the demonstration path, fuel switching to biomass also occurs in some other energy-intensive industries such as wood, pulp and paper production. Biomass use in the wood, pulp and paper production sector steadily increases from current levels, reaching an additional 3 PJ by 2035.
- 70 Overall, the demonstration path takes advantage of the country's currently underused biomass resource to help decarbonise transport and process heat, moving towards a more circular economy. We assume that the biomass resource is from accessible domestic forestry residue and pulp logs. Achieving this uptake will require developing supply chains for gathering and processing biomass along with establishing local markets.
- 71 High-temperature process heat is more challenging to decarbonise and the demonstration path assumes continued use of fossil gas and coal in these sectors. While there is potential to further decarbonise a range of industrial processes through emerging technologies, we assume these are not available for use before 2035.
- 72 The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 5: Reducing emissions from energy and industry* of the 2021 Supporting Evidence.

7.6 Agriculture in the demonstration path

- ⁷³ The two main agricultural greenhouse gases are biogenic methane and nitrous oxide. Biogenic methane has a different target to other gases, recognising the different nature of the gas. Nitrous oxide is included in the long-lived greenhouse gas target.
- ⁷⁴ The long-term scenarios showed that widespread adoption of existing farm management practices would be important for meeting the less ambitious end of the 2050 biogenic methane target. Meeting the more ambitious end would require developing and deploying new technologies.
- ⁷⁵ In the demonstration path, we have also focused on the changes that farmers can make using current technology and practice. Achieving the 2030 targets and putting Aotearoa on track to meet the 2050 targets in the demonstration path involves changes in farming practices. This will take substantial work for the sector to deliver but is achievable with a sustained effort.
- ⁷⁶ New technologies that could reduce biogenic methane emissions from agriculture are not required to meet the recommended emissions budgets but would be of substantial benefit if developed, providing greater flexibility and the ability to reduce emissions further.
- ⁷⁷ Converting to lower emissions land uses such as horticulture also provides an opportunity to reduce emissions in the agricultural sector. However, there are currently barriers.
- ⁷⁸ The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 7: Reducing emissions from agriculture of the 2021 Supporting Evidence*.

7.6.1 Reducing emissions through changes in farming practices

- ⁷⁹ The work of the Biological Emissions Reference Group (BERG), the New Zealand Agricultural Greenhouse Gas Research Centre, and others, has identified several changes farmers can make that can reduce their greenhouse gas emissions. These include improving per animal performance while reducing stocking rates, reducing replacement animals, and moving to a lower input farm system. These options will interact within farm systems. No one approach or option will work for all farmers, nor should all farmers be expected to achieve the same level of emissions reductions.
- ⁸⁰ The key requirement for any practice change to reduce total biogenic methane emissions, and not just emissions intensity, is to reduce total dry matter consumption. The challenge for farmers is to find a better balance between livestock numbers, production levels and feed inputs (supplementary feed and fertiliser), which enables them to maintain farm profitability while reducing emissions. This generally means a greater proportion of dry matter consumed is used for production and less is used for animal 'maintenance'. Numerous modelling studies and farm trials suggest this is possible over time with data, skills and knowledge. With improving animal genetics, the performance frontier is continually advancing.
- ⁸¹ In the long-term scenarios we have made different assumptions about overall changes to livestock numbers and average production per animal that could result from a range of practice changes being adopted across different farms. We have tested these against more detailed assumptions on specific measures used in the BERG work to confirm they are plausible. We have also validated our modelling of emissions against the Ministry for Primary Industries' (MPI's) agricultural greenhouse gas inventory model.

- ⁸² The demonstration path follows the 'Tailwinds' future (see *Chapter 6: Long term scenarios to 2050*) where farmers succeed in making significant productivity gains at the same time as reducing livestock numbers. The alternative paths presented below in Section 7.9 consider a future where productivity improvements are much more limited.
- ⁸³ In the Current Policy Reference case, total dairy cattle numbers fall by around 8% from 2019 levels by 2030 while milk solids production drops by around 4%. This is based on MPI's projections.
- ⁸⁴ In the demonstration path, practice changes enable total dairy cattle numbers to be reduced further - to 13% below 2019 levels - while maintaining roughly the same milk production as in the Current Policy Reference case (Figure 7.13). This is consistent with work for the BERG assessing the potential for increasing individual animal performance and reducing replacement rates.
- ⁸⁵ Sheep and beef animal numbers are projected to fall by around 8% from 2019 levels by 2030 under the Current Policy Reference case, due to continued retirement of farmland and land-use change to forestry. Animal numbers are expressed as a weighted average of sheep and beef numbers based on approximate relative feed intake - one beef cattle is the equivalent of five sheep.
- ⁸⁶ The demonstration path sees deeper reductions in sheep and beef animal numbers of an additional 5 percentage points below 2019 by 2030, with only a small additional drop in meat production of around 1 percentage point. This includes the impact of new native forests established on sheep and beef farms, which is assumed to have a small effect on production.
- ⁸⁷ Through these changes, the demonstration path sees agricultural methane emissions reduced by almost 11% below 2017 levels by 2030.
- ⁸⁸ The changes would lead to a similar drop in nitrous oxide emissions. This includes modelled reductions in nitrogen fertiliser use on dairy farms that would be consistent with the reduction in dry matter consumption per hectare (ha). We estimate a potential reduction on the order of 20% by 2030 in the demonstration path, though the precise number would depend on farmer decisions around use of supplementary feed and grazing off. We have also assumed the share of urea fertiliser coated with urease inhibitor increases to 100% by 2030.

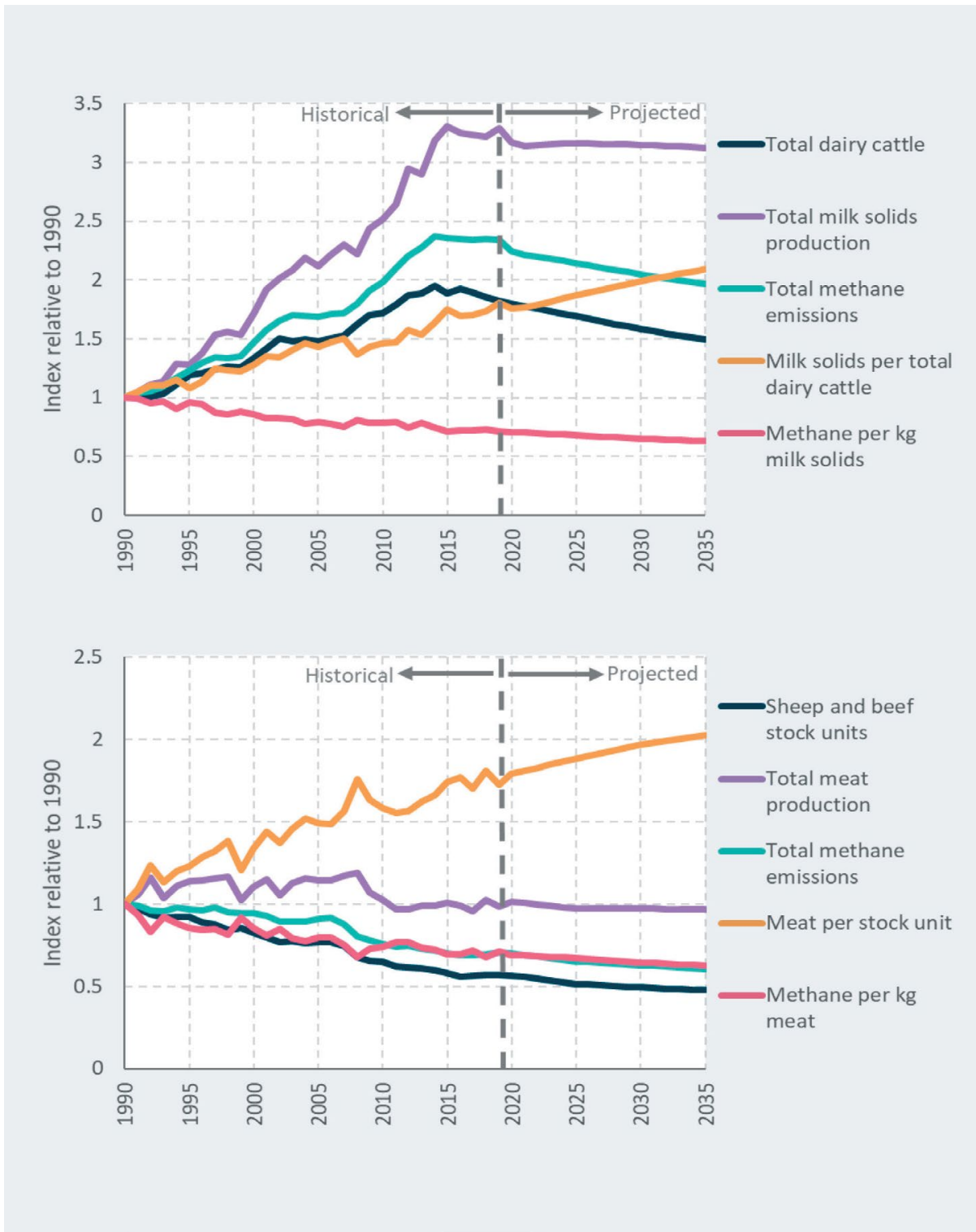


Figure 7.13: Changes in livestock numbers, production and emissions since 1990 and in the demonstration path for dairy farming (top) and sheep and beef farming (bottom)

Source: Commission analysis

7.6.2 New technologies to reduce emissions

⁸⁹ Selective breeding for lower emissions sheep is a proven option which is in the early stages of commercial deployment. The demonstration path assumes that this can be progressively adopted, reducing overall biogenic methane emissions from the sheep and beef farming sector by 1.5% by 2030 and 3% by 2035.

⁹⁰ We have assumed selective breeding does not have an emissions impact before 2025. Breeding for low emissions cattle has commenced, but it will take a decade or so to see an impact on emissions from selective breeding. We therefore assume there is no selective breeding for cattle by 2035.

⁹¹ Biogenic methane inhibitors and vaccines are being researched and trialled. These could reduce the amount of biogenic methane that is released from cattle and sheep. While there has been progress on inhibitors, these are not yet commercially available. There might be an inhibitor on the market in the near future, but there are still barriers to overcome like uncertainties about what their costs could be and how effectively they could reduce emissions.

⁹² In the demonstration path, we have assumed that biogenic methane inhibitors and vaccines are not used before 2035. However, if any of these technologies could be brought to market before 2035, they would provide additional options for meeting the emissions budgets. We will review how these technologies are progressing and will consider changes to the emissions budgets if evidence becomes available that they can be widely adopted in the future.

7.6.3 Converting land to lower emissions land uses

⁹³ In the demonstration path, we assume 2,000 ha of land is converted to horticulture per year from 2025 (Figure 7.14). We expect that this could increase in the future if barriers – such as water availability, labour, supply chains and path to market – are addressed.

⁹⁴ Converting land to exotic and native forests is discussed in the next section.

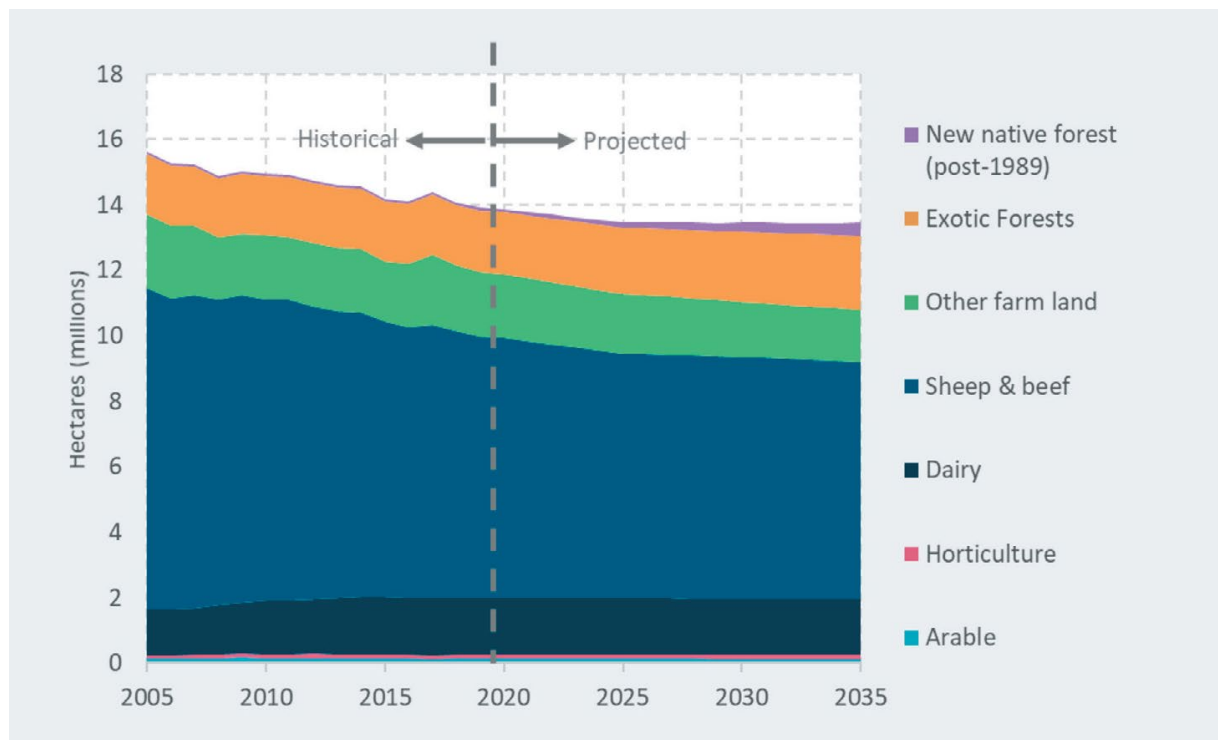


Figure 7.14: Land use for agriculture and forestry in the demonstration path

Source: Commission analysis

7.7 Forests in the demonstration path

- ⁹⁵ The demonstration path would see a significant increase in new native forests established on less productive land, through a combination of active planting and letting land revert to native forests. This is in line with the insights from the long-term scenarios. In these scenarios we saw the need for new native forests to build a long-term carbon sink to offset residual long-lived greenhouse gas emissions from hard-to-abate sectors.
- ⁹⁶ MPI has forecast that there will be around 12,000 ha of new native forests established in 2021. The demonstration path would see this ramp up to 25,000 ha per year by 2030 (Figure 7.15). In total, close to 300,000 ha of new native forests would be established from 2021 to 2035 (Figure 7.14 above). The rate that we can plant or revert native forest would likely be limited by nursery capacity (where planting is needed), pest control and fencing.
- ⁹⁷ Estimates from recent studies suggest there is in the order of 1,200,000 to 1,400,000 ha of marginal land that could be converted to forests, 740,000 ha of which could revert to native forests naturally. As much of this land is steep and prone to erosion, we consider that it would be more suitable for permanent forests, particularly native forests.
- ⁹⁸ Establishing close to 300,000 ha of native forests could cost between \$5 billion and \$15 billion. The carbon benefits alone could outweigh the establishment and maintenance costs after a few decades. This return could be achieved in as short as about 15 years for reverted forests or as long as about 70 years for higher cost planted forests. Native forests also provide a range of benefits.
- ⁹⁹ In the demonstration path, exotic forestry planting would continue the trajectory expected under Current Policy Reference scenario up until 2030, averaging around 25,000 ha per year over the decade. From 2030 onwards, the rate of exotic forestry planting for carbon removals would reduce. In total, around 380,000 ha of new exotic forestry would be established from 2021 to 2035.
- ¹⁰⁰ We have assumed there is no change in permanent exotic forest planting beyond what is included in the Current Policy Reference case as additional planting would not be required to reach the 2050 targets.
- ¹⁰¹ As well as planting new forests, the demonstration path would see reduced deforestation, which is still a considerable source of emissions in Aotearoa. The demonstration path assumes that no further native deforestation occurs after 2025.

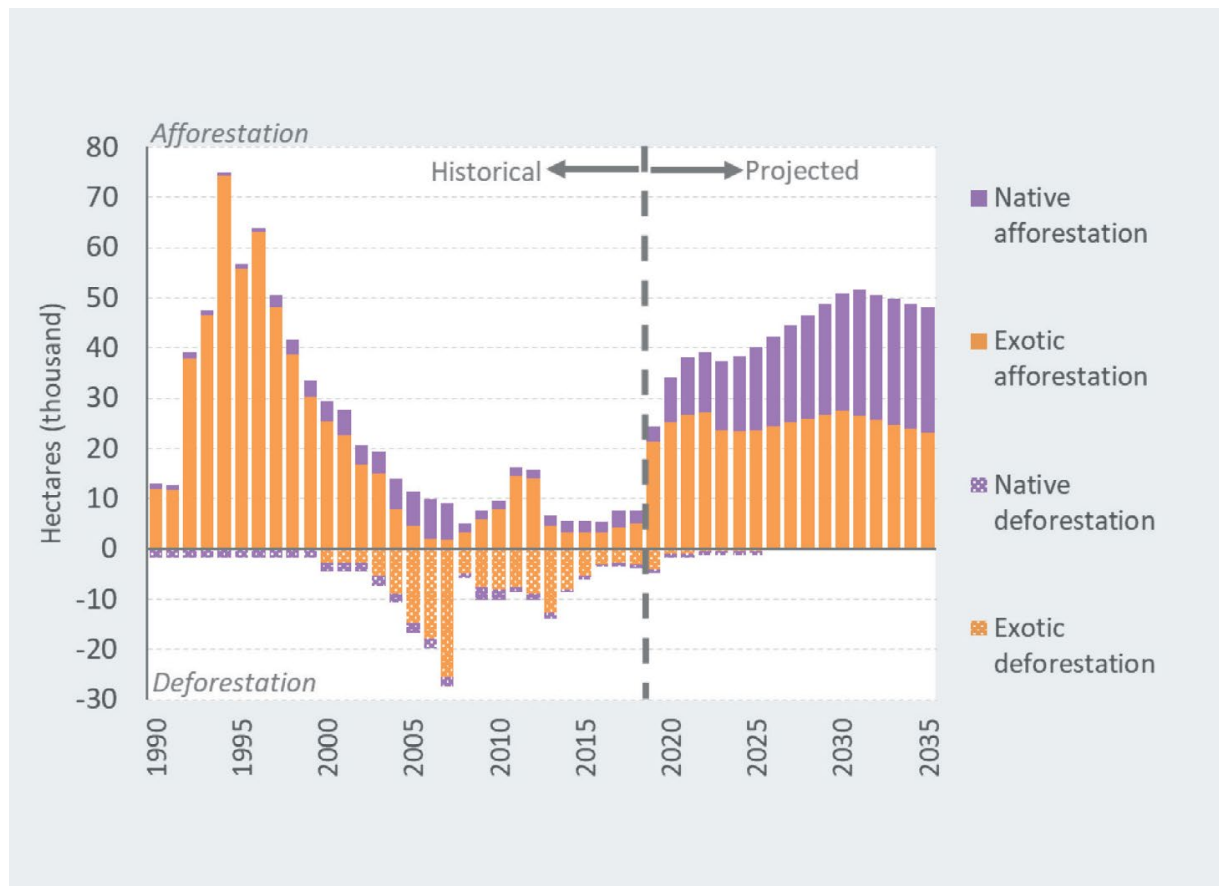


Figure 7.15: Afforestation and deforestation by year in the demonstration path

Source: Commission analysis

- 102 Trees can help in the transition to a low emissions Aotearoa in other ways.
- 103 Bioenergy offers a low cost route for decarbonising some sectors, including process heat. Overall, there appears to be a large potential biomass supply from pulp logs and collecting and using waste from forestry and wood processing.
- 104 However, availability is likely to vary across the country due to regional mismatches in supply and demand, and the cost of transporting biomass. While the supply of biomass residues may appear to be abundant in some regions, trade-offs may also need to be made when deciding what parts of the economy to decarbonise using biomass first.
- 105 Timber can displace emissions-intensive materials such as steel and cement in buildings. This reduces embodied emissions and can lock up carbon for several decades.
- 106 The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 9: Removing carbon from our atmosphere* of the *2021 Supporting Evidence*.

7.8 Waste and F-gases in the demonstration path

- 107 Reusing and recovering waste materials is a key part of a circular economy. The demonstration path would see a reduction in the amount of waste generated, and a focus on reducing the amount of organic waste, such as food, wood and paper, that goes into landfills. Overall, the share of total organic waste avoided or recovered from landfill would increase to 28% by 2030 (Figure 7.16).
- 108 Waste emissions can be further reduced by increasing the amount of methane that is captured and destroyed from landfills. This could be achieved through upgrading or installing new landfill gas capture systems, or by diverting organic waste from sites without landfill gas capture to those with capture. Installing gas capture at existing sites that have received substantial volumes of organic waste in the past would be particularly impactful as it enables the capture of legacy emissions as this waste decomposes.
- 109 In the demonstration path we assume that by 2030, it is possible to capture roughly one-quarter of the methane that would have been emitted from landfills currently without capture systems (non-municipal and smaller municipal landfills). We also assume that the efficiency of existing gas capture systems is slightly increased.
- 110 Overall, these changes see methane emissions from waste falling 29% by 2030 relative to 2017 levels in the demonstration path.
- 111 The evidence base underpinning these assumptions and the full reasoning is outlined in *Chapter 8: Reducing emissions from waste of the 2021 Supporting Evidence*.

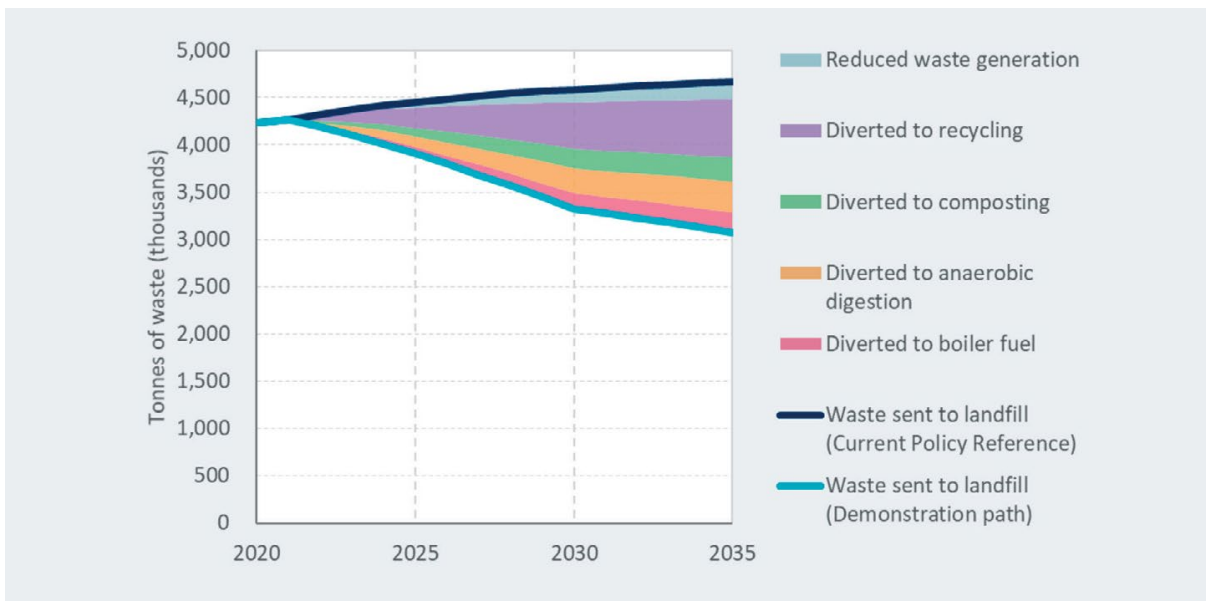


Figure 7.16: Total organic waste sent to landfill in the demonstration path

Source: Commission analysis

- 112 Fluorinated gases, particularly hydrofluorocarbons (HFCs), are greenhouse gases that are primarily used as refrigerants in fridges, freezers and air conditioning systems. The demonstration path assumes greenhouse gas emissions from HFCs reduce by 21% by 2030 and 32% by 2035 relative to 2019, in line with the actions Aotearoa takes under the Kigali Amendment to the Montreal Protocol. This can be achieved through reducing the import of HFCs contained within products, reducing equipment leakage and increasing end-of-life recovery of products that contain these gases.

7.9 There are different ways Aotearoa could meet the budgets

- ¹¹³ We are required under the Climate Change Response Act 2002 to recommend emissions budgets that are ambitious but achievable. There is inherent uncertainty when assessing the future – some technologies may develop faster than predicted, while others may be slower or not become commercially viable.
- ¹¹⁴ To ensure that emissions budget levels are achievable, we have tested to ensure that they can be met across a range of future circumstances.
- ¹¹⁵ Being able to meet the budgets in different ways gives us confidence that there is enough flexibility in how the recommended emissions budgets can be met. Putting Aotearoa on track to its emissions targets and playing its part in the global effort to limit warming to 1.5°C requires budgets to be set at an ambitious level that will require hard work to achieve. However, if we make them too hard, there is no flexibility if things do not turn out how we plan.
- ¹¹⁶ We have developed two alternative paths to the demonstration path. These build on the long-term scenarios and demonstrate how the recommended emissions budgets could be met with different mixes of actions. This helps to test the degree of flexibility the budget levels allow and how slower progress in some areas could be made up for by further progress in others. It also helps to understand which actions are critical in any path.
- ¹¹⁷ The specific variations in alternative paths A and B (see *Chapter 6: Long term scenarios to 2050*) compared with the demonstrated path are set out in Table 7.3. Other actions common to all three paths are as described in the previous section above.
- ¹¹⁸ Figure 7.17 shows the emissions and removals for each path over the three budget periods. The alternative paths would meet the overall emissions budgets defined by the demonstration path to within 1 MtCO₂e. They would also meet the 2030 biogenic methane target.
- ¹¹⁹ The alternative paths would also achieve broadly the same balance of long-lived gases and biogenic methane within the budgets. Due to the different warming impacts of different greenhouse gases, altering the balance of long-lived gases and biogenic methane would impact the country's contribution to warming and our ability to meet the 2050 targets.

7.9.1 Alternative path A: Less technological change, more behaviour change

- ¹²⁰ We have tested whether our recommended emissions budgets could still be met through a slower uptake in electric vehicles (EVs) and with less emissions reduction achieved through changes in farm management practices. In this case, the emissions budgets could be met through:
- Further reducing travel and shifting to lower emissions travel modes such as walking, cycling and public transport
 - Further improving the emissions efficiency of internal combustion engine (ICE) vehicles entering the fleet, particularly through higher uptake of conventional hybrids
 - Further land-use change from livestock agriculture into horticulture and exotic forestry
 - Further reducing the amount of organic waste sent to landfill
 - Further increasing end of life capture and destruction of F-gas refrigerants
 - An earlier switch away from fossil gas use in the wood processing sector

7.9.2 Alternative path B: More technological change, less behaviour change

¹²¹ We have also tested whether our recommended emissions budgets could be met if people do not change behaviour as far as assumed in the demonstration path. In this case, the emissions budgets could be met through:

- further accelerating uptake of EVs so that by 2030 all new light vehicles entering the country are electric
- a biogenic methane inhibitor being widely adopted on dairy farms, reducing biogenic methane emissions from dairy cattle by around 5% in 2030 and 15% by 2035
- further increases to landfill gas capture coverage and efficiency.

¹²² This path would overachieve the third emissions budget by 8 MtCO₂e, illustrating the opportunities to extend future ambition through driving strong and early adoption of key technologies.

Table 7.3: Actions and outcomes that differ between the demonstration path and alternative paths A and B

	Demonstration path	Alternative path A	Alternative path B
EV share of light vehicle registrations	50% by 2029 ~100% by 2032	50% by 2031 ~100% by 2035	50% by 2027 ~100% by 2030
Household light vehicle travel	36 billion vehicle-km in 2035 (5% increase from 2019)	33 billion vehicle-km in 2035 (5% decrease from 2019)	39 billion vehicle-km in 2035 (12% increase from 2019)
Fuel economy of ICE cars entering fleet	Average improves to 7.1 L per 100 km by 2035 (20% lower than 2019)	Average improves to 6.0 L per 100 km by 2035 (32% lower than 2019) with higher share of conventional hybrids	Same as demonstration path
Low carbon liquid fuels	12 PJ (~270 million litres) per year by 2035, including non-transport use		None
Electric air travel	5% of domestic air passenger-km electric by 2035	None	10% of domestic air passenger-km electric by 2035
A large pulp mill conversion to high efficiency recovery boiler	2030	2025	2030

Farm management changes	Reduce average emissions per ha by 13% for dairy and 4% for sheep and beef by 2035 relative to 2019	Reduce average emissions per ha by 8% for dairy and 1% for sheep and beef by 2035 (compared with baseline reduction of 6% for dairy and increase of 3% for sheep and beef)	
Biogenic methane inhibitors and vaccine	None	Reduces dairy enteric methane by 5% by 2030 and 15% by 2035	
Exotic afforestation	Average of 25,000 ha per year to 2030	Average of 29,000 ha per year to 2030	Same as demonstration path
Land-use change to horticulture	2,000 ha per year converted to horticulture from 2025	From 2021, additional 3,500 ha per year converted from dairy	Same as demonstration path
Waste recovery/diversion	Reduce total organic waste to landfill by 34% by 2035, relative to current policy reference case	Reduce total organic waste to landfill by 51% by 2035, relative to current policy reference case	Same as demonstration path
Landfill gas capture	By 2035: Average municipal landfill capture efficiency increased from 68% to 73% Capture systems cover 60% of methane generated from smaller and non-municipal landfills	Municipal landfill capture efficiency increased to 80%; Capture systems cover 73% of methane generated from smaller and non-municipal landfills	
HFCs	32% emissions reduction by 2035, relative to 2019	39% emissions reduction by 2035, relative to 2019	Same as demonstration path, relative to 2019

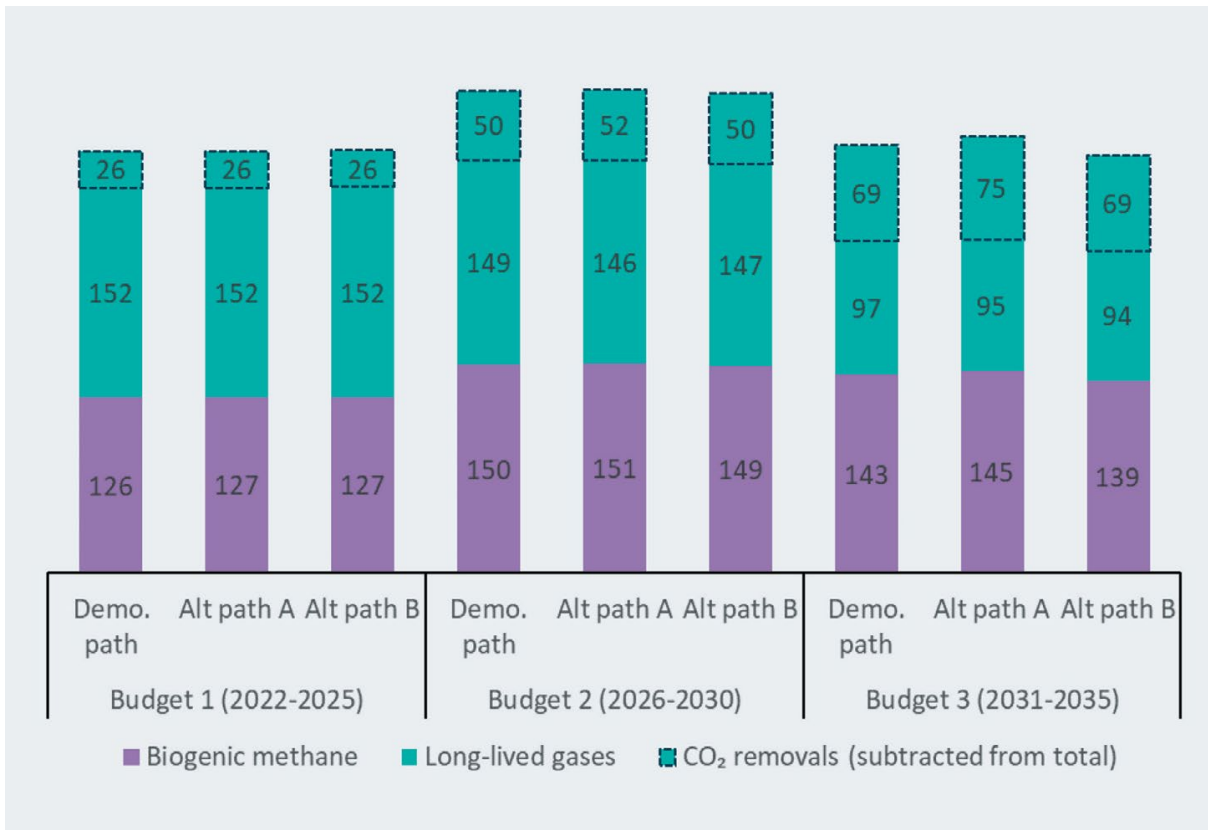


Figure 7.17: Emissions and removals by budget period in the demonstration path and alternative paths A and B

Source: Commission analysis

7.10 Risks to meeting the budgets and opportunities to outperform

¹²³ We have undertaken sensitivity analysis to test how further uncertainties could impact on the ability to meet the recommended emissions budgets.

¹²⁴ Figure 7.18 shows the modelled impact on emissions in each budget period for the 13 individual factors tested.

¹²⁵ Holding all other assumptions constant, we have modelled how the demonstration path would be affected by:

- **Slower or faster rates of population and GDP growth.** We have tested population growth rates 0.4 percentage points faster or slower, and GDP growth rates 0.3 percentage points higher or lower, based on government projections.
- **Continued operation of the New Zealand aluminium smelter.** We have tested what happens if the smelter continues to operate beyond 2024. Two variants have been modelled to highlight different potential outcomes for the electricity sector. The first assumes full certainty that the smelter will continue to operate (solid bars in Figure 7.18). The second assumes ongoing uncertainty around whether the smelter will continue to operate, resulting in lower investment in new renewable generation (hatched bars in Figure 7.18).
- **Potential closure or continued operation of other large industrial emitters.** For illustrative purposes, we have tested the impact if steel production, oil refining or methanol production were to close for the last two years of each budget period. For methanol, we have also tested a case where full output resumes from 2026 with the reopening of the mothballed Waitara Valley methanol train.
- **Variability in hydro in-flows.** We have estimated the variability in emissions that could occur with more dryer or wetter hydro years occurring in the budget period, compared to mean hydro years as assumed in our modelling.
- **Uncertainty in projected levels of afforestation and deforestation.** We have tested using the high and low bounds of the Ministry of Primary Industries' projections for exotic afforestation and deforestation of post-1989 forests.
- **Potential for constrained supply of used EVs.** We have tested what happens if imports of used EVs are constrained to the same level as in the Current Policy Reference case (assuming no other changes in the vehicle market).
- **Uncertainty around projected energy and vehicle costs.** We have tested high and low values for EV costs, oil price, capital cost reductions for renewable generation, and biomass prices. Note that in our transport modelling, the oil price only affects the choice of vehicle technology – it does not affect travel demand or choice of travel options.

¹²⁶ Appendix 1 in *Chapter 12: Long-term Scenarios to meet the 2050 target* of the *2021 Supporting Evidence* provides further detail on the assumed variations or sensitivity ranges tested in each case, compared with what is assumed in the demonstration path.

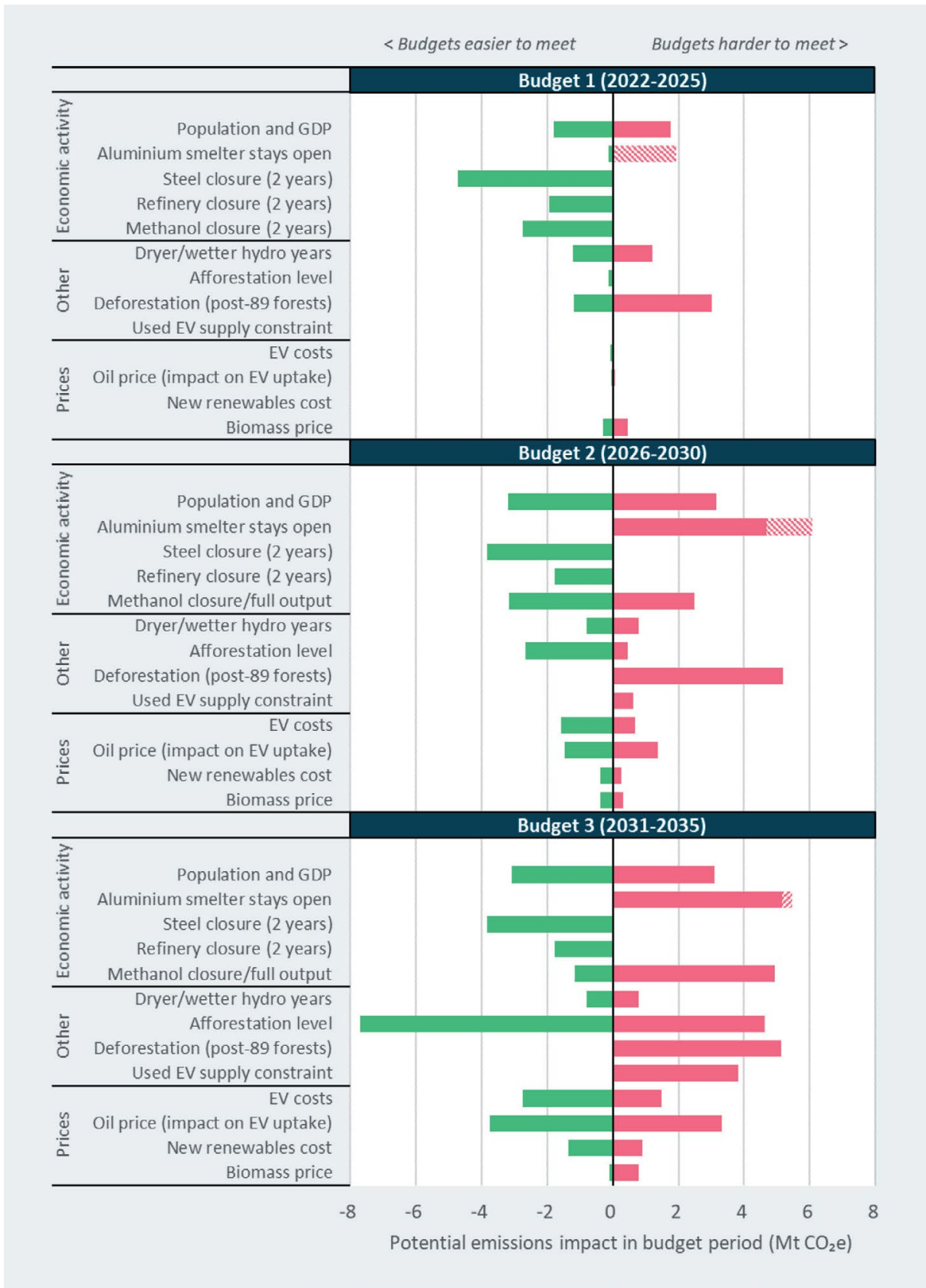


Figure 7.18: Sensitivity analysis of budget period emissions to selected factors or events

Source: Commission analysis

127 The range of impact for the individual sensitivities tested is less than 2% of the total emissions budget for Budgets 1 and 2. For most, the range of impact is less than 1%. For some – particularly afforestation and those affecting EV uptake – the impact is minimal in Budget 1 but is larger by Budget 3 due to cumulative effects and the time taken for forests to grow.

128 Overall, this assessment gives us confidence that the risks these uncertainties pose for meeting the recommended budgets are manageable. In general, the Government can manage these risks through aiming to outperform the budgets in its emissions reduction plan. This will provide headroom to accommodate unexpected events that increase emissions, as well as underperformance against expectations in some areas.

129 For example, the faster progress and further actions seen in the Tailwinds scenario would deliver further emissions reductions that significantly outweigh the upside risks identified in the sensitivity analysis (Figure 7.19). The biggest opportunities seen here are in faster uptake of EVs, further behaviour change in transport, and successful adoption of new methane-reducing technologies in agriculture. By the same token, the risks of delayed action and slower progress seen in the Headwinds scenario are much larger than any risks identified through our sensitivity analysis.



Figure 7.19: Where our recommended emissions budget levels sit relative to the Headwinds and Tailwinds scenarios. The Tailwinds scenario would deliver a further 4 Mt CO₂e in emissions reductions in budget period 1 than our recommended emissions budgets.

Source: Commission analysis

130 Two specific risks our assessment highlights for the first budget period may warrant particular attention from the Government:

- **Deforestation of post-1989 forests.** We have assumed no change from the Ministry for Primary Industries’ projected deforestation area over the first emissions budget period, but there is a considerable uncertainty range around this. Some post-1989 forests have no deforestation liability because they are not registered in the New Zealand Emissions Trading Scheme (NZ ETS), and some post-1989 forests that are registered in the NZ ETS have no incentive to replant after harvest due to their age class (this differs from pre-1990 forests which face a deforestation liability through the NZ ETS). Under current policy the Government has limited ability to affect deforestation decisions about these forests.

- **Uncertainty around the future of the New Zealand aluminium smelter.** If the smelter were to unexpectedly stay beyond its currently signalled closure in 2024, this would lead to more fossil fuel electricity generation in addition to the direct emissions from the smelting process. The continued operation of the aluminium smelter could result in continued baseload thermal generation and new fossil gas peaker plants to meet growth in electricity demand across the economy. However, if this were to be signalled early and with certainty, this would likely bring forward construction of renewable generation projects and minimise the increase in fossil fuel electricity generation. Taking steps to provide greater certainty to the electricity sector could help to mitigate this and other risks. We discuss this further in *Chapter 15: Policy direction for energy, industry and buildings*.

¹³¹ We have not attempted to quantify how potential future updates to *New Zealand's Greenhouse Gas Inventory* could impact on meeting budgets. We discuss how such updates can be handled in *section 10.8 of Chapter 10: Rules for measuring progress towards emissions budgets and 2050 targets*.

7.11 What does this mean for policy?

¹³² We have recommended emissions budget levels that are technically achievable and economically affordable. We have demonstrated there are multiple ways to achieve our recommended emissions budgets and tested their sensitivity to our assumptions.

¹³³ But our recommended emissions budget levels are also ambitious. There is some but not a lot of flexibility in how they can be delivered – there are a number of actions that are critical under all scenarios. Meeting these budget levels relies on moving as quickly as real world constraints allow. The changes that are needed will not be delivered without hard work from individuals, Iwi/Māori, the private sector and public sector.

¹³⁴ There are a number of critical outcomes that Aotearoa will need to achieve:

- Expanding native forests to build a long-term carbon sink.
- Increasing the number of people who walk, cycle, use public transport and emerging low emissions options like e-scooters and e-bikes rather than petrol cars.
- Accelerating EV uptake and phasing out light ICE engine vehicle imports sometime between 2030-2035 – consistent with the phase out dates being set by a growing number of countries – and importing more efficient ICE vehicles, including conventional hybrids, while the EV supply grows.
- Improving the efficiency of heavy transport and freight, including through freight optimisation, and increasing the share of rail and coastal shipping.
- Scaling up low emissions fuels like biofuels or hydrogen-derived synthetic fuels. Biofuels are particularly useful in decarbonising the current vehicle fleet.
- Increasing energy efficiency in homes, commercial and public buildings.
- Phasing out new fossil gas connections and switching existing fossil gas appliances to low emissions fuels.
- Eliminating coal use in commercial and public buildings by 2030, and for food processing before 2040.
- Expanding the electricity system in a timely, reliable, and affordable way, while managing the opposing risks of under or over-investing in the system. Over-investment risks increasing the delivered cost of electricity or stranded assets, which would disincentivise electrification. Under-investment risks delaying progress on wider decarbonisation efforts in transport, industry, and buildings.

- Adopting farm management practices that will reduce biogenic methane and nitrous oxide emissions.
- Developing and deploying new technologies that could reduce biogenic methane emissions from agriculture.
- Opening up opportunities for more conversion to lower emissions production systems and land uses, including horticulture.
- Increasing the availability of low-waste and low emissions options for businesses and consumers when purchasing and disposing of goods.

135 Government will need to use its policy levers to enable, incentivise, or require changes as appropriate. There are challenges and barriers to meeting emissions budgets, but there are barriers that can be overcome through policy (see *Chapter 11: Approach to developing advice on policy direction* for more information).

136 Looking internationally, it is clear that policy can be designed to deliver these actions. The countries that have had the most successful EV uptake have had a range of policies to encourage that uptake. The countries that have developed markets for low carbon energy have had policy to support that.

137 To deliver these emissions budgets, the Government will need to encourage a wider set of actions than what is simply 'necessary' under any one of the paths to meet the emissions budgets. The Government should aim to overachieve the emissions budgets as some policies and actions may not deliver the expected reductions, and some technologies may not develop as expected.

138 Building in this flexibility and keeping options open will be important. Keeping options open will allow Aotearoa to adjust course as the low emissions transition proceeds. In this way government, industry, businesses and individuals will be able to adapt as new information, technologies and approaches are developed – which can help support a lower cost and more equitable transition.

139 There are some low regret choices that are sensible to adopt under any future, such as increasing energy efficiency and accelerating electrification of the transport fleet. It is also possible that some policies or approaches could shut down future options, and this should be avoided. For example, some infrastructure investments or urban planning decisions might lock Aotearoa into modes of transport or ways of living that make it hard to take advantage of new technologies in the future.

140 At the same time, it will also be important that we build on our successes – such as our already highly renewable electricity generation – and accelerate progress where possible, and make decisions that take advantage of key windows of opportunity. When important new opportunities are identified, the Government will need to act swiftly and decisively to drive faster and deeper emissions reductions. At times, the Government and businesses might need to invest significantly in key technologies to help make the transition cheaper and faster.

141 Uncertainty about the future is not a reason for delay. In fact, it is a reason for stronger action. It is important that we chart a path forward that has enough flexibility to ensure it is resilient.

Box 7.3: Key changes we have made to our modelling as a result of consultation feedback

During consultation, we received feedback from submitters about our models and assumptions. The key areas where we received feedback from submitters and made changes to our modelling in response to new evidence are detailed by sector in Table 7.3 below. In some cases, we made amendments to the assumptions we used in the demonstration path. In other cases, we made amendments to the alternative paths, long-term scenarios or carried out sensitivity analysis.

We do not intend for the demonstration path to be a prescriptive path that Aotearoa must follow to meet our recommended emissions budgets, but rather as a path to show that our recommended emissions budgets are achievable. Assessing the level at which to set assumptions in the various scenarios and paths is a difficult task. Reality will pan out differently. However, by running various scenarios, paths and sensitivity analyses, we are confident that our recommended emissions budgets are achievable and ambitious, with sufficient flexibility around how they can be met.

Table 7.3: Feedback we received about our assumptions and modelling, and what we have changed.

	Key feedback we received	What we have changed since our 2021 Draft Advice for Consultation
Transport	Our active and public transport assumptions did not reflect the difference between urban areas and rural areas.	<p>We modelled regional shifts to better reflect the differences between urban and rural areas. Instead of averaging our results across Aotearoa, we modelled five regions: Auckland, Waikato, Wellington, Canterbury and Rest of Aotearoa.</p> <p>We increased our assumptions on the proportion of travel shifting to both public and active transport in urban areas in our scenarios and paths. These changes are more reflective of the transport targets set out in regional climate plans such as the <i>Auckland Climate Action Plan</i>. We reduced our assumption on the proportion of people shifting to public transport in provincial areas, and increased shifting to some modes of active transport, such as cycling. In aggregate, this has increased the level of ambition in our mode shift assumptions in the demonstration path.</p> <p>We have also tested the impact of greater or reduced mode shift in our alternative paths A and B.</p>

Our EV uptake may be too ambitious in the short term as Aotearoa could face supply issues.

We carried out additional analysis on potential supply constraints for EVs. As a result, we reduced the level of supply of *used* EVs available in the 2020s in the demonstration path. However, we have not changed our assumptions for how fast *new* EVs will be adopted as the global EV market is rapidly developing. We expect that any supply constraints Aotearoa may face for new EVs would be minor and short lived.

We also increased the rate of fuel efficiency improvements for imported ICE vehicles in the demonstration path. This includes a faster uptake of conventional hybrid vehicles in the used import market. This is due to tighter constraints on the supply of used EVs.

EVs are a key technology for meeting the third emissions budget. In alternative path A, we tested whether the budgets can still be met through a slower EV uptake.

We carried out a sensitivity analysis on EV costs, the oil price, and supply constraints on used EVs to test how variations to our assumptions could impact meeting the emissions budgets.

Our heavy transport assumptions were too conservative and needed to consider the potential for more efficiency improvements and greater use of low emissions fuels such as biofuels or hydrogen.

We introduced new assumptions on operational efficiency improvements for road freight in the demonstration path.

We also increased the amount of biofuels in the demonstration path to be in line with the level in our Tailwinds scenario – double what it was in our *2021 Draft Advice for Consultation*. This reflects potential supply from other feedstocks, such as tallow or imported feedstocks.

We did not specifically model hydrogen use in heavy transport as the ENZ model does not include this functionality. However, the heavy transport that becomes electric in the model could include hydrogen fuel cell vehicles.

We had not included low emissions aircraft, particularly electric aircraft in our primary path. Aviation could use all of the biofuels that we modelled if international aviation was to be included in future budgets.

We included some electrification of short haul domestic air travel in the demonstration path from 2030 onwards based on feedback from sector stakeholders and our analysis.

As noted above, we increased the supply of biofuels in the demonstration path. For simplicity, we have modelled this as an equal share across all domestic transport fuels. Our assumptions are for domestic use only and do not consider biofuel use in international aviation and shipping.

Buildings	<p>Our assumptions around the energy efficiency improvements possible in buildings were too conservative.</p> <p>Our assumptions on the cost of transitioning away from fossil fuelled heating systems were too low.</p>	<p>We carried out additional analysis on potential rates of energy efficiency improvements across different building types. However, we have not changed our modelling assumptions. Rather, we put increased emphasis on the emissions reductions that could be achieved through building design and construction practices in our qualitative discussion.</p> <p>We also highlight the work being undertaken by the Ministry of Business, Innovation and Employment’s Building for Climate Change programme to address operational energy and embodied emissions in Part two of our advice: <i>Emissions reduction plan advice</i>.</p> <p>We carried out additional analysis on the lifetime costs of new gas connections compared to continued use of fossil fuels. We assumed a 25% reduction in heat demand in existing commercial and public buildings by 2035, compared to a 16% reduction in our <i>2021 Draft Advice for Consultation</i>.</p>
Electricity	<p>Our wholesale electricity price trajectory underestimated near-term wholesale electricity prices. However, the longer-term price trajectory was largely in line with industry and other stakeholders’ expectations.</p> <p>Our assumption that high emissions intensity geothermal power generation stations would become uneconomic and close due to a rising emissions price was not nuanced enough.</p>	<p>We re-ran EnergyLink’s EMarket and I-Gen models, which complements our ENZ modelling. We refined the methodology to better model peak demand and reflected higher starting prices in line with current conditions. We explicitly included certain market conditions such as tight gas supply, low wind generation and low hydro lake storage levels in the model.</p> <p>We also carried out sensitivity analyses through the EnergyLink models where 1) fossil gas prices increase and 2) the smelter remains open.</p> <p>We refined the ENZ model with updated network development and cost allocation settings, and modelled a move to cost-reflective pricing by 2030.</p> <p>We refined the ENZ model to differentiate between existing geothermal fields and new fields. For each grouping, the model now specifies average emissions intensity, natural degassing rate, a location factor, and individual operation and maintenance costs.</p> <p>In the Tailwinds and Further Technology scenarios, a carbon capture rate of 35% is applied.</p>

Our assumptions about Methanex exiting the market in 2029 was too early.

We adjusted Methanex's exit so that it is no longer based on the 2029 end date of their publicly available gas supply contracts. The modelling now stages their closure to 2040. This assumption was changed in the Current Policy Reference case and flows through to the demonstration path.

This is compatible with modelled fossil gas supply but assumes continued investment to enhance extraction from onshore and offshore fields.

Our assumption about Tiwai Point aluminium smelter's exit did not align with Rio Tinto's publicly signalled date.

We adjusted our assumption so that all potlines at the smelter close by 31 December 2024 to align with the publicly signalled closure date. Previously, the smelter underwent a staged closure from August 2024 to August 2027, closing one potline at a time. This assumption was changed in the Current Policy Reference case and flows through to the demonstration path.

We carried out sensitivity analysis on the smelter's closure. The results of this are discussed in Section 7.10.

Our assumption that NZ Steel's emissions reduce by 10% as part of the COVID-19 economic shock did not eventuate.

We adjusted our assumption so that NZ Steel's emissions remain constant at 2018 levels. The *2021 Draft Advice for Consultation* had modelled a 10% reduction in fuel use and emissions from 2020. This assumption was changed in the Current Policy Reference case and flows through to the demonstration path.

Our assumption about energy efficiency improvements in the food processing sector was too ambitious as remaining opportunities to further improve efficiency can be costly.

In the demonstration path, we adjusted the annual rate of energy efficiency improvements in the food processing sector from 1.3% to 1.1%, in line with the Further Behaviour and Further Technology scenarios.

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Agriculture</p>	<p>Our assumptions about on-farm improvements were overly optimistic and beyond what can be achieved.</p> <p>We ‘stacked’ mitigations that could not be added together.</p> <p>Our assumptions about how much land might convert to horticulture were too low.</p>	<p>We revised the productivity projections in the Current Policy Reference case based on new data and information from MPI and further analysis. This included separating out estimated meat production from the dairy sector, and sheep and beef sector, and updating assumptions on factors contributing to future production such as lambing rates. The result of this is significantly lower projected productivity improvements for the sheep and beef sector.</p> <p>We also revised downwards the assumed potential of on-farm management practice improvements for sheep and beef. We did this after reassessing our assumptions against evidence including the Biological Emissions Reference Group’s 2018 report (BERG report). We found that, by looking at potential contributions from individual measures to improve productivity, the reduction in stock numbers we had previously assumed would likely only be achievable with reduced production.</p> <p>Separately, we have tested our modelled emissions outcomes under the demonstration path against MPI’s more detailed Greenhouse Gas Inventory model for validation.</p> <p>We checked our modelling assumptions. They are based on the BERG report, which included the ‘stackability’ of how different emissions mitigations interact. Our modelling avoids double-counting emissions reductions from technologies and practices.</p> <p>We used different assumptions for land-use change to horticulture in the different paths to explore the effects of different levels of land-use change to horticulture. In the demonstration path, we assumed 2,000 ha per year converting to horticulture. In alternative path A, we tested removing some of the barriers by increasing the rate of conversion to horticulture to 3,500 ha per year.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Forestry</p>	<p>Our modelling did not take into account the loss in production due to native forests</p>	<p>The <i>2021 Draft Advice for Consultation</i> assumed that native afforestation would not result in any loss of grazing land. We have updated our modelling so that native afforestation now results in an effective loss in grazing land of 20% of the area afforested. This recognises that a lot of new native forests will be established on steeper, erosion prone land with relatively low grass growth.</p>

Our assumptions on the amount of landfill gas (LFG) capture were low.

We have strengthened our assumptions based on submitter feedback and further analysis of the potential for installing new LFG capture systems at existing sites.

We assumed that 50% of emissions from landfills that do not currently have LFG capture will be subject to gas capture by 2030. This is an increase from 10% in our *2021 Draft Advice for Consultation*. We have assumed the efficiency of the LFG capture is 52%. This means a total of 26% of the methane that would have been emitted from these landfills is captured.

In the Tailwinds scenario, we assume that the proportion of gas subject to capture is 65% by 2030 and the efficiency of the LFG capture systems is 68%.

Our assumptions on the amount of organic waste diverted from landfill were not ambitious enough.

We increased the proportion of organic waste recovered in 2030 from 21% in the *2021 Draft Advice for Consultation* to 28% in this report.

In the Tailwinds scenario, the proportion of organic waste recovered in 2030 is 42%.