He Pou a Rangi Climate Change Commission

Report on the potential domestic contribution to Aotearoa New Zealand's second nationally determined contribution

October 2024

Disclosure statement

As anticipated by the appointment criteria, our board members come from varying fields such as adaptation, agriculture, economics, te ao Māori and the Māori—Crown relationship. While a number of board members continue to hold roles within these fields, our advice is independent and evidence-based. The Commission operates under its Interests Policy, which is derived from the Crown Entities Act 2004. You can read more about our board members on the Climate Change Commission website. The Commission regularly updates and publishes on its website a register of relevant board interests.

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Part A: Context and results

Scope

In June 2024, the Minister of Climate Change (the Minister) requested a report from the Commission on how much reduction in domestic emissions Aotearoa New Zealand could feasibly achieve as part of its second nationally determined contribution (NDC2), and, where possible, the impacts associated with those emissions outcomes. This request supersedes the 2023 request from the previous Government.

The Minister's request was made under section 5K of the Climate Change Response Act (the Act). As with all the statutory deliverables on the Commission's work programme, the Act places strict requirements on the scope and considerations for our advice.

Due to the timing of this request, we have altered our usual approach to producing a report for the Minister and have opted for a technical, focussed briefing that re-uses analysis from our *Draft advice on the fourth emissions budget*. Additional background and context for the draft scenarios for future emissions provided in that draft advice can be found on our website.[1]

Any use of international cooperation as part of NDC2 is outside the scope of the Minister's request to the Commission and not covered by this report. This should be considered when using our advice.

The Commission was not asked for advice on what NDC2 should be. This report provides independent advice on one aspect of the Government's consideration of an appropriate NDC2 commitment. In addition to the achievability and impacts of net domestic emissions reductions as covered by this report, the Government's NDC2 decision is likely to also need to consider:

- policies in the final second Emissions Reduction Plan (ERP2) and the contribution they make to the third emissions budget (and NDC2 period), being 2031–2035
- international obligations under the Paris Agreement, including Article 4, paragraphs 2[2] and 3[3]
- Aotearoa New Zealand's national circumstances
- the need for stronger collective global action to be consistent with the Paris Agreement's long term temperature goal (per the first global stocktake under the Paris Agreement)
- available information about plans for strengthened targets among other countries
- opportunities and risks of any international cooperation for the NDC2 target
- latest emissions projections.

The Government will also need to consider how it will present the NDC2 target and how it will measure progression between its first nationally determined contribution (NDC1) and NDC2, including any contribution from international cooperation. The numerical analysis in this report can help inform the

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[1] He Pou a Rangi Climate Change Commission. (2024). *Draft advice Aotearoa New Zealand's fourth emissions budget*. https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/preparing-advice-on-emissions-budgets/advice-on-the-fourth-emissions-budget/draft-advice-emissions-budget-4/

[2] "Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions."

[3] "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."

Government's decision but is not advice about how to present the target, how to measure progression or whether a given emission level represents progression.

Due to the timing of the Minister's request, this report relies on draft scenarios for future emissions out to 2050 that were developed for our *Draft advice on the fourth emissions budget*. The Commission consulted on this draft advice between 8 April and 31 May 2024 and supporting documents can be found on the Commission's website. These scenarios take into account government policies as at July 2023 and the 2023 New Zealand Greenhouse Gas Inventory (GHG Inventory). New information, including updated GHG Inventory data, government policy, government emissions projections, and the feedback received through engagement on our *Draft advice on the fourth emissions budget* will change the scenarios. When considering NDC2, the Government should consider the most recent information available, including the Commission's updated emission scenarios to be published by the end of the 2024 in the final advice on the fourth emissions budget.

Our scenarios are not predictions or forecasts, and they are not prescriptive. Rather they illustrate what multiple credible outcomes across the economy could mean in total if the underpinning actions and assumptions play out. Uncertainty in the assumptions behind the draft scenarios is likely to affect the feasibility of emissions reductions and removal levels, as well as the associated impacts and their distribution. The mix of actions across sectors, managing impacts and handling risk and uncertainty, are things for the Government to consider as part of emissions reduction plans, in setting NDC2 and any potential approach to international cooperation.

The report includes comparison of draft scenarios and domestic emissions budgets for information only. It is indicative and not advice about the budgets or the adequacy of the draft scenarios to meet them.

In line with the scope of Minister's request, we have not considered the impact of any future changes to Aotearoa New Zealand's emissions accounting approaches. These scenarios are contingent on the accounting methodologies in place at a given time. If the Government makes changes to its emissions accounting approach for NDC1 and NDC2, such as updating the NDC1 budget or accounting for land use, land use change and forestry[4], the analysis in this report should be re-considered in light of the new circumstances, to remain a useful input into NDC2 decision making.

Compliance with the terms of reference and the Climate Change Response Act 2002

The terms of reference provided by the Minister for this section 5K request under the Act are published on the Commission's website.[5]

This report complies with the terms of reference by:

- presenting three scenarios of domestic emissions for 2022–2050, based on feasible assumptions for emissions reductions and removals and plausible rates of change in technology, systems, and the cost of mitigation options (Part B and Table A5)

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[4] including publishing details of a Forest Reference Level or plans to make use of additional natural sinks and sources

[5] He Pou A Rangi Climate Change Commission (n.d.). *Report on the domestic contribution to the second nationally determined contribution.* https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/NDC2/NDC2-s5k-CCRA-TOR.pdf

- describing the underpinning actions and assumptions within these scenarios that reduce and remove emissions by sector (Part B)
- describing, where possible based on available evidence and modelling, associated positive and negative impacts (Part B)
- including a variety of approaches for target presentation and emissions accounting (Table 3) and including a presentation of domestic emissions for the NDC2 period that facilitates straightforward comparison with NDC1 (Table 3 and Table 4) and domestic emissions budgets (Table 5).

This report has been prepared consistently with the purpose provision of the Act (section 3) and of the Commission (section 5). By supporting Government decisions on NDC2, the report helps "enable New Zealand to meet its international obligations under […] the Paris Agreement" (section 3(1)(a), in particular article 4, paragraphs 2[6] and 3[7] of the Paris Agreement.

We also considered all section 5M matters under the Act.

Our work draws on engagement with iwi/Māori and stakeholders, including through our call for evidence[8] in 2023, to understand a broader context around some of the actions that we are assessing, gain insights into latest trends, and test our assumptions.

Through engagement, previous consultations, and Maui.Tech case studies we have heard about iwi/Māori climate leadership, expressed through intergenerational taiao strategies and grounded in tikanga and mātauranga Māori. A key element for Aotearoa New Zealand to reduce emissions is engagement with iwi/Māori to continue climate leadership. Our analysis and engagement with communities shows this will support faster emissions reduction and help achieve an equitable transition for the benefit of all New Zealanders – as set out in our December 2023 advice to the Government on its next emissions reduction plan.[9]

Results

Detailed results are presented in Part B of this report, with additional technical material in appendices and published on our website.

It is our understanding that Aotearoa New Zealand intends to meet the NDC1 commitment (2021–2030) through both domestic action and international cooperation to reduce net emissions.[10] Our analysis

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[6] "Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions."

[7] "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."

[8] He Pou A Rangi Climate Change Commission. (2024). *Call for evidence: Emissions reduction targets and emissions budgets.* https://haveyoursay.climatecommission.govt.nz/comms-and-engagement/p2050/

[9] He Pou a Rangi Climate Change Commission. (2023). *2023 Advice on the direction of policy for the Government's second emissions reduction plan*. https://climatecommission.govt.nz/public/Advice-togovt-docs/ERP2/final-erp2/ERP2-Final-Advice-forweb.pdf

[10] International cooperation refers to activities under Article 6 of the Paris Agreement, which might include, for example, purchasing emissions reductions generated overseas.

shows that it would be feasible to achieve greater net emissions reductions in the NDC2 period (2031–2035) than the NDC1 commitment, through domestic action alone.

Actions would be needed before 2031 to achieve the emission reduction and removal actions for the NDC2 period within these draft scenarios. Beyond 2035 emissions levels continue to fall in the draft scenarios, which could impact future NDCs. Delays in taking action, or policies that promote higher emissions activities and behaviours, risk the indicated emissions reductions and removals becoming unachievable over the NDC2 period, and beyond.

As noted above, the feasible level of emissions reductions and removals for the NDC2 period and associated impacts under these draft scenarios may change based on feedback we received during consultation on the *Draft advice on the fourth emissions budget*, changes in government policy since July 2023, the updated GHG Inventory, and updated emissions projections released by Government. Any Government changes to emissions accounting could also change the results.

Our analysis does not constitute advice on an appropriate level for NDC2, an appropriate target presentation, whether a given emissions level represents progression on NDC1, or how to measure progression. The Government will need to make its own decision about an appropriate NDC2 commitment, including any international cooperation, considering Aotearoa New Zealand’s international obligations.

Part B: Technical analysis

Analytical approach

Scenario structure

Our analysis draws on the scenario structure and modelling from our *Draft advice on the fourth emissions budget*. In this advice we present three draft scenarios: a scenario with a higher level of change called High Technology and High Systems Change (draft HTHS), a scenario with a lower level of change called Low Technology and Low Systems Change (draft LTLS), and a central pathway (draft EB4 demonstration path)[11], as well as a reference scenario reflecting government policies at 1 July 2023. Focusing on these potential futures allows demonstration of a range of scenarios the Government can consider in determining Aotearoa New Zealand's domestic contribution to NDC2.

We found the three draft scenarios all result in lower net emissions than the reference scenario, but differ in the speed and adoption rates of technology and systems change, with the draft HTHS achieving more emissions reductions sooner. Systems change achieves reductions in emissions by changes in behaviours or practices, often with co-benefits such as health or environmental savings. Examples of high systems change include converting more marginal and erosion prone land to native forests or shifting more trips from light vehicle travel to walking, cycling and public transport.

While this advice focuses on the NDC2 period (2031–2035), it draws on our draft scenarios covering the period 2022–2050. It is important to consider the full scenario period, as a significant amount of the emissions reductions in the NDC2 period result from actions taken prior to 2031. Likewise, emissions reductions that occur after 2035 are linked to actions taken in the years prior.

All draft scenarios are designed to be technically and economically achievable, assuming plausible rates of change in technology, systems, and the price of mitigation options. The draft HTHS assumes a relatively ambitious pace and scale of change and more optimistic assumptions over technology readiness.

All draft scenarios are at or below zero net accounting emissions of greenhouse gases, other than biogenic methane, in 2050 and subsequent years, with a contribution from carbon dioxide removals through ongoing afforestation.

Assessing impacts

The Act requires us to consider a broad range of matters when developing our advice, including matters under section 5M, where relevant.

Our approach to section 5M matters in the report includes:

- considering current scientific knowledge, technological developments, and economic and broader impacts and their distribution when developing the draft scenarios

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[11] Estimates for total net emissions, and emissions by sector, are taken from our draft EB4 modelling results in ENZ. Estimates for the overall impact to the economy are taken from C-PLAN. ENZ and CPLAN are both Commission models and were quality assured, internally and externally, prior to releasing our EB4 consultation draft. Details of the assumptions in each scenario, model outputs, and supporting material about the models can be found on our website.

- assessing specific effects on iwi/Māori informed by feedback from previous engagement
- considering the actions of other countries, as part of impact and sensitivity analysis when developing the draft scenarios (e.g. international emissions pricing and trade competitiveness).

For this report, we estimate impacts in relation to the NDC2 period. As in our *Draft advice on the fourth emissions budget*, we have included selected (co-)benefits and negative impacts where evidence or modelling is available.

For each sector we detail the key emissions reduction and removal actions for each draft scenario and their likely effect on emissions. For brevity we generally don't describe an action more than once if it does not differ between scenarios, and we focus our description on the incremental (ie. 'additional') actions that reduce emission further in the draft EB4 demonstration path and HTHS scenarios relative to the draft LTLS.

As in our *Draft advice on the fourth emissions budget*, the analysis focuses on the following emitting sectors:

- energy
- industrial processes and product use (IPPU)
- transport
- agriculture
- forestry
- waste.

Sectoral actions and impacts

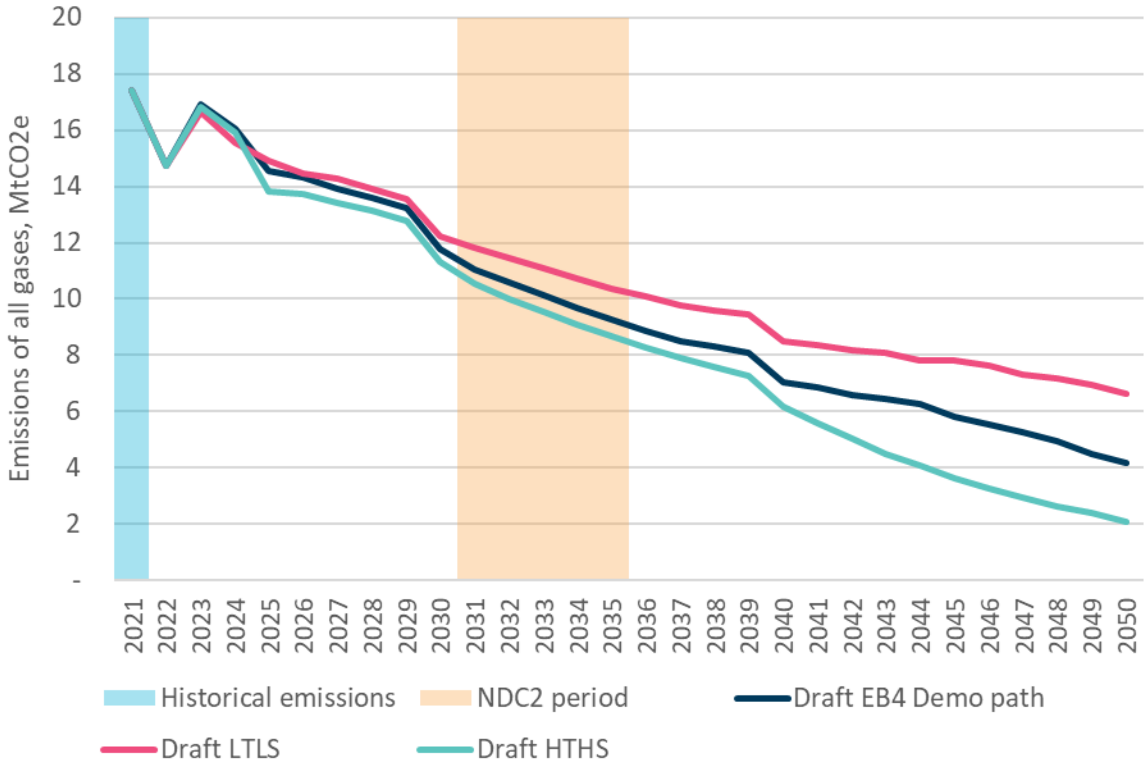
Energy

Figure 1 shows energy sector emissions under the draft scenarios. Energy emissions come from burning fuels to produce useful energy (for example industrial heat to produce milk powder), as well as emissions from electricity generation. In 2021 energy sector emissions accounted for 22% of Aotearoa New Zealand's gross emissions.[12] Note that transport emissions are covered separately in a later section. This differs to the GHG Inventory, which reports transport as part of energy sector emissions.

The energy sector plays a crucial role in decarbonising other sectors' emissions. For example, increasing our capacity to generate, transmit, and distribute renewable electricity is necessary to facilitate the electrification of transport, homes, and buildings. Energy users can also play an important role in efficient energy use and in managing electricity demand during periods of tight supply, such as short-term peaks during winter mornings and evenings, as well as for longer durations when inflows to the hydro lakes are low.

[12] Commission analysis: *ENZ results for draft EB4 advice* available on our website.

Figure 1: Energy sector emissions



Source: Commission analysis

Energy actions in our draft scenarios to 2030

To enable emissions reductions in the NDC2 period at levels implied from our three draft scenarios, we assume the following actions have occurred by 2030:

- 45–50 TWh of renewable electricity generation in 2030 (up from 35 TWh in 2021, a 27–42%[13] increase)
- ongoing efforts to transition to low carbon energy sources in process heat (leading to phasing out coal for low-medium temperature process heat by 2037)
- geothermal carbon capture and reinjection at 100% efficacy for Ngāwhā, expanded to Ōhaaki at 80% efficacy (by 2026).

Note all draft scenarios assume one methanol train[14] closure by the end of 2029.

Key actions in the NDC2 period for energy

Key opportunities to reduce emissions in this sector including transitioning away from fossil fuels in electricity generation and industry, increasing supply of renewable electricity, energy efficiency and

[13] Percentage changes do not precisely match TWh changes shown here due to calculating with precise numbers then rounding results.

[14] This refers to methanol manufacturing by Methanex NZ.

demand management for electricity, and deploying further carbon capture and reinjection technology to reduce fugitive emissions from geothermal electricity generation.[15]

None of our draft scenarios include abatement opportunities for preventing fugitive emissions from fossil fuel extraction and distribution due to uncertainty about whether mitigation technology will be deployed in New Zealand. The emissions impact from the combustion of oil and gas also far outweighs the emissions associated with its production. Our draft scenarios assume fugitive emissions from oil and gas production decrease in line with the shift away from fossil fuel consumption.

Energy emissions in the draft Low Technology Low Systems Change scenario

Low carbon energy transition

In this draft scenario, there is a transition from fossil fuels to low carbon energy sources over longer timelines relative to the draft EB4 demonstration path and draft HTHS scenarios for process heat, space and water heating, and off-road mobile machinery (for example, commercial fishing vessels, and farm, forestry, and mining machinery). This includes a gradual and then complete shift away from:

- coal in commercial buildings by 2037
- coal in low-medium temperature process heat applications (such as food processing) by 2037
- fossil gas in low-medium temperature process heat applications (such as food processing) by 2050
- fossil gas in space and water heating for commercial/residential buildings by 2060
- electrification of mobile machinery and offroad vehicles.

Increasing supply of renewable electricity

This draft scenario also requires increasing supply of renewable electricity, with generation increasing from 45 TWh in 2030 to 52 TWh in 2035.[16]

Improved demand management for renewable electricity

Improved demand management for renewable electricity, including energy efficiency, plays a role in this draft scenario. The draft LTLS scenario assumes low levels of electricity system demand side response[17] (compared to very low levels in the reference scenario). Improved energy efficiency also means electricity demand for space and water heating reduces by 12% for households by 2050 versus 2020, and 33% in commercial settings.

Geothermal carbon capture and reinjection

Geothermal carbon capture and reinjection reduces total emissions from new fields by 50% compared to a counterfactual of no deployment of this technology to new fields.

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[15] Geothermal electricity generation results in fugitive emissions of CO_2. This technology enables these emissions to be captured and reinjected into the field. While this reinjection is not permanent, the technology can continue to capture and reinject these emissions over time.

[16] Not including co-generation of heat and electricity.

[17] These are measures that enable electricity consumers, in particular high users, to reduce their electricity consumption during periods of constrained supply, and/or high prices.

Energy emissions in the draft EB4 demonstration path

The draft EB4 demonstration path assumes further measures to shift away from coal in cement production by 2035, a faster shift away from fossil gas in space and water heating for commercial/residential settings (by 2050, 10 years sooner than the draft LTLS) and faster electrification of mobile machinery and offroad vehicles.

In this draft scenario, renewable electricity generation increases a further 5 TWh to 57 TWH in 2035.

In terms of demand management for renewable electricity, the draft EB4 demonstration path assumes medium levels of electricity system demand side response, and higher reductions in household and commercial space/water heating demand (-19% and -43% by 2050 versus 2020 respectively).

For geothermal carbon capture and reinjection, we assume an increase in efficiency for Ōhaaki (90%), other existing fields (83%) and new fields (90%).

Energy emissions in the draft High Technology High Systems Change scenario

In this draft scenario, the low carbon energy transition is accelerated by:

- faster shift away from fossil fuels in low-medium temperature industrial process heat (by 2045, five years sooner than the draft EB4 demonstration path)
- faster shift away from coal in cement production (by 2030, five years sooner than the draft EB4 demonstration path)
- fastest electrification of mobile machinery and offroad vehicles.

In this draft scenario, renewable electricity generation increases a further 2 TWh to 59 TWh in 2035. We assume greater capital cost reductions for renewable electricity generation, and a faster cost reduction for grid scale batteries (-4% per annum). We also assume high levels of electricity system demand side response. Geothermal carbon capture and reinjection increases in efficacy for Ōhaaki (100%) and new fields (100%).

Summary of impacts

Emissions levels

In the draft LTLS scenario, we estimate gross emissions of all greenhouse gases from energy in the NDC2 period to be 55.4 $MtCO_2e$. Additional effort in the draft EB4 demonstration path would reduce emissions in this period by 9% (-4.7 $MtCO_2e$). In the draft HTHS scenario emissions reduce a further 2.8 $MtCO_2e$ to 47.9 $MtCO_2e$.

Economic and sectoral impacts

Our analysis finds that short-term investment to switch to electric space and water heating, and to low emissions energy sources for process heat, will deliver long term cost savings. The faster the switching to low-emission energy sources for homes, buildings and industry occurs, the quicker the tipping point from costs to benefits is reached. Therefore, with pipeline gas phasing out more slowly in the draft LTLS, there is a risk of energy users missing out on benefits that could have been realised had switching occurred sooner.

In all cases however, switching must be managed to not be so fast as to exceed the overall adaptive capacity of the energy system – for instance where new electricity supply cannot be commissioned quickly enough to meet new demand.

In general, we expect that making greater use of demand-side response and energy storage will result in more efficient utilisation of electricity infrastructure and hence lower costs for electricity consumers. As the draft EB4 demonstration path and draft HTHS scenario assume more demand response, these scenarios could expect greater benefits in this respect.

Low demand response will require further investment in flexible electricity supply and/or energy storage to meet higher periods of peak demand, and further investment in transmission and distribution networks. High demand response will require investments in systems and infrastructure that enable greater data collection, access to data, data sharing and uptake of smart systems. This could also require regulatory amendments. We expect the costs of investment in systems and infrastructure that enable demand response to be significantly less than investing in new flexible supply and associated network infrastructure.

Distributional impacts

The higher ambition draft scenarios are expected to result in more energy efficiency savings for households.[18] However, the upfront costs of electric appliances such as heat pumps, and removing and replacing fossil fuelled appliances, will be a barrier for lower income households, including in the lead up to the NDC2 period. This could mean that these households could face higher energy costs than households who are able to pay the upfront cost of these technologies.

Regions with a greater reliance on employment in extractive fossil fuels industries will be the most impacted by the reduced consumption of these fuels in the higher ambition scenarios. However, the higher ambition scenarios should result in more revenue opportunities and jobs in the electricity sector, energy efficiency, bioenergy and the bioeconomy. For example, Boston Consulting Group estimated $42 billion of investment is needed in electricity generation, transmission, and distribution in the 2020s to meet the needs for rapid electrification of the New Zealand economy.[19]

Māori account for a higher share of employment in emissions-intensive industries than in low emissions intensity industries and Māori employees have historically fared poorly in transitions, being more likely to be made redundant during recessions and finding it more difficult to find re-employment.[20] Māori are over-represented compared to non-Māori in lower-skilled jobs, providing lower employment stability and less resilience to automation[21]. This creates risk of employment disruption for Māori in the transition to a low emissions economy. It is important to note however that Māori employment in

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[18] Noting these assume appropriate policies and measures are put in place to achieve these efficiencies.

[19] Boston Consulting Group. (2022). *The Future is Electric: A Decarbonisation Roadmap for New Zealand's Electricity Sector.* https://www.bcg.com/publications/2022/climate-change-in-new-zealand

[20] Ministry of Business Innovation and Employment. (2021). *The emissions exposure of workers, firms and regions*. https://www.mbie.govt.nz/dmsdocument/13781-the-emissions-exposure-of-workers-firms-and-regions.

[21] BERL. (2021). *Māori economy emissions profile.* https://www.mbie.govt.nz/dmsdocument/17448-maori-economy-emissions-profile

higher-skilled jobs has been growing in recent years, increasing from 47,500 to nearly 87,200 between 2006 and 2018.[22]

Co-benefits

Reduced reliance on fossil fuels in commercial and residential buildings will improve indoor and outdoor air quality. This occurs in all three draft scenarios, but at different paces according to scenario ambition. Hence air quality benefits will be achieved faster in the draft EB4 demonstration path compared to the draft LTLS scenario, and faster again in the draft HTHS. Improving energy efficiency will mean warmer/dryer buildings in all draft scenarios, noting this improvement will be greater in both the draft EB4 demonstration path and HTHS scenarios.

Principal risks and uncertainties

Energy security and affordability is a notable risk to our economy. The transition away from fossil gas will need to be carefully managed to ensure security of supply while limiting impact on consumers, noting gas also plays an important role in providing flexible electricity generation to help manage peak periods currently.

For example, recent data from Ministry of Business, Innovation and Employment (MBIE) suggests that potential gas supply from existing fields may be less than previously expected and likely insufficient to meet demand in the short to medium term.[23] We have already seen the impact of this, with gas prices increasing rapidly in 2024, and Methanex pausing production to on-sell gas to electricity generators.[24,25] Tight gas supply, together with a dry hydrological year, has resulted in electricity price spikes too, with gas unable to provide the seasonal 'firming' it has historically, resulting in greater use of coal and diesel-fired generation at a higher cost.[26, 27] This all has implications for firms and households, with a potential loss of jobs if firms are unable to economically operate, and higher energy prices eventually flowing through to higher household bills.

At the time of writing, the future operation of Methanex is uncertain. The timing of any future reopening or closure of Methanex trains is likely to have significant flow on impacts on fossil gas and electricity markets, including gas producers' incentive to invest in development to bring gas to market, as well as overall emissions levels for the NDC2 period.

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[22] BERL. (2021). *Māori economy emissions profile.* https://www.mbie.govt.nz/dmsdocument/17448-maori-economy-emissions-profile

[23] Ministry of Business, Innovation and Employment. (2024). *Gas production forecast to fall below demand.* https://www.mbie.govt.nz/about/news/gas-production-forecast-to-fall-below-demand

[24] Natural gas spot market price data available at https://www.emstradepoint.co.nz/

[25] Methanex. (2024). *Methanex Corporation to temporarily idle New Zealand operations to assist in approving energy balances*.https://www.methanex.com/news/release/methanex-corporation-to-temporarily-idle-new-zealand-operations-to-assist-in-improving-energy-balances/

[26] Energy News. (2024). *Genesis has been operating all three Rankine units at Huntly recently, almost entirely on coal.* https://www.energynews.co.nz/news/coal/163640/coal-imported-huntly-amidst-gas-hydro-shortages

[27] Average daily electricity prices reached over $800 / MWh in early August, up from around $250 / MWh at the beginning of winter, according to Electricity Authority data. Electricity Authority Te Mana Hiko. (2024). *What was behind high wholesale electricity prices.* https://www.ea.govt.nz/news/eye-on-electricity/what-was-behind-high-wholesale-electricity-prices/

Energy affordability is a risk that will need to be carefully managed to avoid significant hardship on households and firms.

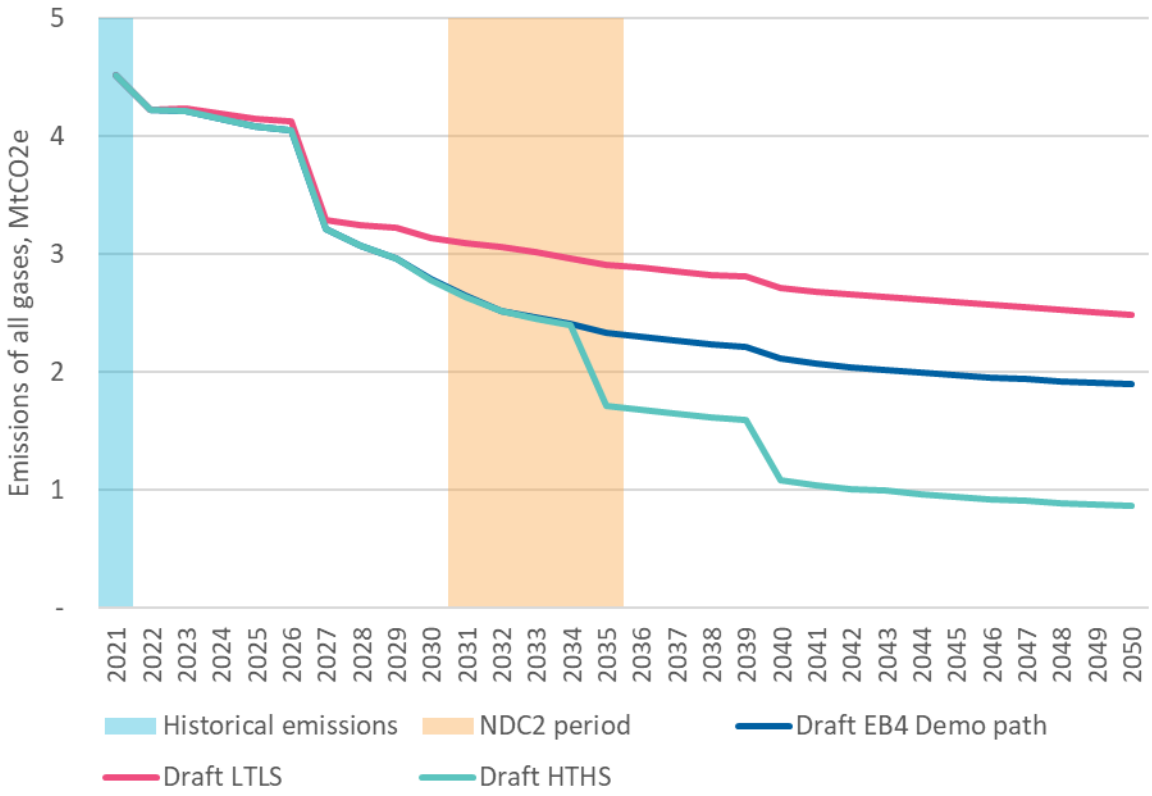
There are uncertainties for costs of low emissions technologies, noting Aotearoa New Zealand has little direct influence on supply and market prices for these. The uncertainty here is the highest for the draft HTHS scenario as it draws more heavily and sooner on technology.

The effect of these issues on emissions projections and associated impacts will be explored further in our final advice on the fourth emissions budget delivered in December 2024.

Industrial processes and product use

Figure 2 shows emissions from industrial process and product use under the draft scenarios. Emissions from industrial activities that are the result of energy consumption, such as combustion of fossil fuels for process heat and electricity usage to power machinery, are part of the energy sector. However, emissions that are by-products of industrial processes, or from the use of products such as refrigerants, are considered industrial processes and product use (IPPU). Examples of these are emissions of carbon dioxide and perfluorocarbon gases (PFCs, a type of f-gas) resulting from the industrial process/chemical reactions required in aluminium smelting.[28] In 2021 IPPU emissions made up 6% of Aotearoa New Zealand's gross emissions.[29]

Figure 2: Emissions from industrial processes and product use



Source: Commission analysis

[28] Note, emissions from fuel combustion for process heat in aluminium production, as well as indirect emissions from consumption of electricity, are included as emissions in the energy sector.

[29] 2023 GHG Inventory.

Actions in our draft scenarios to 2030 for IPPU

Achieving emissions reductions in the NDC2 period at the level implied by our three draft scenarios is enabled by deploying electric arc furnace technology, which will reduce coal use in steel production by 50% (by 2027).

Key actions in NDC2 period for IPPU

Key opportunities to reduce IPPU emissions include transitioning to low emissions production processes (for production of aluminium, steel) and avoiding emissions of f-gases.[30]

Our draft scenarios do not include abatement opportunities for IPPU emissions from lime production such as carbon capture and storage[31] as there is uncertainty that they could be deployed in cost-effective ways in time for NDC2.

Draft Low Technology Low Systems Change scenario

This scenario follows the same assumptions as the reference scenario. These are:

- 50% reduction in coal use for steel production with deployment of electric arc furnace technology by 2027 (transitioning to low emissions productions processes)
- following action required from the Kigali Amendment to the Montreal Protocol – hydrofluorocarbons (HFCs) reduce by 49% by 2040 relative to 2022 (avoiding emissions of f-gases).

Draft EB4 demonstration path

In addition to the draft LTLS, this scenario:

- assumes coal use in steel production can be further reduced by 76% in 2032 rather than 50% in 2027) through use of electric arc furnace technology
- goes further to reduce HFCs 62% by 2040.

Draft High Technology High Systems Change scenario

In addition to the draft EB4 demonstration path, this draft scenario includes:

- deploying zero carbon anodes in aluminium production by 2035
- deploying green hydrogen to decarbonise the remaining 25% of steel production (by 2040).

Summary of impacts

Emissions levels

In the draft LTLS scenario, we estimate gross emissions from IPPU to be 15.0 $MtCO_2e$ in the NDC2 period. In this same period, we estimate emissions would be 18% lower in the draft EB4 demonstration path (12.4 $MtCO_2e$). In the draft HTHS scenario, emissions could reduce a further 0.7 $MtCO_2e$ (to 11.7 $MtCO_2e$).

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[30] Primarily from refrigerants.

[31] Locally, lime is primarily used to produce cement, an input for concrete and mortar. It is also used as an input for other processes such as steelmaking, pulp and paper manufacturing, food processing and water treatment. About two thirds of emissions from lime production are the result of the calcination reaction, the chemical process used to produce lime and clinker (lime for cement production). The remaining emissions from lime are from process heat which is included as part of the energy sector.

Distribution of impacts across sector

The inclusion of electric arc furnace technology will mean economic opportunities for firms involved in scrap steel recycling. Higher levels of scrap steel utilisation or switching to a hydrogen-based production process will mean less revenue opportunities from mining of iron sands and from mining and importation of coal.

Zero carbon anodes are likely to increase the cost of producing aluminium (in the draft HTHS scenario). Cost data on these anodes is commercially sensitive, as such we are not able to estimate what the change in costs might be. As we assume these would be deployed in 2035, they will have a relatively small impact on emissions and costs in the NDC2 period.

There will be higher costs of avoiding HFCs emissions in the draft EB4 demonstration path and draft HTHS scenario. Impacts of this will depend on policy settings.

Co-benefits

Conversion of steelmaking to use scrap steel in electric arc furnace systems will mean fewer environmental impacts from iron sand mining, and better outdoor air quality due to less coal used in the production process. It also aligns with circular economy objectives as scrap steel is recycled for use in steelmaking. These benefits will be highest in the draft EB4 demonstration path and draft HTHS scenario.

Principal risks and uncertainties

There are uncertainties over how a scrap steel recycling scheme will be managed to ensure sufficient supply, including for the step up to 75% conversion to electric arc furnace technology.

For the draft HTHS, there is uncertainty over supply and price of electricity to enable cost-efficient production of hydrogen on site. In particular, it is uncertain whether a sufficient quantity of 'firmed' (i.e. non-intermittent) electricity can be supplied to the site at a price that would enable cost efficient hydrogen production at the scale needed. There is additional uncertainty around the use of green anodes in aluminium production as the technology is still under development.

There are uncertainties over a rising price of carbon and its impacts on cement production. A relatively high domestic price may make it more economic to import clinker from overseas.

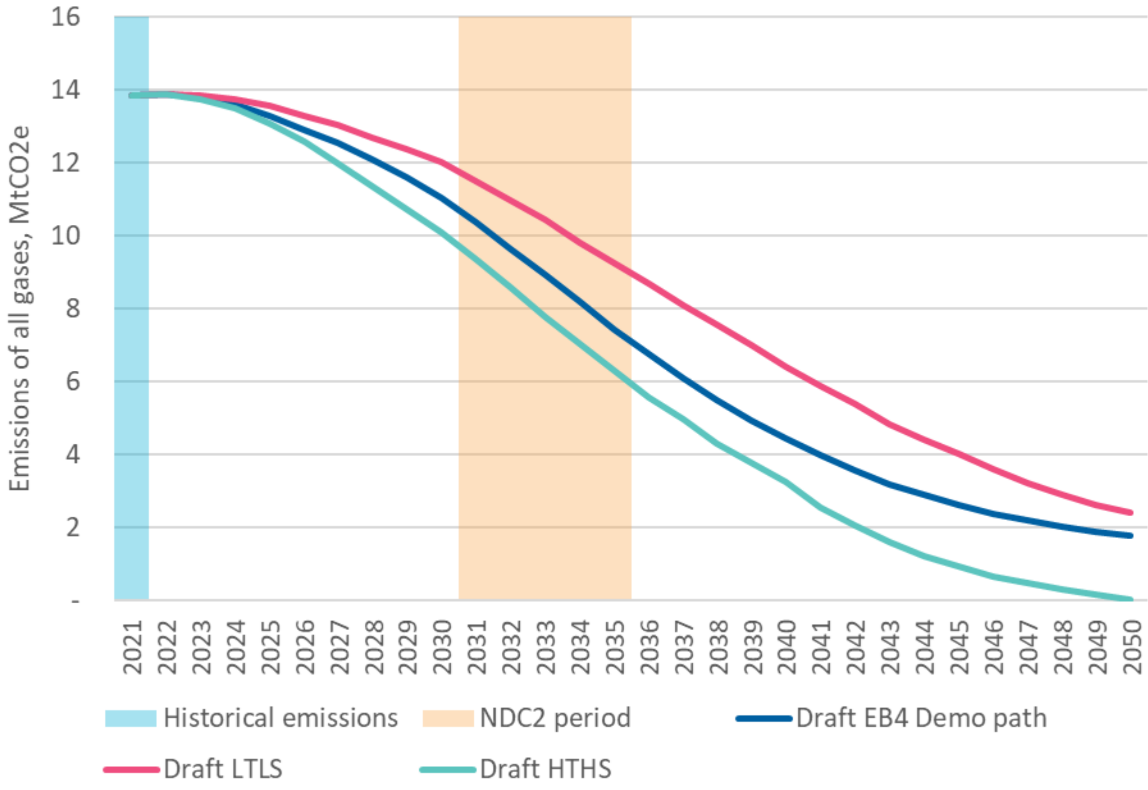
Transport

Figure 3 shows transport sector emissions under the draft scenarios. In Aotearoa New Zealand, transport emissions come from these modes: road, rail, aviation and marine. There are passenger and freight components for each of these modes, and these can occur through either domestic or international travel. Our analysis focuses on emissions from domestic travel as target accounting does not currently include emissions from international shipping and aviation.[32] In 2021 emissions from transport made up 17% of our domestic gross emissions.[33]

[32] Note the Commission is providing advice to Government by 31 December 2024 on whether these emissions should be included in our 2050 target.

[33] Commission analysis: *ENZ results for draft EB4 advice* available on our website

Figure 3: Transport sector emissions



Source: Commission analysis

Transport actions in our draft scenarios to 2030

Decarbonising road transport will be the biggest factor to enable emissions reductions in the NDC2 period to the levels implied in our three draft scenarios. For the draft LTLS this includes growing the electric vehicle (EV) share for:

- light passenger vehicles (LPV) to 16% of fleet (1% in 2021)
- light commercial vehicles (LCV) to 4% of fleet (0% in 2021)
- buses to 24% of fleet (1% in 2021).

In this timeline all draft scenarios have a small but growing share of medium and heavy electric trucks entering the fleet. The draft EB4 demonstration path and draft HTHS have higher EV uptake in this timeline across all vehicle classes. For the draft EB4 demonstration path we assume lower growth in road vehicle kilometres travelled (VKT) in 2030 (+4% versus +18% for the draft LTLS scenario, compared to 2021 levels). For the draft HTHS we assume no change in VKT from 2021 levels.

Key actions in NDC2 period for transport

Key opportunities to reduce Aotearoa New Zealand's domestic transport emissions include decarbonising road transport and freight, modal shift to public and active transport, and decarbonising aviation. Decarbonising road transport provides the greatest potential for emissions reductions at low costs relative to other abatement opportunities. This is even true for medium and heavy freight transport, where battery electric vehicles are on track to reach price parity with internal combustion engine (ICE) vehicles in total cost of ownership by 2031 and 2033 respectively.[34] Walking and cycling are zero emissions modes of travel (excluding any emissions from infrastructure investment, manufacturing and shipping). A shift towards these active travel modes offers further emissions reduction opportunities. While domestic aviation remains a hard to abate sector, opportunities such as battery electric airplanes and low carbon liquid fuels are assumed to emerge in time for NDC2.

Draft Low Technology Low Systems change scenario

As the data table (Table 1) at the end of this section shows, there is a significant step up in the number of EVs in this draft scenario relative to the reference scenario. The share of electric light passenger vehicles by 2035 is nearly 18 percentage points higher in the draft LTLS compared to the reference scenario, reaching a total share of 38.1%. The LTLS share of electric light commercial vehicles increases from 7.8% to 11.2%. There are more than three times as many electric buses for the draft LTLS scenario than the reference scenario (39.1% versus 12.4%). This draft scenario assumes phaseout of new LPV/LCV/bus ICE vehicles by 2040, and used by 2042. The cost of batteries for electric vehicles are assumed to decrease 66% by 2035 from 2023 prices.

In terms of decarbonising freight, the share of medium sized electric trucks reaches 4.9% in 2035, while heavy electric trucks reach 1.5% (compared to 3.6% and 0.7% in the reference scenario). We assume measures are taken to phaseout new heavy ICE vehicles by 2045, and medium ICE trucks by 2035 through a mixture of electrification and hydrogen technology.

For rail and coastal shipping the share of tonne kilometres is assumed to be the same in the draft LTLS scenario as the reference scenario, falling to 12.8% and 11.6% respectively by 2035 (compared to 13.7% and 12.4% in 2019). Rail electrification is assumed to reach a 23% share (tonne kilometres) by 2026, compared to no change in the reference scenario. Rail efficiency improvements increase by 0.5% per annum, compared to 0.25% in the reference scenario.

Total VKT increase by 18.2% in 2035 from 2021 levels, the same as the reference scenario. Modal share by 2035 of public transport (5.3% versus 3.5% in 2019), walking (1.5% versus 1.6% in 2019) and cycling (0.6% - unchanged from 2019) are at the same level as the reference scenario.

For domestic aviation, air passenger kilometres travelled grow by 41% from 7.4 billion in 2019 to 10.4 billion in 2035 (the same as the reference scenario). By 2035, 8% of passenger kilometres travelled are in small battery electric aircraft (0% in reference scenario). By 2035, low carbon liquid fuels are 5% of all fuels used (0% in reference scenario).

Draft EB4 demonstration path

In the draft EB4 demonstration path scenario in 2035, the EV share of LPVs rises to 48.1% (an increase of 10.0 percentage points from the draft LTLS). For LCVs, the EV share is 12.5 percentage points higher than the draft LTLS (23.7% vs. 11.2%). Electric buses represent just over half of the bus fleet (51.4%). In this draft scenario, the phaseout of new LPV/LCV/bus ICE vehicles is brought forward to 2032, and 2035 for used vehicles.

In 2035 the EV share for medium trucks increases from 4.9% in the draft LTLS to 9.1%. In the draft EB4 demonstration path 2.0% of the heavy vehicle truck fleet are EVs, compared to 1.5% in LTLS, noting these reflect a small share of the overall fleet. There are no hydrogen trucks in this draft scenario.

[34] These are estimates from our reference scenario. For the draft HTHS scenario this happens earlier.

Modal share of rail shipping increases to 15.9% in 2035 (from 13.7% in 2019). Modal share of coastal shipping also increases to 14.4%, two percentage points higher than 2019. Rail electrification is assumed to reach a 23% share in 2026 and then an 80% share by 2050 (tonnes per kilometre).

These is slower growth in VKT in this draft scenario, limited to 3.6% growth in 2035 (compared to 2021 levels). Modal shift in 2033[35] increases to 8.9% for public transport, to 1.9% for walking and to 1.9% for cycling.

Assumptions for decarbonising aviation are the same as in the draft LTLS.

Draft High Technology High Systems change scenario

By 2035 EVs reach a 54.7% share of the LPV fleet, 26.8% of the LCV fleet, and 58.5% of the bus fleet. This scenario assumes a phaseout of new LPV/LCV/bus ICE vehicles by 2030, and used by 2035. The cost of EV batteries is assumed to reduce by 79% by 2035 (from 2023 levels), 13 percentage points higher than the other scenarios.

By 2035 the EV share of fleet reaches 11.8% for medium trucks, more than three times the number in the reference scenario and more than double the draft LTLS. The EV share of heavy trucks reaches 1.7% in 2035. This draft scenario assumes measures are in place to phase out new heavy ICE trucks by 2030, and used by 2035. As in the draft EB4 demonstration path there are no hydrogen trucks.

Modal share of rail freight reaches 18.5% in 2035, and 17.3% for coastal shipping. We assume rail efficiency improvements of 0.75% per annum, with rail electrification share reaching 23% in 2035 and 100% by 2040 (tonnes per kilometre).

VKTs in 2035 are 1.9% lower than 2021 levels. Modal shift in 2033 increases further to 11% for public transport, to 2.1% for walking and to 2.6% for cycling.

In the draft HTHS scenario, we also assume domestic air passenger kilometres travelled reduces over time, 20% by 2050 (relative to 2019 levels). By 2035, 28% of small aircraft domestic kilometres travelled are by electric aircraft. Low carbon liquid fuels represent 20% of total fuel used for domestic air passenger travel.

Table 1 Road transport EV share of fleet in 2035 by mode and draft scenario

Road transport EV share of fleet in 2035 by mode and scenario	Reference scenario	Draft LTLS	Draft EB4 demonstration path	Draft HTHS
Light passenger vehicles (LPV)	20.4%	38.1%	48.1%	54.7%
Light commercial vehicles (LCV)	7.8%	11.2%	23.7%	26.8%
Buses	12.4%	39.1%	51.4%	58.5%
Medium trucks	3.6%	4.9%	9.1%	11.8%
Heavy trucks	0.7%	1.5%	2.0%	1.7%

Source: Commission analysis

[35] Note 2035 figure is not directly available from modelling outputs.

Summary of impacts

Emissions levels

We estimate transport emissions in the NDC2 period for LTLS to be 52.0 MtCO_2e. For the draft EB4 demonstration path, emissions are 44.6 MtCO_2e, 14% lower than in the draft LTLS. Emissions in the draft HTHS reduce to 39.1 MtCO_2e, 12% lower than in the draft EB4 demonstration path and 25% lower than in the draft LTLS.

Economic and sectoral impacts

All draft scenarios offer significant medium and long-term savings in terms of total cost of transport across passenger and freight transport, for households and businesses. These savings are largely the result of lower operational costs for electrified transport. For the draft EB4 demonstration path and draft HTHS, further savings are achieved from higher uptake in EVs. For the draft LTLS, these savings are estimated at $4.2 billion[36] over the NDC2 period (five-year total). For the draft EB4 demonstration path this estimate increases to $5.1 billion. Further and faster action in draft HTHS increases this estimate to $9.5 billion. Our modelled levels of public and active transport in the higher ambition scenarios are likely to require further investment in targeted infrastructure.

All our draft scenarios assume greater electrification of transport. This has workforce implications over time, meaning less demand for ICE mechanics and greater demand for those with the skills to maintain EVs. The transition away from ICE vehicles is faster in the higher ambition draft scenarios.

Distributional impacts

Higher ambition draft scenarios are more equitable in that they give greater access to low-cost transportation options particularly in urban areas, assuming sufficient investment in public and active transport initiatives that incentivise uptake to our modelled levels.

While EVs currently offer significant total cost of ownership savings for households, their higher capital cost is a barrier for those of lower incomes. This issue is expected to diminish overtime, as the cost of EVs decreases, however it is likely that people on lower incomes may not be able to access the benefits of owning an EV without support, and will be further disadvantaged by having older, higher consumption internal combustion vehicles. In the near term we also expect the domestic supply of used EVs to increase. The actual impact on households will depend on any relevant policies put in place.

Co-benefits

In addition to significant total cost of transport savings, higher electrification of transport also offers substantial savings to the health system due to reduced local air pollution from ICE vehicles. The benefits we calculate build on findings from recent public health research in Aotearoa New Zealand.[37] This researched quantified the cost to society of premature death, as well as illness and disease, from a range of respiratory and cardiac conditions associated with poor air quality including asthma.

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[36] Transport costs are expressed in real 2023 NZD and are Commission estimates derived from specific ENZ model runs.

[37] Kuschel, G., et al (2022). *Health and air pollution in New Zealand 2016 (HAPINZ 3.0): Volume 1 – Finding and implications.* https://environment.govt.nz/assets/publications/HAPINZ/HAPINZ-3.0-Findings-and-implications.pdf

Compared to the reference scenario, for the draft LTLS we estimate savings of $2.3 billion[38] over the NDC2 period (five-year total). These savings increase to $9.3 billion in the draft EB4 demonstration path and $12.1 billion in the draft HTHS scenario, demonstrating there is significant additional value for respiratory and cardiac conditions alone in going faster and further to electrify transport.

Higher modal share for walking and cycling can also improve an individual's physical and mental health. While we are unable to quantify these savings, there will be more potential savings in the draft EB4 demonstration path than the draft LTLS, with the highest savings in the draft HTHS.

Principal risks and uncertainties

There are a number of uncertainties for the transport sector for the NDC2 period, including:

- availability of EVs and infrastructure (higher EV share of fleet will require more charging infrastructure and higher supply of used EVs)
- sufficient electricity supply (higher EV share of fleet will require additional generation capacity and/or demand response for peak periods)
- availability of infrastructure for active / public transport (increasing modal share will likely require further investment in infrastructure)
- availability of alternative fuels (for the draft LTLS, uncertainty over price and supply of hydrogen fuel and infrastructure. For the draft HTHS, uncertainty over price and supply of low carbon liquid fuels and infrastructure).

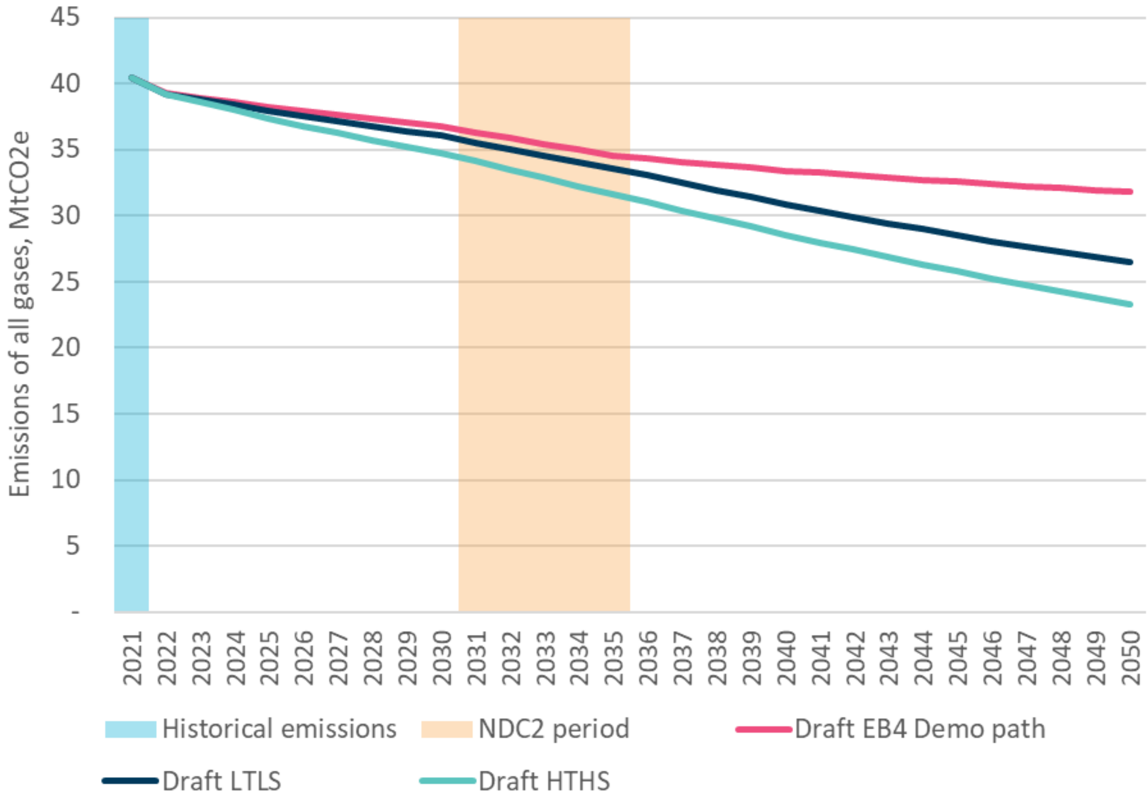
Agriculture

Figure 4 shows agriculture sector emissions under the draft scenarios. In 2021 agriculture emissions accounted for 51% of Aotearoa New Zealand's domestic gross emissions profile.[39] Biogenic methane accounts for approximately 81% of sector emissions. This gas is produced by ruminant livestock (primarily dairy cows, beef cattle and sheep). The remaining emissions are largely nitrous oxide, a greenhouse gas that is the result of soil micro-organisms reacting to livestock urine and synthetic fertilisers.

[38] Real 2023 NZD.

[39] Based on carbon dioxide equivalent emissions on a GWP100 basis.

Figure 4: Agriculture sector emissions



Source: Commission analysis

Our scenarios to 2030 for agriculture

To enable emissions reductions in the NDC2 period at levels implied from our three draft scenarios, we assume the following actions by 2030:

- conversion of about 3kha of dairy land per annum to lower emissions land uses (including horticulture)
- build-up of low methane breeding for sheep from 2023 and introduction of low methane breeding for dairy by 2029.[40]

The draft EB4 demonstration path and draft HTHS assume further reductions in ruminant herd sizes and stocking rates. For the draft LTLS these are at similar levels to the reference scenario. The draft HTHS assumes higher reductions in both dairy land (~6kha per annum) and sheep and beef land (~110kha per annum).

Note that in this report herd sizes, stocking rates and land-use change are national level aggregate figures from our modelling, which deliver a particular emissions outcome. There could be significant variation across the country driven by farmer and landowner decisions based on individual circumstances.

[40] External forecasts for availability of low methane dairy breeding technology vary but are consistent with our assumption. For example, the Livestock Improvement Corporation (LIC) forecast in 2023 that their catalogue would include low methane bulls by 2027. LIC. (2023). [LIC_Sustainability2023_Web3.pdf (d1r5hvvxe7dolz.cloudfront.net)]

Key actions in NDC2 period for agriculture

Key opportunities for Aotearoa New Zealand to reduce its agricultural emissions in the NDC2 period include improving farm management practices (including deployment of available technologies) and converting land to lower emissions uses.

The work of the Biological Emissions Reference Group (BERG), the New Zealand Agricultural Greenhouse Gas Research Centre, and others, has identified that changes in farm management practices, such as reducing stocking rates and fertiliser on most farms can reduce emissions while improving animal performance (productivity).[41,42]

Of the potential new methane reducing technologies that may come to market in future years, we consider that only low methane breeding dairy is likely to be able to be deployed in time to provide significant emissions reductions in the NDC2 period. We do not have evidence that low methane breeding for beef cattle or methane inhibitors suitable for our domestic pastoral farming systems will be available for the NDC2 period. For methane vaccines, forecasts indicate these could be available by 2035, the tail end of the NDC2 period. Given this, we expect the contribution of any other new methane reducing technologies to NDC2 will be relatively small. However, their overall contribution for later periods, as we approach 2050, is expected to be significant.

Draft Low Technology Low Systems change scenario

In this draft scenario we present the assumption of reduced herd sizes and stock per hectare for dairy, beef and sheep, resulting from farmer choices related to land use, stock numbers and stocking rates alongside productivity improvements. From 2021 to 2035, the number of dairy milking cows reduces by 8% and the number of cows per hectare reduces by 6%. Overall sheep and beef cattle stock units reduce by 17% in this period, with a 4% reduction of stock units per hectare. Low methane breeding for sheep is assumed to begin deployment in 2023, at 6% efficacy (reduction in overall biogenic methane), reaching peak adoption of 97% of stock by 2039. Ecopond[43] is assumed to be deployed from 2024 at 90% efficacy, peaking at 8% of effluent ponds by 2041. Animal productivity is assumed to grow at a rate of 1% per annum. The share of urea fertiliser coated with urease inhibitor rises to 100% by 2035.

This draft scenario assumes conversion of land to lower emissions uses. From 2021 to 2035, 2% of dairy land is converted to other uses (approximately 3 kha per annum). Horticultural land in this period has an overall increase of 54% (about 4 kha per annum). In this period sheep and beef land reduces by 13%, or around 72kha per annum. This is similar to the reference scenario, which is reflective of recent trends and of structural trends in the sheep and beef sector generally.

Low methane breeding for dairy milking cows, a new methane reducing technology, is assumed to be available from 2029. Our draft LTLS scenario assumes low methane genetics for 62% of dairy livestock by 2037 (at a 20% efficacy).

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[41] Farms that are already operating at close to optimal efficiency may not be able to reduce emissions without reducing profitability, but many farms are expected to be able to reduce emissions while maintaining or increasing profitability

[42] BERG. (2018). *Report of the Biological Emissions Reference Group (BERG).* https://www.mpi.govt.nz/dmsdocument/32125/direct

[43] Ecopond is a system that uses ferric sulphate to treat farm dairy effluent and prevent methane emissions.

Draft EB4 demonstration path

Comparing farm management practices in the draft EB4 demonstration path to the draft LTLS from 2021–2035, the key changes for the draft EB4 demonstration path are:

- fewer dairy milking cows (decrease of 12% vs. 9%)
- fewer dairy cows per ha (decrease of 11% vs. 6%)
- sheep and beef stock units are about the same (18% vs. 17%)
- fewer sheep and beef stock units per ha (decrease of 6% vs. 4%)
- a slightly higher per annum animal productivity growth rate (increase of 1.1% vs. 1.0%)
- a faster shift to urease-coated urea fertiliser (100% by 2030 vs. 100% by 2035).

Comparing land conversions in this same period to the draft LTLS, key changes for the draft EB4 demonstration path are:

- a smaller reduction in dairy land: -1% (-1 kha per annum) compared to -2% (-3 kha per annum)[44]
- a smaller increase in horticultural land: 28% (2 kha per annum) compared to 54% (4 kha per annum).

Note the level of change for sheep and beef land is the same for both scenarios: -13% (-72kha per annum).

The only change for new methane reducing technologies is the inclusion of methane vaccines from 2035 at a 30% efficacy (for dairy cows, beef cattle and sheep). Their arrival late in the NDC2 period means their impact on NDC2 emissions would be small.

Draft High Technology High Systems change scenario

Comparing farm management practices in the draft HTHS to the draft EB4 demonstration path from 2021–2035:

- draft HTHS has fewer dairy milking cows (-15% vs. -12%)
- draft HTHS has fewer sheep and beef stock units (-24% vs. -18%).

Note the change in dairy cows and sheep/beef stock units per hectare in this period are the same for the draft HTHS as the draft EB4 demonstration path (-11% and -6% respectively). The change in animal productivity per annum is also the same (1.1%).

Comparing land conversions in this same period for the draft EB4 demonstration path, key changes for draft HTHS scenario are:

- a larger reduction in dairy land: -5% (-6 kha per annum) compared to -1% (-1 kha per annum)
- a larger reduction in sheep and beef land: -20% (-110 kha per annum) compared to -13% (-72 kha per annum)
- a larger increase in horticultural land: 93% (7 kha per annum) compared to 28% (2 kha per annum).

The only change for new methane reducing technologies is the inclusion of a methane inhibitor for dairy cows from 2030, at a 7% efficacy. This is considered both a high technology and high systems change

[44] Note that although there are smaller reductions in use of land for dairy in the draft EB4 demonstration path than in the draft LTLS, other changes including in stocking rates and emissions intensity mean that dairy emissions are slightly lower in the draft EB4 pathway than the draft LTLS.

mitigation due to the additional effort and investments required when adopting this in a pastoral based farming system.

Summary of impacts

Emissions levels

We estimate agricultural emissions in the NDC2 period for the draft LTLS to be 177.1 $MtCO_2e$. For the draft EB4 demonstration path, emissions are 172.8 $MtCO_2e$, 2% lower than in the draft LTLS. Emissions in the draft HTHS reduce to 164.4 $MtCO_2e$, 5% lower than in the draft EB4 demonstration path and 7% lower than in the draft LTLS.

Agricultural emissions reductions are primarily from methane, with nitrous oxide contributing 0%, 6% and 8% of reductions in the draft LTLS, EB4 demonstration path and HTHS scenarios respectively.

Economic and sectoral impacts

Our modelling estimates changes in agricultural sector revenues as a result of changes to herd sizes, stocking rates, and land use alongside expected animal productivity gains. By 2035 dairy revenue is estimated to be 1%, 4% or 8% lower than the reference scenario in the draft LTLS, EB4 demonstration path and HTHS scenarios respectively. We estimate 2035 sheep and beef revenue to be 1.5% higher, 0.1% lower and 8% lower than the reference scenario in the draft LTLS, EB4 demonstration path and HTHS scenarios respectively. Conversely, land conversion from ruminant pastureland to low emissions uses, such as horticulture and forestry, is expected to result in more revenue for these uses.

Distributional impacts

The central North Island could see the highest levels of dairy land converted to higher value lower emissions uses. Otago and Southland could see the highest levels of sheep and beef land converted to forests. Wholesale conversion of sheep and beef land to forestry could have significant impacts on surrounding rural communities, in particular for land converted to permanent forestry as this could generate fewer jobs than production forestry.

Māori collective owners[45] of land are heavily invested in agriculture, including significant interests in sheep and beef. Māori landowners also face constraints on their freehold that limit future economic opportunities (for example a share of marginal and erosion prone land, and land that is fragmented into small parcels). As such Māori agriculture interests are more exposed to change during the transition.

Co-benefits

Further reductions in ruminant livestock herd sizes and stocking rates in the draft EB4 demonstration path and draft HTHS could improve quality of freshwater, noting more horticulture land is likely to increase agricultural demand for freshwater.

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[45] The terms 'Māori collective owners of land' and 'Māori landowners' are used in this report to cover the collective owners of Māori land (as regulated by Te Ture Whenua Māori Act 1993) and other Māori land entities which serve similar purposes. The distinctive characteristic is the collective ownership structure and its impact on land management and investment opportunities (as in our advice about Māori land in *Ināia tonu nei*, see pages 158 and 217).

Principal risks and uncertainties

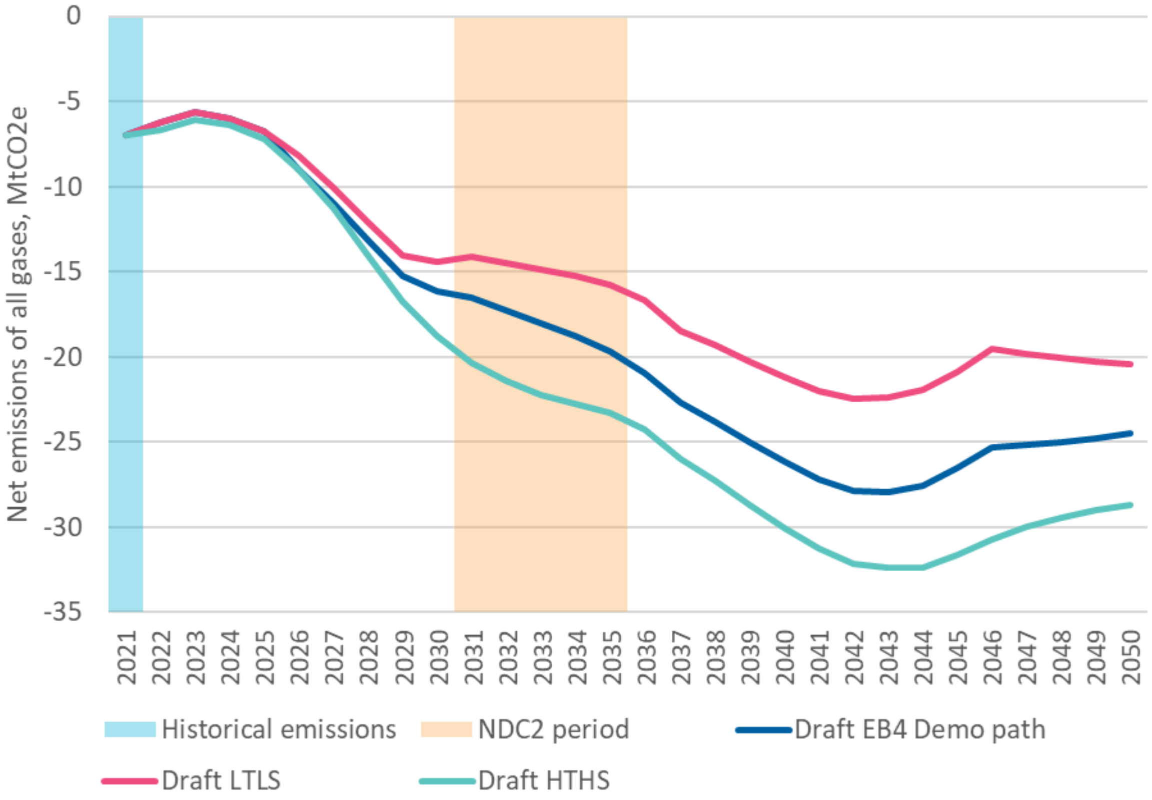
There is uncertainty over the effectiveness and availability of low methane breeding for dairy to contribute to reductions in the NDC2 period.

There is also uncertainty over broader policy settings and incentives to reduce agriculture emissions. This includes timing and settings for emissions pricing, and final decisions on the review of the 2050 target.

Forests

Figure 5 shows forestry sector emissions under the draft scenarios. Forests contribute to emissions reductions when they remove CO_2 from the atmosphere. They also contribute to emissions when forests are harvested, deforested or damaged.[46]

Figure 5: Forestry sector net emissions (removals)



Source: Commission analysis

[46] Note that emissions from forest damage arising from natural disturbance may be adjusted for in some circumstances per international IPCC guidance, depending on the accounting provisions applied.

Our scenarios to 2030 for forests

For the draft LTLS, we assume 322kha of exotic production forest ('exotic forest') is planted between 2021–2030, noting from 2024[47] this is constant at 21kha per annum. We also assume 135kha of native forests planted in this period.

For the draft EB4 demonstration path there is an additional 75kha of exotic forest planted to 2030, and from 2024 there is an average planting rate of 30kha per annum. There is an additional 15kha of native forests planted in this period.[48]

For the draft HTHS, there is an additional 40kha of exotic forest planted in this period (versus the draft EB4 demonstration path). This is the result of higher planting to 2027 (52kha annual average from 2021), with slightly less planting from 2028 (21kha annual average to 2035). Planting of native forests in this period is substantially higher than the draft EB4 demonstration path (412kha compared to 150kha), and we assume from 2024 this occurs at a rate of 55kha per annum.

Notes on higher planting levels in the draft High Technology High Systems change scenario

An annual average of 52kha of exotic afforestation, for the period 2021–2027, is in line with actual and estimated planting in recent years. However, the 2023 Afforestation and Deforestation Intentions survey estimates 18kha of exotic afforestation in 2025, and this decreases to 8kha by 2030.[49] Afforestation intentions are dynamic, with future planting influenced by a number of factors including, but not limited to, current and expected future land-use restrictions, the New Zealand Emissions Trading Scheme (NZ ETS) settings and carbon prices.

An annual average of 55 kha of native afforestation is nearly seven times the current afforestation estimates for 2022 (8kha). An annual average of 8kha itself represents an annual level that has not been reached since the mid-1990s when Aotearoa New Zealand submitted its first national GHG Inventory to the UNFCCC.

While these levels of planting are on the ambitious end of achievability, they are possible with a national commitment underpinned by supportive policies. Without this support it is unlikely these levels of afforestation could be achieved. It is also important to note that the level of removals in the NDC2 period is dependent on the timing of planting from now until the start of the NDC2 period and delays in afforestation would reduce achievable emissions removals.

Key actions in NDC2 period for forests

It takes time for a newly planted forest to become a net sink of carbon dioxide.[50] This means only forest planted prior to 2030 is able to contribute to emissions reductions in the NDC2 period. Afforestation

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[47] This is down from historical highs in the previous years, noting 2022 and 2023 values were estimates at the time of our analysis.

[48] The levels of afforestation are subject to particular uncertainty.

[49] Manley, B. (2024). *Afforestation and Deforestation Intentions Survey 2023*. Ministry for Primary Industries. https://www.mpi.govt.nz/dmsdocument/62313-Afforestation-and-Deforestation-Intentions-Survey-2023

[50] When converting grassland to exotic forests, there is initially a net loss of carbon dioxide from biomass and soil. It takes approximately four years after planting for the new forest to be a net sink.

that takes place during the NDC2 period will contribute to emissions reductions in the decades that follow.

Draft Low Technology Low Systems change scenario

This scenario assumes 105kha of exotic afforestation and 79kha of native afforestation.

Draft EB4 demonstration path

This scenario assumes 139kha of exotic afforestation and 125kha of native afforestation.

Draft High Technology High Systems change scenario

This scenario assumes 96kha of exotic afforestation and 277kha of native afforestation.

Summary of impacts

Emissions levels

The draft LTLS would contribute removals totalling 74.6 $MtCO_2e$ for the NDC2 period. In the draft EB4 demonstration path, removals increase a further 21% to 90.4 $MtCO_2e$. The draft HTHS increases these removals to 110.1 $MtCO_2e$, or 48% more removals than the draft LTLS.

Economic and sectoral impacts

The employment profiles of productive, permanent carbon and permanent native forests are different from those under the current land use. Productive forests offer more job opportunities since permanent exotic forests typically require a smaller workforce to manage after planting. Setting up and maintaining new native forests, at levels indicated in our draft scenarios, is likely to require a larger workforce. Land that regenerates to native forest from a local seed source, may require less planting effort but may have other opportunities such as in maintenance and pest control.

Distributional impacts

Rural communities face significant impacts where whole farm conversion to forestry occurs, in particular when set up as permanent forests.

A large proportion of forested Māori freehold land was planted before 1990. Any land planted before 1990 is ineligible for earning units under the ETS for carbon removals, and if such land is deforested then landowners (including Māori landowners) incur an emissions liability under the ETS. We have also heard feedback from iwi/Māori that these financial penalties are preventing iwi/Māori from converting exotic forest to native forest, even when the latter offers land resilience benefits.

Co-benefits

There are biodiversity benefits associated with planting native forests[51]. These increase with draft scenario ambition, with benefits continuing to grow for a long time after the NDC2 period (due to their relatively slower growth rates).

Principal risks and uncertainties

We note the following risks and uncertainties for removals by forestry in our draft scenarios:

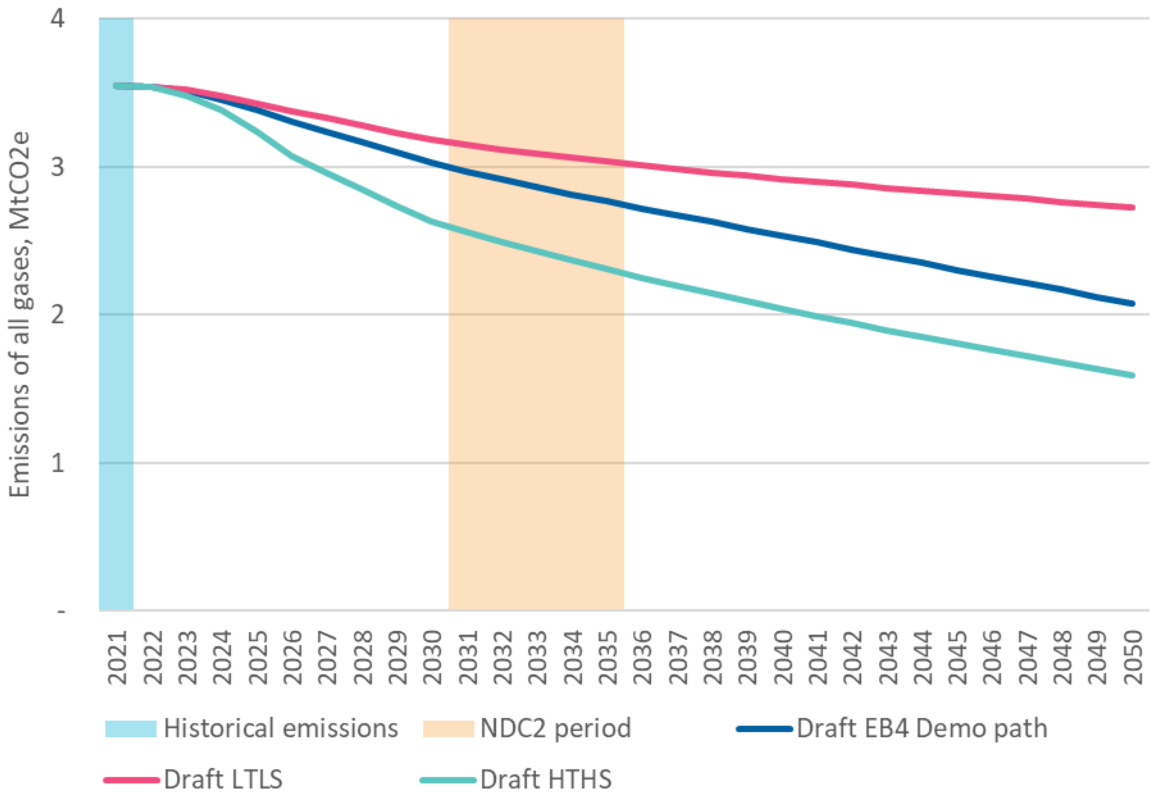
[51] Carswell et al. (2015). *Restricting new forests to conservation lands severely constrains carbon and biodiversity gains in New Zealand.*

- ensuring sufficient incentives for planting in line with our draft scenarios, including NZ ETS settings, the carbon price and complementary policies relating to land use and forestry which sufficiently consider broader impacts including on rural communities
- costs of setting up and managing native forests at levels in our draft scenarios, and how these costs might change over time in a changing climate
- levels of deforestation, which can be highly variable from year to year
- permanence and durability of land-based removals in a changing climate.

Waste

Figure 6 shows waste sector emissions under the draft scenarios. Emissions from waste account for 4% of Aotearoa New Zealand's gross emissions profile in 2021. Emissions are 93% from biogenic methane from decomposing organic waste.

Figure 6: Waste sector emissions



Source: Commission analysis

Our draft scenarios to 2030 for waste

To enable emissions reductions in the NDC2 period at the levels in our three draft scenarios, we assume the following actions by 2030 (compared with 2021 levels):

- 360–492kt less organic waste sent to landfill (a 4–5% reduction)
- 241–368kt more organic waste sent to composting facilities (an increase of 58–89%)
- 113–257kt more organic waste sent to anaerobic digestion facilities (from 0kt in 2021)

- an increase in coverage and efficiency of landfill gas capture facilities (higher coverage and efficiencies for the draft EB4 demonstration path and HTHS).

Key actions in NDC2 period for waste

Draft Low Technology Low Systems change scenario

In 2035 we assume (relative to 2021):

- 342kt less organic waste is sent to landfill (a 4% reduction)
- 280kt of organic waste is diverted to composting facilities (a 67% increase)
- 130kt of organic waste is diverted to anaerobic digestion facilities (from 0kt in 2021).

Draft EB4 demonstration path

In 2035 we assume (relative to 2021):

- 475kt less organic waste is sent to landfill (a 5% reduction)
- 451kt of organic waste is diverted to composting facilities (a 109% increase)
- 254kt of organic waste is diverted to anaerobic digestion facilities (from 0kt in 2021).

Draft High Technology High System change scenario

In 2035 we assume (relative to 2021):

- 532kt less organic waste is sent to landfill (a 6% reduction)
- 439kt of organic waste is diverted to composting facilities (a 106% increase)
- 306kt of organic waste is diverted to anaerobic digestion facilities (from 0kt in 2021).

Summary of impacts

Emissions levels

We estimate emissions in the NDC2 period for the draft LTLS to be 15.4 $MtCO_2e$. For the draft EB4 demonstration path, emissions are 14.3 $MtCO_2e$, 7% lower than in the draft LTLS. Emissions in the draft HTHS reduce to 12.2 $MtCO_2e$, 15% lower than in the draft EB4 demonstration path and 21% lower than in the draft LTLS.

Economic and sectoral impacts

There are infrastructure costs associated with higher diversion of waste to composting and anaerobic digestion facilities, as well as for increasing landfill gas capture coverage and efficiency.

While these draft scenarios could mean fewer jobs associated with landfills, these are expected to be offset by more jobs in resource recovery.

Distributional impacts

Higher costs of waste management could be passed on to households and businesses (noting price signals can help shift behaviour to minimise these costs). Higher waste avoidance is likely to require changes to how goods are consumed, used and disposed of.

Co-benefits

Less waste going to landfills will mean less land is needed, which in turn lowers risks of pollution to surrounding land, water and air.

Principal risks and uncertainties

Actions in the draft scenarios require changes in behaviours and habits of households and firms, and these increase with draft scenario ambition. This includes adherence to more stringent waste system regulations, and these could require enforcement measures to ensure compliance. As such social license will be an important consideration for changes to this sector.

Summary of key actions by sector

Key actions in the draft scenarios that make significant contribution to emissions reductions and removals across sectors in the NDC2 period are:

- decarbonising road transport through electrification and mode shift
- decarbonising process heat and production processes
- changes to sheep, beef and dairy herd sizes through farmer choices related to land use, stock numbers and stocking rates alongside productivity improvements
- low methane breeding for sheep and dairy
- expansion of geothermal carbon capture and reinjection
- diversion of organic waste and landfill gas capture
- maintaining high rates of afforestation
- increased renewable electricity generation
- management of electricity system (including demand management and increased storage) to support decarbonisation across sectors.

Economic impacts

We have used a computable general equilibrium (CGE) model (C-PLAN) to estimate the economic impact of each draft scenario relative to the reference scenario.[52] CGE models provide the most insight when comparing modelling results across scenarios. From 2022 onwards projected GDP under the different scenarios begins to diverge, reflecting emissions reduction and removal actions taken in the economy prior to 2031. **Table 2** shows GDP figures and the difference versus the reference scenario at 2030 and at 2035.

Table 2 GDP under different draft emission scenarios (real 2017 NZD)

Scenario	2030 GDP, $b	2035 GDP, $b	2030 vs. reference, $b	2035 vs. reference, $b	2030 vs. reference, %	2035 vs. reference, %
Reference	$ 372	$ 403				
Draft LTLS	$ 372	$ 403	-$ 0.1	-$ 0.3	0.0%	-0.1%
Draft EB4 demo path	$ 371	$ 402	-$ 0.6	-$ 1.2	-0.2%	-0.3%
Draft HTHS	$ 371	$ 400	-$ 1.0	-$ 2.7	-0.3%	-0.7%

The model used does not capture all costs and benefits associated with greenhouse gas emissions reductions and removals. As noted above, our analysis also shows substantial health benefits of

[52] More details on the models used can be found on our website.

decarbonising transportation. We estimate additional benefits from reduced air pollution over the 2031–2035 period (five-year total) of $2.3 billion[53] (draft LTLS), $9.3 billion (draft EB4 demonstration path) or $12.1 billion (draft HTHS).

Overall domestic contribution to an NDC2 target

Approach

Emissions under our draft scenarios during the NDC2 period can be compared with the NDC1 commitment in several ways. Aotearoa New Zealand's NDC1 commitment,[54] covering 2021–2030, includes two presentations:

- a 'point year target' to reduce net greenhouse gas emissions to 50% below gross 2005 levels by 2030
- a 'budget approach target' to reduce net greenhouse gas emissions to 41% below gross 2005 levels by 2030.

Both approaches correspond to the same multi-year emissions budget of 571 $MtCO_2e$ for NDC1, but the lines defining the targets have different starting points and slopes.

To allow comparison between NDC2 period emissions from our draft scenarios and the NDC1 commitment we have:

- adjusted the NDC1 budget approach target (41%) and budget (571 $MtCO_2e$) into the 2023 GHG Inventory basis,[55] which is used for our draft scenarios, and
- converted the total NDC2 period emissions under our draft scenarios into point year and budget approach target presentations[56].

We have included a variety of target presentation methodologies as explained in Annex 1. We do not know what approach the government will use and this report does not include advice on what approach is appropriate.

We have also included annual average emissions for the NDC1 and NDC2 commitment periods for transparency.

NDC2 contribution

Table 3 shows our draft scenarios converted into NDC2 target presentation, and what target they could deliver over 2031–2035 if there were only a domestic contribution to NDC2, under a variety of target presentation methodologies, as explained in Annex 1. **Table 4** shows NDC1 figures as submitted and as adjusted for the 2023 inventory.

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[53] Real 2023 NZD.

[54] As updated in 2021.

[55] Methodological changes are regularly made to the GHG Inventory, which can result in revised estimates of historical emissions when the Inventory is published each year, as well as consequential changes to other emissions time series which use the Inventory as an input.

[56] In other words, for each scenario, we have used cumulative 2031-35 emissions from the scenario as the 'budget' for the NDC2 period, together with the appropriate 2030 start year emissions for each target presentation methodology (**Table A1**), to calculate 2035 end year emissions. See **Annex 4** for more details.

Table 3 Draft emission scenarios converted into NDC2 target presentation, and what target they could deliver over 2031–2035 if there were only a domestic contribution to NDC2, under a variety of target presentation methodologies. See Annex 1, Table A1 for an explanation of the different methodologies.

	Draft LTLS	**Draft EB4 demo**	**Draft HTHS**	**Draft LTLS**	**Draft EB4 demo**	**Draft HTHS**	**Draft LTLS**	**Draft EB4 demo**	**Draft HTHS**	**Draft LTLS**	**Draft EB4 demo**	**Draft HTHS**
	NDC2 starts at NDC1 endpoint, as set in 2021			*NDC2 starts at NDC1 endpoint (adjusted for 2023 inventory, holding 50% constant)*			*NDC2 starts at NDC1 endpoint (adjusted for 2023 inventory, holding 41% constant)*			*NDC2 start at projected 2030 net emissions per relevant emissions scenario*		
Methodology (refer Table A1)	**2a**			**2c**			**2b**			**3**		
'Point year': net emissions in 2035 as a % reduction on gross 2005 emissions	-40%	-54%	-69%	-39%	-53%	-69%	-40%	-54%	-69%	-47%	-58%	-69%
Methodology (refer Table A1)	**1a**			**1c**			**1b**			**N/A**		
'Budget approach': net emissions in 2035 as a % reduction on gross 2005 emissions	-46%	-60%	-75%	-44%	-58%	-74%	-45%	-59%	-75%	N/A	N/A	N/A
Annual average emissions budget ($MtCO_2e$), 2031–2035	48.1	40.9	33.0	48.1	40.9	33.0	48.1	40.9	33.0	48.1	40.9	33.0

Table 4 NDC1 figures as set in 2021 and as adjusted for the 2023 GHG Inventory

	NDC1 (as set in 2021)	**NDC1 Adjusted** **(2023 inventory, hold 50% constant)**	**NDC1 Adjusted** **(2023 inventory, hold 41% constant)**
'Point year' endpoint (net emissions in 2030 as % reduction on gross 2005 emissions)	-50%	-50%	-49%
'Budget approach' endpoint (net emissions in 2030 as % reduction on gross 2005 emissions)	-41%	-42%	-41%
Annual average emissions budget ($MtCO_2e$), 2021–2030	57.1	56.1	56.7

Under these comparators the draft EB4 demonstration path and draft HTHS scenario show deeper reductions during the NDC2 period through domestic action alone than the corresponding NDC1 target presentation (as set in 2021 and as adjusted for the 2023 inventory), for each target presentation methodology we considered (noting NDC1 is also understood to rely on a contribution from international cooperation). The draft LTLS shows deeper reductions than NDC1 under some of, but not all, the target presentations we considered.

Nationally determined contributions are covered by article 4 of the Paris Agreement, which includes the following obligations:

> "Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions." (article 4, paragraph 2)
>
> "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." (article 4, paragraph 3)

As part of its NDC2 decision, the Government will need to consider how it will present NDC2 in a way that meets Paris Agreement obligations including how it will measure progression between NDC1 and NDC2, including any contribution from international cooperation. The numerical analysis in this report can help inform the Government's decision but is not advice about appropriate target presentation methodologies, how to measure progression or whether a given emissions level represents progression.

Contribution to domestic targets

Emissions reductions count towards Aotearoa New Zealand's legislated domestic targets under the Act as well as NDCs[57]. The NDC2 period corresponds to the third domestic emissions Budget (EB3). **Table 5** shows net target accounting emissions under domestic targets and our draft scenarios with the notified EB2 and EB3 budgets set by the Government in 2022. For the purposes of the comparison in this report, we have also included adjusted EB2 and EB3 figures to account for changes in the 2023 inventory.

Note that we have included this comparison of draft scenarios and the domestic emissions budgets for information only. It is indicative and not advice about the budgets or the adequacy of these draft scenarios to meet them. There is a specific process under the Act for updating budgets for methodological and significant changes. Our final advice on the fourth emissions budget will update our draft scenarios for the 2024 inventory and provide advice about whether any changes are needed to the second and third emissions budgets.

Table 5 Emissions under draft emission scenarios and domestic emissions budgets (as notified and also as adjusted for 2023 inventory), $MtCO_2e$

	Draft EB4 demonstration path	Draft LTLS	Draft HTHS	EB2 (notified)	EB3 (notified)	EB2 (2023 inventory)	EB3 (2023 inventory)
2026–2030 total	278	293	260	305	N/A	297	N/A
2031–2035 total	205	240	165	N/A	240	N/A	233

Technical notes

All our figures use target accounting[58] in the 2023 GHG Inventory basis to allow straightforward comparison with NDC1 and domestic emissions budgets which also use this.

We have not included net figures under inventory-based accounting as government projections on this basis were not available for the relevant period. We have assumed that no credits or debits are generated from use of a Forest Reference Level or from other natural sinks and sources beyond managed forests.

Aotearoa New Zealand's GHG Inventory and NDC1 include emissions for Tokelau (0.005 percent of Aotearoa New Zealand's gross emissions in 2021[59]). Figures in our draft scenarios, adjusted NDC1, and NDC2 target presentations do not include Tokelau's emissions in the base year or commitment period. This does not materially change the results.

Annexes 1 and 4 provide further technical details on calculation methods used for target presentation.

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[57] All three scenarios are consistent with achieving the 2050 Target.

[58] 'Inventory-based accounting' includes a broader scope of emissions sinks and sources than target accounting and is used by many countries in NDCs. We were unable to provide figures under inventory-based accounting as data were not available.

[59] https://www.tokelau.org.nz/Bulletin/May+2023/Tokelaus+Greenhouse+Gas+Inventory+1990-2021.html

Annex 1: Accounting and presentation methods

Emissions accounting

The New Zealand Government applies two approaches to emissions accounting: ‘inventory-based accounting’[60] and ‘target accounting’.[61] The latter counts only ‘additional’ removals and emissions from forests, applies ‘averaging’ across commercial forestry rotations and excludes emissions and removals from non-forest land.

Aotearoa New Zealand uses target accounting for its domestic emissions budgets and for NDC1. The Commission’s draft scenarios in this report also use target accounting, including GWP100 conversion factors from the IPCC 5th Assessment Report applied to greenhouse gases. This ensures results are comparable as required by the Terms of Reference and is also consistent with international obligations under the Paris Agreement.[62]

Emissions scenario data is provided under both gross and net target accounting (Annex 3). We considered also producing results under inventory-based accounting, but this was not feasible since projections for 2031–2035 on this basis were not published in 2023.

Target presentation

Target presentation refers to how emissions reduction commitments are described, as well as the related methodologies by which the corresponding targets and budgets are mathematically related.

NDC1 includes three target presentations:

a) 50% reduction in net emissions by 2030 relative to gross 2005 emissions (starting from 2020 actual net emissions) (‘**Point year target**’)
b) 41% reduction in net emissions by 2030 relative to gross 2005 emissions (starting from 2020 target net emissions under Aotearoa New Zealand’s 2013–2020 target under the Convention) (‘**Budget approach’**)
c) a provisional 571 MtCO_2e multi-year emissions budget for 2021–2030 (‘**Multi-year Budget’**).

Presentations a, b and c were mathematically equivalent in 2021 when the NDC1 was set, although GHG Inventory updates mean this is no longer the case, as discussed further below.

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[60] Inventory-based accounting covers all emissions and removals as included in New Zealand’s National Inventory Report submitted to the UNFCCC.

[61] Target Accounting applies a modified activity-based (MAB) method, which distinguishes “additional” from “business-as-usual” changes in forest carbon stocks. The approach is a continuation of that applied by New Zealand for the period 2013 to 2020, and where the ‘modified’ prefix relates to the introduction of ‘averaging’ for new forests planted post-1989 once they reach their long-term average carbon stock.

[62] See decision 18/CMA.1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement, paragraph 37 of its annex refers.

Methodological improvements

Methodological changes are regularly made to the GHG Inventory, which can result in revised estimates of historical emissions when the Inventory is published each year, as well as consequential changes to other emissions time series which use the Inventory as an input.

The NDC1 figures submitted by New Zealand used the 2021 GHG Inventory while the Commission's draft scenarios use the 2023 GHG Inventory. Therefore we have adjusted NDC1 figures in the report as well as domestic emissions budget figures into 2023 inventory basis to allow comparison on a consistent methodological accounting basis. We understand that the Government will update NDC1 for GHG Inventory changes but we do not have a confirmed methodology for how it will do this.

The three NDC1 target presentations were equivalent when the current NDC1 was set, but inventory updates mean reported emissions have changed in years that provide inputs to the target calculation (1990, 2005 and 2020). As a result, the relationship between the three target presentations has changed so that they are no longer consistent. Any adjustment to these NDC1 figures potentially affects i) the starting point for a budget line drawn for the NDC2 period, and ii) the NDC1 comparator for NDC2 target presentations.

Target presentations included in this advice

At the time of writing, we are not aware of a confirmed methodology from the government for the target presentation methodology for NDC2. The terms of reference for this work asked the Commission to include a variety of approaches for target presentation. In deciding which presentations to include, we applied the following principles:

1. precedent in NZ's international commitments
2. previous Commission advice
3. international obligations and expectations
4. internal consistency
5. data availability, and
6. transparency.

Based on these principles, we have included the methods in Table A1 in this report. We have taken the 2031–2035 net emissions from our draft scenarios and converted these into each of these target presentations. See Annex 4 and the accompanying spreadsheet on our website for more details on these calculations.

Table A1 Target presentation methodologies included in this report for the NDC2 period

Reference	Name as used in report	2030 Start point	Variations
1a	'Budget approach'	41% below gross 2005	As set in 2021
1b	'Budget approach'	41% below gross 2005	Adjusted for 2023 inventory holding 41% constant
1c	'Budget approach'	41% below gross 2005	Adjusted for 2023 inventory holding 50% constant
2a	'Point year'	50% below gross 2005	As set in 2021
2b	'Point year'	50% below gross 2005	Adjusted for 2023 inventory holding 41% constant
2c	'Point year'	50% below gross 2005	Adjusted for 2023 inventory holding 50% constant
3	'Point year'	Projected net emissions	Per emissions scenario
4	Annual average emissions	N/A	N/A

Methods 1 and 3 have the precedent of being used in NDC1 as set in 2021. We have included variations 1a, 1b and 1c to reflect GHG Inventory updates since 2021, as described further below.

Method 2 (and variations 2a, 2b, and 2c) was not included in NDC1 (the line defining the 50% below gross 2005 by 2030 NDC1 'point year' figure starts at 2020 actual emissions rather than at the previous target). However, it draws on the precedent set by NDC1 (as set in 2021 and 2016), of defining emissions budgets by drawing a line between consecutive international commitments. It is plausible that international expectations would be for the line defining Aotearoa New Zealand's NDC2 to start at NDC1's 2030 headline target for net emissions of 50% below 2005 gross emissions. Including this method provides greater transparency about the range of headline target results under plausible target presentation methodologies.

Note that Method 4 has been included alongside the other methods for transparency.

Annex 2: Full results

Table A2: Numbers used in the report relating to the NDC1 period[63]

	NDC1 (as set in 2021)	NDC1 Adjusted (2023 inventory, hold 50% constant)	NDC1 Adjusted (2023 inventory, hold 41% constant)
Point year (%)	-50%	-50%	-49%
Starting point ($ktCO_2e$)	74,354	72,637	72,637
End point ($ktCO_2e$)	42,961	42,579	43,592
Budget approach (%)	-41%	-42%	-41%
Starting point ($ktCO_2e$)	64,919	64,508	64,508
End point ($ktCO_2e$)	50,694	49,230	50,243
Budget ($MtCO_2e$)	571	561	567
Annual average emissions budget ($MtCO_2e$)	57.1	56.1	56.7
Gross 2005 emissions ($ktCO_2e$)	85,922	85,157	85,157
Gross 1990 emissions ($ktCO_2e$)	68,336	67,903	67,903

Source: Commission calculations

[63] Figures may not match precisely when Annex 4 equations are applied due to rounding. See accompanying spreadsheet which does calculations to full precision before rounding results.

Table A3: Numbers used in the report relating to the NDC2 period[64]

	Draft LTLS	Draft EB4 demo	Draft HTHS	Draft LTLS	Draft EB4 demo	Draft HTHS	Draft LTLS	Draft EB4 demo	Draft HTHS	Draft LTLS	Draft EB4 demo	Draft HTHS
	NDC2 starts at NDC1 endpoint, as set in 2021			*NDC2 starts at NDC1 endpoint (adjusted for 2023 inventory, holding 50% constant)*			*NDC2 starts at NDC1 endpoint (adjusted for 2023 inventory, holding 41% constant)*			*NDC2 start at projected 2030 net emissions per relevant emissions scenario*		
Methodology (refer Table A1)	**2a**			**2c**			**2b**			**3**		
Point year (%)	-40%	-54%	-69%	-39%	-53%	-69%	-40%	-54%	-69%	-47%	-58%	-69%
Starting point ($ktCO_2e$)	42,961	42,961	42,961	42,579	42,579	42,579	43,592	43,592	43,592	52,893	48,562	42,760
End point ($ktCO_2e$)	51,518	39,526	26,440	51,773	39,781	26,694	51,097	39,106	26,019	44,897	35,793	26,573
Methodology (refer Table A1)	**1a**			**1c**			**1b**			**N/A**		
Budget approach (%)	-46%	-60%	-75%	-44%	-58%	-74%	-45%	-59%	-75%	N/A	N/A	N/A
Starting point ($ktCO_2e$)	50,694	50,694	50,694	49,230	49,230	49,230	50,243	50,243	50,243	N/A	N/A	N/A
End point ($ktCO_2e$)	46,362	34,371	21,284	47,339	35,347	22,260	46,663	34,672	21,585	N/A	N/A	N/A
Budget ($MtCO_2e$)	240	205	165	240	205	165	240	205	165	240	205	165
Annual average emissions budget ($MtCO_2e$)	48.1	40.9	33.0	48.1	40.9	33.0	48.1	40.9	33.0	48.1	40.9	33.0
Gross 2005 emissions ($ktCO_2e$)	85,157	85,157	85,157	85,157	85,157	85,157	85,157	85,157	85,157	85,157	85,157	85,157

Source: Commission calculations

[64] Figures may not match precisely when Annex 4 equations are applied due to rounding. See accompanying spreadsheet which does calculations to full precision before rounding results.

Annex 3: Emissions data

Table A4: Historic emissions (1990–2021), used in NDC figures, $ktCO_2e$

	GHG gross	GHG net	Biogenic methane
	MfE, 'Nov 2023 Central projection'		
1990	67,903	68,753	35,143
1991	68,890	69,749	35,412
1992	70,028	71,145	34,987
1993	69,923	71,114	35,243
1994	71,165	72,494	36,077
1995	71,705	72,586	36,477
1996	73,919	73,983	36,896
1997	76,832	75,513	37,776
1998	74,579	71,209	37,084
1999	76,377	70,477	37,226
2000	78,309	72,263	38,131
2001	81,212	72,651	38,514
2002	81,085	70,595	38,198
2003	83,206	72,975	38,521
2004	83,040	75,082	38,548
2005	85,157	81,115	38,842
2006	85,228	83,822	38,740
2007	83,025	86,011	37,834
2008	82,522	68,710	36,415
2009	79,839	68,057	36,390
2010	80,536	68,866	36,426
2011	80,309	67,530	36,680
2012	82,301	71,264	37,212
2013	81,638	72,914	37,405
2014	82,425	71,193	37,659
2015	82,189	70,305	37,098
2016	80,015	68,705	36,621
2017	81,575	71,416	36,711
2018	81,828	71,703	36,822
2019	83,032	73,829	36,837
2020	80,342	72,637	36,695
2021	79,810	72,778	36,294

Source: Ministry for the Environment. (2023). *Historical and projected greenhouse gas emissions*. https://environment.govt.nz/assets/what-government-is-doing/climate-change/2050-historical-and-projected-sectoral-emissions-data-November_2023-for-publishing-v01.xlsx

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Table A5: Emission scenarios (2022–2050), $ktCO_2e$

	GHG gross	GHG net	Biogenic Methane	GHG gross	GHG net	Biogenic Methane	GHG gross	GHG net	Biogenic Methane	GHG gross	GHG net	Biogenic Methane
	Draft ENZ reference scenario (with measures at 1 July 2023)			Draft EB4 Demonstration Path			Draft EB4 LTLS Scenario			Draft EB4 HTHS Scenario		
2022	76,323	70,131	35,836	75,597	69,405	35,216	75,667	69,475	35,273	75,525	68,876	35,157
2023	77,618	71,996	35,234	77,210	71,589	34,803	77,157	71,535	34,916	76,943	70,866	34,664
2024	76,237	70,779	34,752	75,680	69,683	34,435	75,588	69,582	34,632	75,012	68,663	34,049
2025	75,026	68,647	34,269	73,219	66,493	33,951	74,282	67,540	34,236	71,589	64,371	33,326
2026	74,317	66,484	33,997	72,135	63,109	33,529	73,164	64,985	33,912	70,197	61,192	32,671
2027	72,622	62,798	33,738	70,095	59,170	33,135	71,518	61,489	33,597	67,823	56,560	32,095
2028	71,981	59,747	33,509	68,703	55,597	32,735	70,449	58,382	33,277	66,140	52,131	31,532
2029	71,209	56,693	33,287	67,317	52,048	32,340	69,375	55,325	32,962	64,428	47,659	30,993
2030	69,500	53,180	33,075	64,689	48,562	31,952	67,300	52,893	32,655	61,565	42,760	30,466
2031	68,788	51,547	32,871	62,591	46,090	31,436	65,845	51,694	32,212	59,240	38,920	29,841
2032	68,030	50,343	32,680	60,721	43,432	30,932	64,467	49,941	31,785	57,122	35,700	29,230
2033	67,223	48,795	32,499	58,993	40,934	30,452	63,053	48,179	31,361	55,127	32,870	28,619
2034	66,558	47,604	32,423	57,166	38,364	29,943	61,541	46,314	30,916	53,174	30,397	27,993
2035	65,908	46,173	32,377	55,394	35,682	29,473	60,122	44,347	30,500	50,655	27,354	27,392
2036	65,260	44,288	32,333	53,697	32,717	28,915	58,978	42,297	30,273	48,804	24,517	26,773
2037	64,568	41,315	32,290	52,001	29,301	28,356	57,798	39,287	30,044	47,081	21,074	26,162
2038	64,049	39,497	32,253	50,588	26,753	27,819	56,822	37,482	29,822	45,442	18,160	25,566
2039	63,501	37,553	32,215	49,243	24,190	27,290	55,833	35,547	29,600	43,884	15,186	24,979
2040	62,022	34,762	32,178	47,030	20,868	26,772	53,949	32,787	29,380	41,114	11,093	24,404
2041	61,420	32,870	32,144	45,810	18,615	26,295	53,054	31,066	29,219	39,148	7,867	23,849
2042	60,856	31,387	32,114	44,521	16,682	25,819	52,148	29,692	29,058	37,461	5,327	23,304
2043	60,357	30,510	32,082	43,507	15,593	25,359	51,329	28,935	28,900	35,839	3,435	22,772
2044	59,775	29,886	32,055	42,464	14,900	24,908	50,435	28,505	28,744	34,425	2,041	22,252
2045	59,329	30,115	32,028	41,207	14,665	24,457	49,812	28,964	28,590	33,068	1,422	21,743
2046	58,832	30,400	32,004	40,219	14,936	24,031	49,042	29,492	28,437	31,894	1,187	21,253
2047	58,441	30,798	31,982	39,317	14,162	23,615	48,123	28,315	28,289	30,804	830	20,777
2048	58,033	30,292	31,960	38,326	13,312	23,202	47,474	27,399	28,137	29,780	362	20,305
2049	57,590	29,745	31,944	37,261	12,460	22,795	46,796	26,507	27,992	28,832	-183	19,845
2050	57,234	29,247	31,925	36,372	11,898	22,401	46,021	25,571	27,849	27,900	-821	19,394

Source: He Pou a Rangi Climate Change Commission (2024). ENZ results for *Draft advice on the fourth emissions budget*. Modelling and data: Consultation on emissions reduction target and emissions budgets » Climate Change Commission (climatecommission.govt.nz)

Annex 4: Equations used in analysis

All emissions figures used in equations are *net*, target accounting emissions, in 2023 GHG Inventory basis, unless stated otherwise. All emissions figures should be converted to the same units before applying the equations (e.g. ktCO_2e or MtCO_2e).

Basis for NDC calculations

The equations described below are derived from the relationship between three values for an NDC:

- Emissions in the 'start' year, E_0 – the year before the first year of the commitment period, being either E_{2020} (for NDC1) or E_{2030} (for NDC2); this value may be actual emissions (or projected emissions if actual data are not available) or target emissions from the previous international commitment, depending on the method used.
- Emissions in the 'target' year, E_{Target} – the final year of the commitment period.
- The multi-year emissions budget, E_{Budget} – the area beneath the line between the start year and target year emissions, during the commitment period.

Figure 8 at the end of this section shows this relationship for a hypothetical NDC with a five-year commitment period.

Adjusting NDC1 for 2023 GHG Inventory

Firstly, adjusted starting values for the NDC1 target are derived from 2023 GHG Inventory figures: 95% of gross 1990 emissions[65] (Budget approach) or actual 2020 net emissions (point year approach). These provide inputs to **Equation 1** (E_{2020} term) in the steps below.

Secondly, two adjusted NDC1 multi-year budgets (E_{Budget}) are calculated with **Equation 1**, using a) the adjusted point year starting emissions, and b) the adjusted budget approach starting emissions.

Thirdly, the adjusted NDC1 multi-year budgets from Step 2, are used to calculate adjusted NDC1 target % figures (*NDC%*) using **Equation 1a** (the inverse of **Equation 1**).

$$E_{Budget} = 10 \times E_{2020} + 5.5 \times ((1 - NDC\%) \times E_{Gross(2005)} - E_{2020}) \quad \text{[Eq.1]}$$

$$-NDC\% = [(E_{Budget} - 10 \times E_{2020})/5.5 + E_{2020}]/E_{Gross(2005)} - 1 \quad \text{[Eq.1a]}$$

where *NDC%* is the 2030 target (original or adjusted) expressed as a positive percentage; and E_{2020} is the appropriate starting value.

NDC% figures are converted to absolute emissions values, E_{2030}, using **Equation 2**.

This results in two adjusted sets of internally consistent NDC1 target presentations – each derived by holding one target presentation (budget approach % or point year %) constant while allowing the other to vary. These results are shown in **Table A2**. These figures provide inputs to the NDC2 presentations described below.

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[65] Aotearoa New Zealand's 2013–2020 international target is to reduce emissions to 5% below 1990 levels.

$$E_{2030} = (1 - NDC\%) \times E_{Gross(2005)} \quad \text{[Eq.2]}$$

Converting 2031-35 emissions to NDC2 presentation

Corresponding 2035 target emissions (E_{2035}) are calculated from the draft emission scenarios by adapting the method used in the NDC1 calculations for a five-year period instead of a 10-year period. This is shown in **Equation 3**. Emissions in the 'start year', E_{2030} depend on the methodology used – see **Table A1** and **Table A3**.

Emissions budget figures (E_{Budget}) are the five-year total emissions for 2031–35 from either the draft EB4 demonstration path, draft LTLS or draft HTHS scenarios.

Equation 3a is used to convert 2035 target emissions into a percentage target figure (expressed as a positive number).

$$E_{2035} = \frac{E_{Budget} - (5 \times E_{2030})}{3} + E_{2030} \quad \text{[Eq.3]}$$

$$-NDC2\% = \frac{E_{2035}}{E_{Gross(2005)}} - 1 \quad \text{[Eq.3a]}$$

Figure 8 Relationship between starting emissions, target-year emissions and emissions budget for an illustrative, five-year NDC