He Pou a Rangi
Climate Change Commission

Technical Annex

Modelling and analysis to support final advice on Aotearoa New Zealand's fourth emissions budget and the review of the 2050 emissions target including whether emissions from international shipping and aviation should be included

November 2024

Contents

Introduction

He Pou a Rangi Climate Change Commission (the Commission) is publishing this technical annex to provide further information on the modelling, data, and analysis that underpins two separate but related documents:

- our *Advice on Aotearoa New Zealand's fourth emissions budget*
- our *Review of the 2050 emissions reduction target, including whether emissions from international shipping and aviation should be included*.

This technical annex should be read alongside these documents and other supporting material published on our website, which includes:

- assumptions logs and modelling results workbooks
- updated methodologies and user manuals for our models
- external analysis commissioned as part of this work.

This supporting material can be found here: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/preparing-advice-on-emissions-budgets/advice-on-the-fourth-emissions-budget/modelling-and-data-final-report

Separate but connected advice: about our review of the 2050 target and international shipping and aviation emissions, and our advice on the fourth emissions budget

The Commission is an independent Crown entity established by the Climate Change Response Act 2002 (the Act) to provide expert, evidence-based advice and monitoring to successive governments on how to reduce emissions and adapt to the effects of climate change.

Under the Act, the Commission must provide the Government with advice on setting Aotearoa New Zealand's fourth emissions budget by the end of 2024. As part of this work, we advise on the rules that apply to emissions budgets and whether revisions are needed to the first, second, and third emissions budgets. The Minister of Climate Change will set the fourth emissions budget by 31 December 2025.

The Act also requires us to review whether the 2050 target, as created in 2019, is fit for purpose in the current circumstances. We must do this every five years, beginning in 2024. Our advice to the Government covers the outcome of our first review, including whether any changes should be made to the target's timeframe, level, structure, or rules. That advice includes the results of a one-off review under the Act of whether international shipping and aviation emissions should be included in the 2050 target and, if so, how.

In April 2024, we published three consultation documents for feedback. Our final advice is provided as two documents: advice on the fourth emission budget, and a combined report on our review of the 2050 target and inclusion of international shipping and aviation emissions. The two reports we provide to Government at the end of 2024 are connected but necessarily separate. The advice on the fourth emissions budget is aligned with the current 2050 target. It does not take into account any recommendations we make to Government about potential changes to the target.

While each piece of advice has a specific focus, they both deal with Aotearoa New Zealand's journey to becoming and maintaining a thriving, low-emissions economy by and beyond 2050. Together they provide decision-makers and citizens with a clear view of options for Government decision-making that will affect the country's actions, planning and investment for the next 20–30 years.

While this technical annex and the separate assumptions logs are relevant to both final advice documents, chapter references throughout this annex refer to our report *Advice on Aotearoa New Zealand's fourth emissions budget*, unless otherwise stated.

About this document

This document provides further technical information for readers who want to learn more about the modelling underpinning our advice documents.

It includes details on the following aspects of our analysis and proposals:

- our approach to modelling levels of greenhouse gas emissions and the economic impacts of actions to reduce them
- the data underpinning our advice
- how we have defined the reference scenario for each sector
- macroeconomic modelling of scenarios
- emissions from international bunker fuels
- temperature response modelling
- our approach for advising on revisions to budgets.

The Commission's approach to modelling emissions and economic impacts

Why we use models

The Commission uses modelling to inform our advice. Models are tools to help analyse and assess the choices that Aotearoa New Zealand has on how it can reduce emissions. However, on their own, they don't tell the whole story, which is why they are inputs to our broader analysis.

The models we have used can provide useful insights into the dynamics of the economy and the flow-on effects that can occur when one sector makes changes to alter or decarbonise its activity. Our modelling also includes some estimates of costs and savings from taking particular actions. These allow us to understand some of the implications of the different modelled outcomes, and therefore what the impacts could be for businesses, households and the overall economy. The results of the modelling have been used to support the Commission's advice on the fourth emissions budget and review of the 2050 emissions target including whether emissions from international shipping and aviation should be included.

Modelling also allows us to explore the uncertainty around the assumptions in a structured way. We do not use models to forecast what will happen. Instead, they are used to understand what could happen under various sets of assumptions we have made and provide insight into different possible scenarios. The projections made using these assumptions are inherently uncertain, especially when projecting decades into the future. Changes in how people live their lives are not always easy to predict, and new technologies are continually developing. We have therefore used our models to better understand uncertainty through modelling a range of scenarios and pathways, conducting sensitivity analysis and trying to give the best answers possible given the things we know we don't know.

Our modelling builds on the approach taken in *Ināia tonu nei* which was externally reviewed and scrutinised. Since then, we have made improvements to the models to enable us to better reflect mitigation technologies that could be available in the future, as well as understand some of the cost impacts and implications in greater detail. All changes to the models have been externally reviewed.

Our modelling and analysis have been further refined using feedback from consultation earlier in 2024.

Why more than one model is useful

We have used two main models to support our advice. All models are necessarily a simplification of a more complex system and are not intended to represent all aspects of that system in detail. Therefore, it is not possible or appropriate to rely solely on a single model to guide our work. Using a combination of models is helpful because they can provide different insights.

All models have constraints; we specify the constraints of our models in the sections below. By understanding the strengths and limitations of our models we have been able to ensure we draw the appropriate conclusions. In some cases, our models can provide different perspectives on the same parts of the system (for example, the speed at which electric vehicles (EVs) are adopted). Where this is the case, interpreting the different results is helpful to draw conclusions.

Our approach to modelling emissions in ENZ

Overview of ENZ

We produce our emissions scenarios using a purpose-built model called Energy and Emissions in New Zealand (ENZ), developed by Concept Consulting. The Commission purchased ENZ and has worked with Concept Consulting to further develop it to meet our needs.

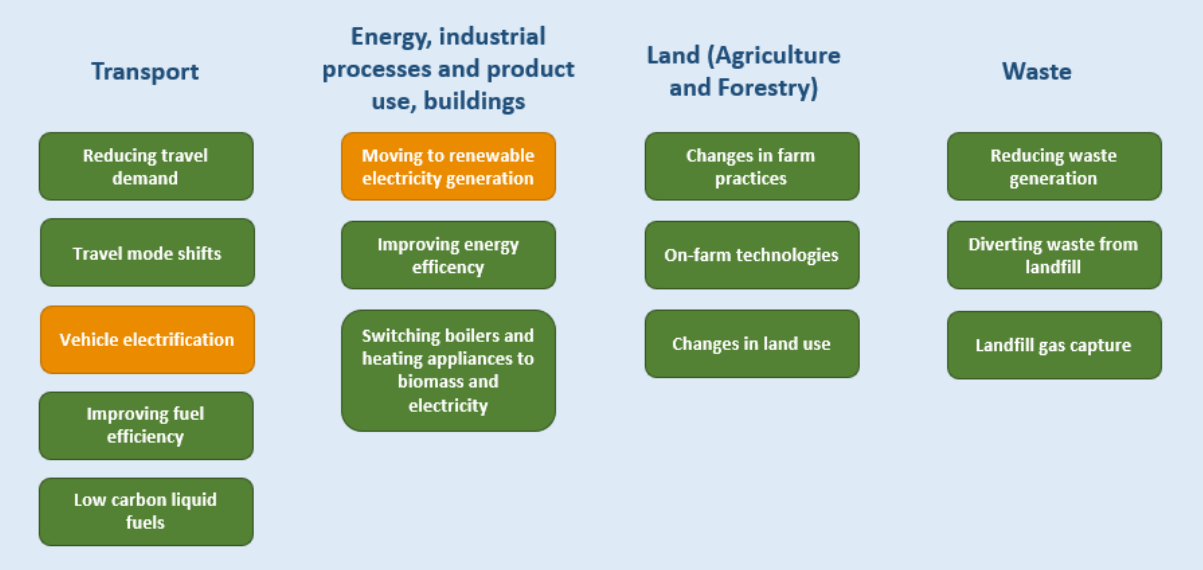
ENZ is a bottom-up, technology-rich model. It allows us to investigate, from a whole-of-system point of view, changes to emitting activities and technologies in each sector of the economy. It allows us to factor in anticipated technological developments or changes in behaviour or practice. ENZ produces economy-wide emissions estimates along with other data and insights such as energy costs.

ENZ models all the relevant sectors of the Aotearoa New Zealand economy – energy, industry, transport, agriculture, forestry, and product use and waste. It gives a detailed sense of feasible emissions reductions in each sector by factoring in specific technologies and emissions reduction opportunities.

The model accounts for key supply chain links between sectors, and resource constraints. For example, if ENZ projects the number of EVs to rise, it also calculates the increase in electricity demand and increases electricity generation accordingly. If ENZ projects a conversion of coal boilers to biomass, it calculates the forestry residues required to supply this.

ENZ deploys emissions reduction technology when it becomes economical to do so, considering various costs. The user can also specify when technology uptake occurs and the extent to which it is deployed to override this economic selection. **Figure 1** below indicates which of these methods was used for each of the key emissions reduction options in the model (information on data sources can be found in 'The data we have used' section later in this report).

__Figure 1:__ Key emissions reduction options represented in the ENZ model. Orange boxes mean that the model simulates their uptake in each year based on costs, available resources and other factors. Green boxes mean that we specify their uptake as an input assumption in each scenario we run.



Source: Commission analysis

Emissions values in ENZ

Emissions values are a proxy used in ENZ to represent the price on a tonne of CO_2e emitted. The emissions values in ENZ are an exogenous input assumption in all scenarios and should not be directly interpreted as emissions prices which would be observed in the New Zealand Emissions Trading Scheme (NZ ETS).

We have used emissions values to determine the speed of adoption for only some mitigations – the selection of electricity generation technologies and electric vehicle uptake. All other actions are selected based on scenario specific assumptions to determine uptake of actions.

We have opted to limit the use of the emissions values to predict the speed of adoption for most measures because:

- In some sectors, for example in process heat, there are constraints beyond the cost of decarbonisation such as supply chain issues and workforce constraints. As these are not modelled explicitly in ENZ we have specified decarbonisation pathways for these sectors externally to the model.
- For some mitigations non-economic factors could drive the adoption.
- Some mitigations provide wider societal co-benefits, which are not considered by the individual decision maker.

We are now using two sets of emissions values from government projections. The first set, from the Government's 2023 agency projections, is used in the demonstration path and all scenarios but for the reference scenario. This approach is therefore unchanged from our draft advice. These emissions values follow the mid-point of NZ ETS settings (cost containment reserve trigger price and reserve trigger price) published by the Ministry for Environment in the 2023 NZ ETS limits and price control settings for units' consultation document. The second set of emissions values that are used for the reference scenario is from the Government's baseline scenario in their interim July 2024 projections released as part of ERP2 consultation (referred to as Government's July 2024 interim emissions projections). These are substantially lower than the emissions values in the Government's official 2023 pathway. To maintain consistency with their projections, we have updated our reference scenario to use the 2024 emissions values.

Our approach to assessing impacts, presented in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*, is unchanged from our draft advice. Emissions values are not considered a cost for the economy as a whole as they represent a transfer between economic agents, so different emissions prices do not affect our overall cost-benefit assessment. However, we do assess how emissions values may affect the distribution of impacts between groups in the economy.

Limitations of ENZ

We have selected a modelling approach that balances the level of complexity with the required outputs and insights. As with any modelling, our approach has some limitations.

ENZ models emissions levels across all key emitting sectors of the economy, based on a set of input assumptions. This involves modelling a broad range of production activities and mitigations. Sectors are modelled in varying levels of detail depending on the level of information available, the complexity of the sector and the materiality of the sector's emissions. However, ENZ is not an optimisation model.

In practice, the uptake of mitigation measures or technologies can be influenced by a number of non-cost factors which ENZ does not have information on.

Further limitations are detailed in **Table 1** below.

Table 1: *Limitations in the ENZ model*

Limitation	Mitigation
The road transport stock module assumes an even distribution of retirement across the fleet. This means that in instances where road travel demand growth is low or negative, EV uptake is constrained, and the EV share is lower than in higher-demand growth scenarios.	To mitigate this effect, we added a dynamic stock turnover feature into ENZ.
ENZ is not a dedicated electricity market model and only models the electricity system at a high level.	We have procured detailed electricity market modelling to complement the results from ENZ (pg. 9). This provides some validation for the higher-level electricity modelling performed in ENZ.
ENZ does not have the functionality to project emissions from f-gases itself and requires assumed projections to be built in.	We rely on projections of f-gas emissions provided by the Ministry for the Environment (MfE), which are built into ENZ for all scenarios.

Further detail on our ENZ modelling is in the *ENZ model technical manual,* and can be found here: https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/Target-and-budgets-final-reports/ENZ-technical-manual-for-final-EB4-advice-191124.docx

Our approach to understanding economic impacts through C-PLAN

Overview of C-PLAN

C-PLAN is a Computable General Equilibrium (CGE). These are a class of models commonly used to help understand some of the economic effects of climate change mitigation.[1] They are also commonly used in other areas of economic policy, such as trade policy.

CGE models estimate the optimal allocation of resources like labour and capital within an economy, while meeting constraints. This allocation of resources determines how much each sector produces. If we make a change in the model that alters how resources are allocated, we can then see how the effects flow through to each sector.

To understand the implications of different emissions trajectories we impose a constraint on the level of emissions in the model. We can also change the technologies available in the model. The model will then find emissions values that allow it to meet this constraint, adjusting the mix of technologies used and the output of different sectors in order to meet the constraint.

C-PLAN is specifically designed to model the effects of technologies or actions intended to reduce greenhouse gas emissions in Aotearoa New Zealand. It includes pricing and quantities for emissions, the ability to switch between energy sources including away from fossil fuels to renewable sources, and a range of emissions-reducing technologies.

A full description of C-PLAN, as it was in 2022, is given in the article *The Climate PoLicy ANalysis (C-PLAN) Model, Version 1.0*[2,i]. For this advice, we have added several new emissions-reducing technologies to the model since the advice for the first three emissions budgets and also updated input data including the global trade data to GTAP 11. No fundamental changes to how the model works have been made. We have also strengthened the links with ENZ in places so that more of the inputs for C-PLAN come from ENZ.

Emissions values from C-PLAN

Emissions values are endogenous in the policy scenarios over the projection period in C-PLAN and play a larger role in C-PLAN than they do in ENZ as most choices are based on prices. Emissions values change the relative prices of inputs and outputs of production, and the relative price changes impact demand for goods and services. This affects how much of each good or service is produced, and the resources and technology used to produce that good or service. Where there are external constraints, like total biomass availability for process heat, it is still price driven but there is a constraint on how much can be used. There is no mechanism to drive uptake of non-economic mitigation technologies apart from (rarely applied) subsidies.

In the reference scenario[ii] in C-PLAN, emissions values are exogenously provided to the model, and (like ENZ) they are from the baseline scenario in the Government's July 2024 interim emissions projections released as part of ERP2 consultation. There are separate values specified for biogenic methane, all other greenhouse gases other than biogenic methane, and forestry emissions. The model then calculates emissions levels based on those values and the mitigations in the model. These mitigations include new technologies, fuel switching, and reducing the level of output from sectors.

In all scenarios and paths modelled, except for the reference scenario, the model solves for the emissions values needed to ensure the emissions constraints are met. Separate emissions constraints are input for biogenic methane and all other greenhouse gases other than biogenic methane. The level of carbon removals by forests are also input as an assumption.

As is the case with ENZ, the emissions values calculated by C-PLAN are not a projection of the NZ ETS price. These values should not be used as any indication of prices that the NZ ETS might require to meet the 2050 target. The emissions prices required to meet the target will depend on a number of choices, including the role of pricing and other policies to meet the target.

Moreover, as an economy wide model, the opportunities for emissions reductions in C-PLAN through technology uptake and systems change are a subset of the larger set of opportunities included in the ENZ model, to ensure

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[i] Niven Winchester and Dominic White, the authors of this paper, led the development of C-PLAN. This development was funded by the Commission.

[ii] See *Chapter 4: Developing the path to the fourth emissions budget*

C-PLAN remains tractable. This results in higher emissions values for the more ambitious emissions reductions modelled. For example, the emissions values for non-biogenic methane emissions in 2050 in the *C-PLAN results for EB4 advice* spreadsheet reach around \$600/tCO_2e in the demonstration path, and around \$3,000/tCO_2e in the HTHS scenario, with much of the price rise happening in the 2040s when ENZ has a number of mitigation options available that C-PLAN does not. In the absence of these post-2040 mitigation options being available in C-PLAN, the only way to achieve the emissions levels in a given scenario is to contract certain parts of the economy.

Limitations of C-PLAN

As with our approach for ENZ, we have selected a modelling approach that balances the level of complexity with the required outputs and insights. As with any modelling, our approach has some limitations.[iii] Like all models, C-PLAN is a simplified representation of a complex real-world system. It is one of several tools we use to aid our thinking and help us understand the implications of our proposals. It is not appropriate to consider the output as forecasts.

CGE models are designed to show how a change in one part of the economy has impacts on other parts of the economy through changes in costs, and supply and demand for goods and for resources. For example, if we place a price on emissions, some sectors like wind electricity will benefit because of greater demand for low-emissions energy (because high-emissions energy is now more expensive). This helps us to see the big-picture effect of our proposals on the economy as well as how things shift between sectors within the economy. When we understand how things shift, we can also use that to infer who will be most affected by changes.

C-PLAN provides a high-level representation of all sectors of the economy, and the interactions between them. It does not include the detailed representation of technologies and mitigations which are able to be included in ENZ.

C-PLAN is not an endogenous technological change model. As such, it does not include any induced innovation in response to prices. This means emissions values (and other prices) in C-PLAN will encourage the uptake of emissions-reducing technologies that are available in the model, but will not result in the invention and deployment of new technologies. New technologies can easily be expected in the future and allow a sector to reduce its emissions cost effectively, rather than reducing output to reduce emissions. Since the scenarios represent the economic outcomes of a given set of assumptions, it is reasonable to assume that the impact on GDP and emissions prices is likely to be upward biased.

Like many CGE models, the model assumes that businesses and households can adjust perfectly in response to the changes happening in the scenarios. In reality, financial, behavioural or technological constraints may mean that this is not possible.

The inputs to the model are based on the current structure of the economy (as given in the GTAP11 database). We cannot be sure that the parameters in the model will stay the same over time, especially if there are large changes in the economy and/or society.

C-PLAN does not consider the expected effects of the physical impacts of climate change (such as droughts, floods, forest fires, changing weather patterns) on economic output. Experience from recent extreme weather events suggests the impact of these events could be substantial. While recovery from these events could boost economic activity in the short term, it diverts resources from other productive uses if resources were already fully utilised.

[iii] To obtain a more complete picture on the economic impacts of reducing emissions, in addition to our modelling we also reviewed a wide range of relevant research, global and local, on the likely benefits and costs of climate action. We provide details on this approach in our main report, most notably in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

Additional modelling that supports our work

Alongside the modelling work undertaken by the Commission, we have procured additional modelling work. This additional modelling helps to address some of the limitations of our internal models as well as giving deeper insights into topics not covered in detail by our own models.

Detailed electricity market modelling

The purpose of this work was to inform the Commission's evidence base and recommendations regarding the construction of new generation assets, retirement of existing assets, and the role of thermal generation in the electricity system. This was done with a view to understanding the emissions consequences of these elements while also considering security of supply and affordability. Specifically, the purpose was to:

- complement and validate the basic electricity system modelling of ENZ with Energy Link's more detailed modelling suite (E-Market and I-Gen models)
- test the impact of varying hydro inflows on the wholesale price of electricity
- validate ENZ outputs such as the future generation stack and thermal operation

Methodology

The approach largely follows that of modelling undertaken with Energy Link to support and inform previous pieces of the Commission's advice, including, *Ināia tonu nei,*[3] *Advice on NZ ETS unit limits and price control settings for 2023-2027,*[4] and *Advice on the direction of policy for the Government's second emissions reduction plan.*[5]

Details of this approach include:

- Scenarios are modelled in ENZ and the electricity demand output from ENZ is used as an input for the Energy Link models.
- We also provide fuel prices, carbon prices, a pathway for distributed solar generation, and levelised costs of electricity as inputs for Energy Link's models. We work with Energy Link to determine some of these factors.
- The market structure is assumed not to change.
- E-Market and I-Gen are run iteratively until a suitable match between supply and demand is reached.[iv,6]

Results

High-level results are presented in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget* with details available in the accompanying spreadsheet: https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/Target-and-budgets-final-reports/Electricity-market-modelling-datasets-for-final-EB4-advice.xlsx

NZ process heat decarbonisation workforce modelling

We procured modelling to understand the workforce requirements for process heat decarbonisation. The decarbonisation of process heat is a critical part of reducing energy emissions. A key constraint and challenge

[iv] For every scenario a 'build' of new generation is established which balances growth in demand and changes in operation of existing generation using a simulation of how market participants decide to build new generation, with future price expectation and earnings as key decision variables. The build sequence is generally from lower cost project to higher cost project, although location on the grid and the generation output profile of different types of renewable generation also play a part. The timing of project development is iteratively refined to ensure that new generation meets its earnings targets. If projects are developed too early, then the market price becomes supressed, and the projects can fail to cover their costs.

faced is ensuring there are sufficient skilled workers who are able to deliver all aspects of the decarbonisation. DETA provided detailed modelling which considered the different kinds of workers needed to deliver decarbonisation projects. They estimated the likely size of the workforce needed and compared this to Ministry of Education data on the numbers of students graduating with the relevant qualifications, as well as immigration data. The results showed that some key skills are likely to be in short supply and concentrated efforts may be needed to lift the number of students studying in these areas.

The *NZ Process heat decarbonisation report* and *NZ Process heat decarbonisation workforce modelling* are published in full on our website and can be found here:

- NZ Process Heat Decarbonisation – Final report
- NZ Process Heat Decarbonisation – Workforce modelling

Updates to our internal models

In preparation for this advice, we made improvements to our modelling. These included adding new features and technologies and improved reporting and structural changes which improved model stability and ease of use. These changes are described in **Table 2** below.

Table 2: *New features added to our modelling since our 2022 NZ ETS advice*

Feature	Description
ENZ	
Improved aviation sector representation	We added a more detailed representation of aviation emissions. This included estimating capital and fuel costs associated with new technologies like battery and hydrogen aircraft. We also added low-carbon liquid fuel blending.
Incorporate vehicle feebate and standard policies	Allow for the inclusion of feebate and emissions standard policies into ENZ.
Added air pollution volume and cost to ENZ	ENZ now projects common air pollutants CO, NOx, and PM 2.5 and uses damage costs to calculate the social cost associated with each pollutant. Pollution volumes were based on fleet averages from Waka Kotahi's Vehicle Emissions Prediction Model (VEPM)[7] and published damage costs using the Health and Air Pollution in New Zealand methodology (HAPINZ 3.0)[8].
Dynamic stock turnover	The stock turnover approach was modified to allow for more vehicle turnover when there is a low or negative growth in vehicle travel. This allows for a better representation of fleet dynamics.
Process heat decarbonisation pathways	Allows non-price driven dynamics to be incorporated into process heat decarbonisation pathways.
Rooftop solar and grid scale batteries	ENZ now has functionality to project residential rooftop solar and grid-scale batteries as part of its electricity generation projections.
Biomass-fuelled electricity generation	We have added functionality to exogenously specify a transition from coal to biomass for the Rankine electricity generation units at Huntly power station.
Committed electricity generation projects	Our list of committed electricity generation projects in ENZ was updated in August 2024 based on publicly available information we could find at that time.

Urea production from hydrogen	ENZ now includes functionality to switch some, or all, urea production to being produced using green hydrogen.
Steel making	ENZ now includes functionality to project steel making produced with an electric arc furnace, green hydrogen, or a combination of the two.
Zero carbon anodes	We have added zero carbon anodes as a mitigation technology available for aluminium production.
Allowing for new industrial electricity demand	ENZ now has functionality to allow for additional electricity load from new green hydrogen or data centre industries.
Demand driven uptake of low carbon liquid fuels	Demand for low carbon liquid fuels can be specified in land, aviation, and marine sectors.
More detailed representation of domestic and international aviation	We added a basic stock model and more detailed representation of the aviation sector to allow better tracking of costs.
Improved approach to costs analysis	This focused on better representing the capital requirement to build electricity to meet demand from sectors like transport and industry. Previously in these sectors we treated electricity supply as a fuel cost amortised over the lifetime of the infrastructure.
Improved modelling of electricity and fossil gas distribution network costs	The transmission and distribution networks for both electricity and fossil gas are now modelled in greater detail. This allows for improved cost estimates.
Multiple emissions accounting approaches for international aviation and shipping	This feature allowed ENZ to support multiple measurement approaches for projecting emissions and fuel demand for international aviation and shipping sectors. Previously ENZ only supported bunker fuels.
Improved reporting	We have updated the way in which ENZ presents the outputs of each model run to be more user friendly for processing and displaying.
C-PLAN	
Technologies for iron and steel production	C-PLAN now includes functionality to project steel making produced with an electric arc furnace, green hydrogen, or a combination of the two. Like the methane-reducing technology for agriculture used in *Ināia tonu nei*, these technologies create the same product from different inputs, partially replacing production from the current method.
Green hydrogen for ammonia and urea production	Green hydrogen is introduced as an optional substitute for coal and gas in the production of ammonia and urea, which make up about 10% of the chemicals, rubber, and plastics industry in C-PLAN.

Zero carbon anodes for aluminium production	Zero carbon anodes were made available as a technology for reducing emissions from aluminium production in some scenarios. This works by providing emissions credits in the model for the reductions, rather than as a substitute method of production.
Changes to EV uptake	EV uptake is now managed using a constraint on uptake, based on ENZ results. Where appropriate, this allows a greater difference than the previous method between the uptake in the reference scenario and the uptake in other paths and scenarios.
N_2O inhibitor for dairy farming	An N_2O inhibitor was made available as a technology for reducing emissions from dairy farming in some scenarios. This works by providing emissions credits in the model for the reductions, allowing it to be used alongside the methane-reducing technologies and other emissions-reducing technologies in agriculture. Due to the high price of the inhibitor, it is not usually taken up by the model.
Improved genetics for livestock	Improved genetics for sheep and beef cattle are included implicitly in the data from ENZ that is used for the reference scenario. Improved genetics for dairy cattle are included as a technology for reducing emissions from dairy farming in some scenarios. Like the N_2O inhibitor, this works by providing emissions credits in the model for the reductions, allowing it to be used alongside the methane-reducing technologies and other emissions-reducing technologies in agriculture.
Closer links to ENZ results	C-PLAN, as used for this work, has closer links to ENZ results for both the reference scenarios and the general scenario and demonstration paths. This includes aligning agricultural productivity and the demand for road transport with the appropriate ENZ values.
Greater use of GHG Inventory data	For this advice, C-PLAN uses much more of the detailed data in New Zealand's Greenhouse Gas Inventory (GHG Inventory) than it did for *Ināia tonu nei* (which relied more on GTAP data for NZ emissions).

Review of our models

Our modelling builds on the Commission's previous analysis. Our models have been developed by internationally renowned experts with a comprehensive understanding of the context and sectors that are represented. As part of developing our advice for *Ināia tonu nei*, experts from Aotearoa New Zealand and around the world also reviewed these models. Our economic models are robust and fit for purpose. Expert reviewers said that they were "impressed by both the scope and detail of the modelling efforts and believe that these provide a robust quantitative framework to support ambitious climate policy proposals for Aotearoa."[v]

For the current advice, we engaged further expertise to support us in model development and to review the changes to the models. Our models were also open for review by stakeholders and the public during the consultation period earlier in 2024.

Concept Consulting

We engaged Concept Consulting to improve and develop the ENZ model in preparation for our draft advice, and again to help with functionality improvements to allow us to take on board feedback received during consultation. For each of the features added to ENZ listed in **Table 2** above, a review process was undertaken

[v] The reviews are available on the Commission's website https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/modelling/

by the Commission's staff and/or experts from Concept Consulting. For key areas like modelling the electricity sector, we engaged additional external expertise to cross check results coming out of ENZ.

Emission Impossible

Emission Impossible Ltd was commissioned to review the analysis of the impacts of air pollution from road transport within ENZ. Emission Impossible is an expert consultancy focusing on air pollution. The team includes co-authors of the Health and Air Pollution in New Zealand study (HAPINZ 3.0), a key piece of evidence about the impacts of air pollution in Aotearoa New Zealand.[9,vi]

They found that our analysis was in line with published methodologies and the results were comparable when adjusted for inflation with other Aotearoa New Zealand studies. Overall, the review found that our analysis of costs was appropriate and robust.

Professor Niven Winchester

To support the development of this advice, we engaged Professor Niven Winchester, the original developer of the C-PLAN model, to update the model to account for new technologies, including many of those listed in **Table 2.** A small number of additional features added by Commission staff were reviewed by Professor Winchester, who also reviewed our overall approach to using C-PLAN for this advice.

The data we have used

Greenhouse gas inventory

New Zealand's Greenhouse Gas Inventory (GHG Inventory) is the official annual report of all anthropogenic (human induced) emissions and removals of greenhouse gases in Aotearoa New Zealand. It is produced annually by the Ministry for the Environment (MfE). For this final advice, we used the 2024 edition of the GHG Inventory, released 18 April 2024, which contains data from 1990 to 2022.

Every year, methodological improvements are made to the way emissions are estimated. These changes follow the Intergovernmental Panel on Climate Change's guidelines for the preparation and continuous improvement of national greenhouse gas inventories. The changes are reviewed by an international team of experts certified by the United Nations Framework Convention on Climate Change. A consequence of methodological changes is that historical data in the GHG Inventory can change from year to year as improvements are made, which can in turn result in changes to the projections of future emissions levels.

Government projections

Every year, the Government produces emissions projections to 2050 based on the latest GHG Inventory data. These projections generally include a 'with existing measures' (WEM) scenario, which accounts for the impact of policies implemented or adopted by the Government. It may also incorporate preliminary estimates of the emissions impact of policies the government intends to implement.

As discussed in Box 4.1 of *Chapter 4: Developing the path to the fourth emissions budget,* government agency projections for 2024 were not available for all sectors by the cutoff date for our analysis of 23 August 2024. We have therefore drawn on two sets of projections, which constituted the latest available information from government agencies by that cutoff date.

[vi] A key finding of this study is that air pollution, from anthropogenic/human sources, is responsible for an estimated 3,300 premature deaths per year in Aotearoa New Zealand, with a social cost estimated at $15.6 billion per year.

This includes 2024 government agency projections for energy, transport, and fluorinated gases, which were used as inputs for analysis in the Government's second emissions reduction plan expected to be released before 31 December 2024. Hereafter, these are referred to as 2024 government agency projections.

2024 government agency projections were not available by 23 August 2024 for the agriculture, forestry, and waste sectors. For these sectors, we have used the Government's July 2024 interim emissions projections, published in the Government's draft second emissions reduction plan released for consultation between 17 July and 25 August 2024.

Our use of government projections in developing our reference scenario is described in further detail on a sectoral basis in the 'Reference scenario alignment' section later in this document.

GTAP database

The GTAP database[vii] is prepared by the Global Trade Analysis Project at Purdue University in the United States. It has input-output tables that show what each sector makes and sells, and extra data such as emissions by sector and trade data for 65 sectors and 141 countries/aggregate regions, all carefully balanced to meet accounting identities.

C-PLAN uses an aggregated version of GTAP to provide the structure of the economy in Aotearoa New Zealand and in the rest of the world, as well as trade data and emissions from the rest of the world. As it is such an important data source for C-PLAN, the latest available year of GTAP data sets the starting year for C-PLAN.

In *Ināia tonu nei* and in the draft advice on the fourth emissions budget that went to consultation, C-PLAN used the GTAP10 database for 2014. For our final advice on the fourth emissions budget, we have upgraded to the GTAP11 database (the latest available) for 2017 and changed the base year accordingly. In changing the base year, we also needed to change the year we took emissions data from the GHG Inventory for Aotearoa New Zealand, and the relative global price of oil in the model.

Other key data sources

In addition to the GHG Inventory and the government projections data, we have used external data from a range of sources. These data are used to better model the underlying drivers of emissions and/or provide the economic inputs needed for the Commission's models.

The key external data sources used are listed in **Table 3**.

Table 3: *Key external data sources*

Source	Description
2022 fleet statistics (Ministry of Transport)	Historical data (up to 2022) on all road vehicles, vehicle age, travel by vehicle and fuel type. Used to update base year fleet information across the ENZ transport model, including the number of vehicles entering and exiting, proportion of new and used vehicles and age profile of the fleet. We also included data to August 2024 on vehicle entry from the motor vehicle register.
Vehicle fleet emission model 2024 update (VFEM) **(Ministry of Transport)**	This provides further detail on vehicle travel and fuel economy https://www.transport.govt.nz/statistics-and-insights/fleet-statisticshttps://www.transport.govt.nz/statistics-and-insights/fleet-statistics

[vii] https://www.gtap.agecon.purdue.edu/databases/v10/index.aspx

Oil price	Oil prices to 2030 were taken from the International Energy Agency (IEA) and then held constant from 2030 to 2050 https://www.iea.org/reports/oil-2024#overviewhttps://www.iea.org/reports/oil-2024#overview
GDP	GDP forecasts are taken from Treasury's Budget Economic and Fiscal Update 2024 https://www.treasury.govt.nz/publications/budgets/forecasts
Electricity and other energy data	Historical electricity generation and energy use data from the Ministry of Business, Innovation and Employment. We also use the Energy Efficiency and Conservation Authority's Energy End-Use Database which contains historical energy use by fuel type linked to the end use of the fuels. https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/ https://www.eeca.govt.nz/insights/data-tools/energy-end-use-database/
Ministry for the Environment f-gas projections	ENZ does not have any functionality to model HFC stocks and emissions directly. Instead, we have relied on projection estimates supplied by MfE.
Forestry costs	We commissioned Scion to provide an analysis of cost estimates for establishment, tending, harvesting, and log transport.[10]
OECD and IEA	For C-PLAN, global GDP projections and global electricity projections by generation type come from the OECD and the IEA respectively. Global emissions prices are derived from the IEA's *Global Energy and Climate Model Documentation Announced Pledges Scenario.* Refer to the assumptions spreadsheets published as part of the supporting material for this work for more information.

Assessment of emissions reduction and removal opportunities

A requirement in the Act is to consider how emissions budgets may realistically be met. There is a vast amount of evidence available from within Aotearoa New Zealand and internationally that has underpinned our analysis.

The Commission's approach to developing this advice is based on tested methodology, building on the approach and process developed when the Commission advised on the first three emissions budgets in 2021.

Our approach, as an independent Crown entity, is founded on research, evidence, and modelling, and draws on the expertise of our Board of Commissioners, He Pou Herenga (a Māori advisory body to the Board), and staff.

In preparing this advice on the fourth emissions budget, we have examined the latest publicly available data on the country's emissions profile (the 2024 edition of the GHG Inventory) and the scientific evidence about options for reducing emissions. This final advice is updated to reflect new data and information available since we published the draft advice, and feedback from consultation.

We are informed by evidence and insights gathered by engaging with people on the ground, including through consultation on the draft advice, and the earlier call for evidence. This is built into our modelling approach and informs the shaping of our advice.

Where we identified significant gaps in the required evidence, we engaged external expertise to assist in developing an evidence base. The key externally supplied evidence is discussed below.

Report on agricultural greenhouse gas mitigation technologies

We are aware of a number of methane-reducing technologies that could become commercially viable before the start of the fourth emissions budget period. Given their high potential for emissions reductions, and uncertainties on their availability (including timelines and costs), we sought an up-to-date independent assessment on these technologies. In particular, we wanted to understand what these technologies are and to further understand their:

- timeline to implementation
- barriers to use in Aotearoa New Zealand
- potential costs associated with the technologies
- potential adoption rates
- potential efficacy.

We commissioned The Agribusiness Group to undertake this analysis. The report informed our assumptions for agricultural technologies in our modelling. These technologies are described in greater detail in *Chapter 3: Recommended level for the fourth emissions budget* and *Chapter 5: Sector contributions to meeting the fourth emissions budget*. The *Report on agricultural greenhouse gas mitigation technologies* by The Agribusiness Group is published in full on our website and can be found here: https://www.climatecommission.govt.nz/public/Uploads/EB4/supporting-docs/Report-on-agricultural-mitigation-technologies-Final.pdf

New Zealand process heat decarbonisation report

One of the areas identified for further investigation was to explore process heat decarbonisation in greater depth. In particular, we wanted to understand the capability of Aotearoa New Zealand to deliver process heat decarbonisation projects the time frame in which decarbonisation could be completed. We commissioned DETA to undertake this analysis. Their analysis estimated the amount of effort required to complete decarbonisation, considering constraints including supply chains, electricity supply, and workforce.

This report helped inform our assumptions on the phase-out of fossil fuels in process heat. The report on *NZ process heat decarbonisation* and *NZ process heat decarbonisation workforce modelling* is published in full on our website and can be found here:

- NZ Process Heat Decarbonisation – Final report
- NZ Process Heat Decarbonisation – Workforce modelling

Reference scenario alignment

Our advice on the fourth emissions budget presents a reference scenario alongside our four scenarios to 2050 and the EB4 demonstration path (detailed in *Chapter 4: Developing the path to the fourth emissions budget*). This reference scenario is designed to represent what projected emissions would look like if there were no further emissions reduction policies or measures implemented, other than those already in place, or which the government intends to enact (where estimates of impact on emissions are available). In our analysis, the reference scenario provides a counterfactual for examining impacts associated with the recommended level of emissions reductions.

As outlined in the 'Government projections' section above, we have developed our reference scenario based on the latest available information provided to the Commission by government agencies under embargo as of 23 August 2024. This includes using data from the 2024 government agency projections and the baseline scenario in the Government's July 2024 interim emissions projections. What data set has been used for each sector and how it aligns is discussed in more detail in the below sections.

The emissions projections from our reference scenario for different sectors broadly align with the relevant comparator from the two data sets listed above. It is not necessary to achieve complete alignment with the government projections for the intended use of the reference scenario, which is to be a counterfactual for examining the impacts of the emissions reductions across various scenarios. Our analysis of mitigation potential in each sector is not defined relative to the reference scenario but instead includes economically and technically feasible actions that can deliver emissions reductions under different scenarios.

There may also be differences between the Government's projections that are released through the publication of the final second emissions reduction plan in December 2024 and the reference scenario we used for the analysis to inform this advice. We do not expect the differences between government projections and the reference scenario used to inform this advice will be large enough to change our assessment of the overall impacts of the recommended budget.

Transport sector alignment approach

Activity and emissions for road transport in the reference scenario are based on the 2024 government agency projections provided by the Ministry of Transport (MoT). The modelling provided included three scenarios for EV uptake: base, fast, and slow. We based our reference scenario on the MoT base EV uptake scenario.

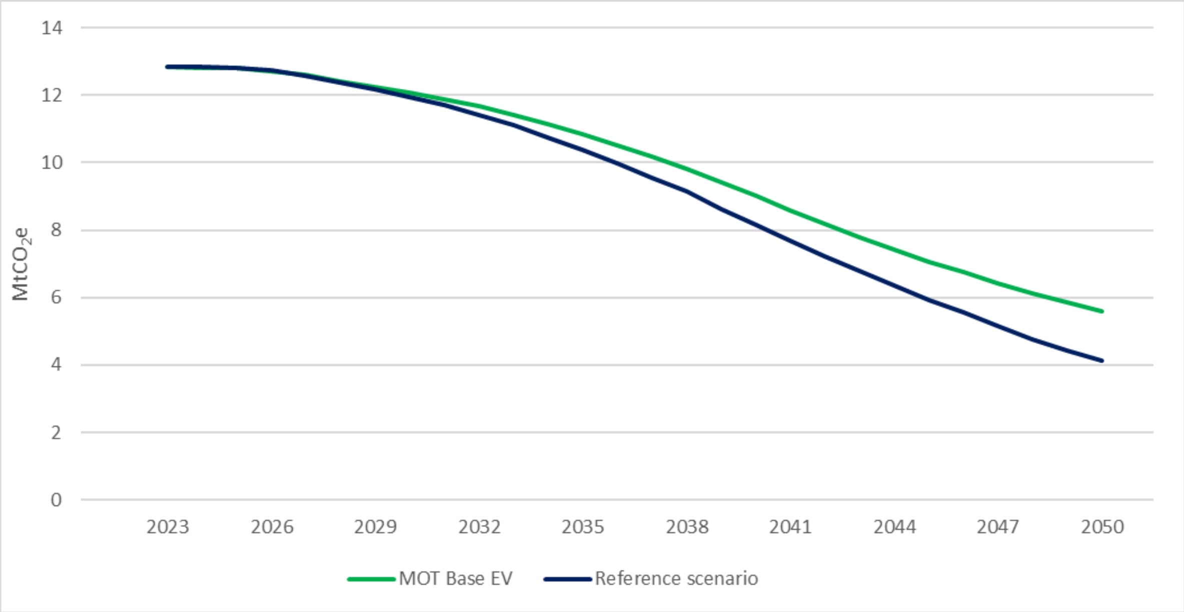
The ENZ model was calibrated against the 2024 government agency projections to achieve closer alignment between the reference and the base scenarios. Calibration involved adjusting a range of assumptions to align the two models as closely as possible.

Data from the 2024 government agency projections provided by MoT were also used for aviation. The projections included three scenarios: central, high, and low, and included baseline activity demand as well as emissions projections for the years 1990 to 2050. We aligned aviation energy demand in the reference scenario as closely as possible to the central scenario.

For the rail and marine sectors, our reference scenario is calibrated to historical oil consumption data reported alongside the 2024 Energy in New Zealand publication.[11] Projections beyond 2023, which is the most recent year for which actual consumption data was available, are based on our assumptions about sub-sector activity, efficiency, and technology adoption. In ENZ, activity demand projections were combined with efficiency, technology adoption, and fuel-switching assumptions to project future demand in non-road sectors.

Road transport emissions projections in the 2024 MoT base EV uptake scenario and reference scenario are closely aligned until 2030. After 2030, different vehicle stock modelling, including vehicle turnover, vehicle travel by age, and uptake rate of non-EV fuel types leads to deviating emissions. The cumulative result in the reference scenario is 1.4 $MtCO_2e$ fewer emissions in 2050 than the 2024 MoT base EV uptake scenario.

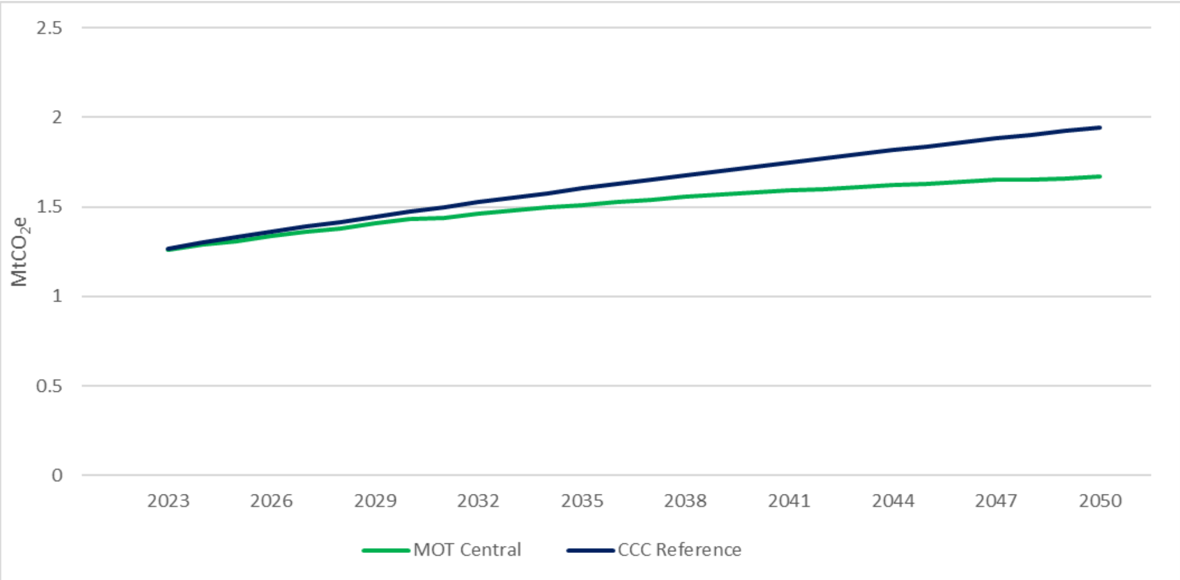
Figure 2: *Road transport emissions compared with the Ministry of Transport 2024 base EV uptake scenario*



Source: Commission analysis

Domestic aviation projections deviate gradually throughout the projection period. Emissions in the reference scenario are higher than the 2024 MoT central scenario by 0.14 $MtCO_2e$ in 2040 and 0.28 $MtCO_2e$ in 2050; the key driver for this difference is efficiency improvement assumptions. MoT's projections assume a constant rate of efficiency improvement. In contrast, in ENZ, overall efficiency is divided into three components (new aircraft, existing aircraft, and operational improvement) linked through a simplified stock turnover model.

Figure 3: *Aviation emissions compared with the Ministry of Transport 2024 central scenario*



Source: Commission analysis

Overall, when the road and aviation sectors are aggregated, the difference between the reference scenario and the 2024 government agency projections provided by MoT is reduced. The two projections deviate by 7% (0.7 $MtCO_2e$) in 2040 and 16% in 2050 (1.4 $MtCO_2e$).

Agriculture, forestry, and waste

The reference scenario for agriculture, forestry, and waste aligns closely with the Government's July 2024 interim emissions projections. For agriculture, the reference scenario uses underlying activity data from the Ministry for Primary Industries (MPI), a subset of the Government's July 2024 interim emissions projections. This data includes information on productivity, emissions intensity, stock numbers, and land-use areas, and enables us to replicate historical and projected emissions from those government projections.

For forestry, historical data from the 2024 edition of the GHG Inventory and MPI projections for afforestation and deforestation, a subset of the Government's July 2024 interim emissions projections, are inputs for the reference scenario. ENZ models subsequent growth and sequestration using this input data, which ensures close alignment with projected emissions from the ERP2 consultation modelling.

For waste, we use projections for different waste types and volumes from the Government's July 2024 interim emissions projections. These projections are then fed into ENZ to determine decomposition, levels of methane, and gas capture rates.

Industry, energy, and buildings alignment approach

Except for f-gases, we do not directly use government projections to formulate our reference scenario for the sectors within the energy, industry, and buildings areas. Instead, we take some information from government projections to help inform us in specifying settings in the model, where that information exists, and in other cases, we use our judgement to specify assumptions that aim to reflect current policy to the best of our ability.

For example, the government has explicitly stated that, where aluminium production was modelled as ending in 2024 in its 2023 projections, it is now assumed to continue, in both sets of 2024 projections. This matches with what we assume in ENZ. In contrast, for fuel switching assumptions, for example, we do not necessarily have sufficient information to replicate the 2024 government agency projections in ENZ. In this case, we have specified model settings so as to achieve outcomes reflective of our best estimate of the likely effect of current policy.

In addition to the assumption on aluminium production noted above, other key assumptions for the reference scenario include:

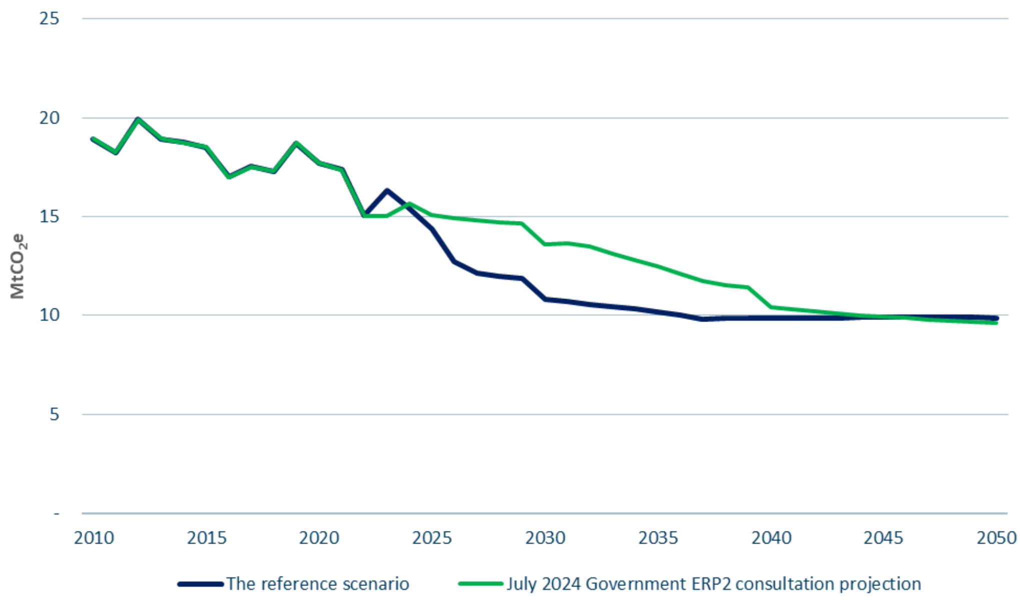
- Steel production – in the reference scenario we assume a 50% reduction in emissions from steel production from 2027. This is based on the deal announced between the Government and NZ Steel to install an electric arc furnace at the Glenbrook Steel Mill. This aligns with the Government's July 2024 interim emissions projections.
- Coal for low-medium temperature process heat (including in the residential and commercial buildings sectors) is phased out by 2037 in accordance with the national policy statement.
- Methanol production is assumed to undergo a staged exit with one train closing by 2026 and the second train closing by 2030. This is broadly aligned with the 2024 government agency projections, in which methanol production undergoes a gradual phaseout during this period.
- For f-gases, we have directly used projections provided by MfE as part of the 2024 government agency projections, as ENZ does not have the functionality to model these.

Non-transport energy and IPPU emissions in the reference scenario

In the reference scenario, key drivers of reductions are process heat decarbonisation measures (i.e., fuel switching from coal), efficiency improvements, and the substitution of fossil-fuelled baseload generation with new renewables in the electricity sector.

Figure 4 below shows non-transport energy emissions in the reference scenario and in the Government's July 2024 interim emissions projections, the most recent, complete publicly available comparator.

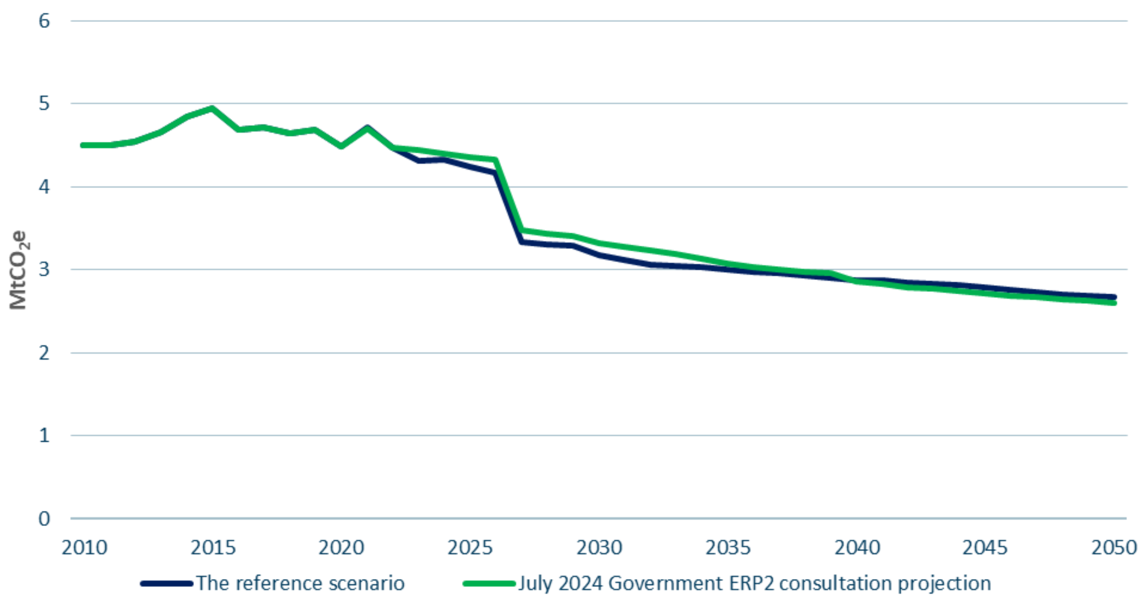
Figure 4: Non-transport energy emissions under the reference scenario and the Government's July 2024 interim emissions projections



Source: Commission analysis

The government projections are higher than the reference scenario. A key difference is higher electricity generation emissions in the Government's July 2024 interim emissions projections due to more coal and gas-fired generation in those projections compared to our reference scenario. **Figure 5** shows the same comparison but for industrial process and product use emissions.

Figure 5: *IPPU emissions in the reference scenario and the Government's interim July 2024 ERP2 consultation projections*



Source: Commission analysis

Figure 5 shows close alignment between the reference scenario and Government's July 2024 interim emissions projections. The electric arc furnace is one of the key drivers of IPPU emissions reductions in the reference scenario, accounting for the large decrease in emissions in 2027. The steady decline from 2027 onwards is largely due to a gradual decline in HFC emissions, which, in our reference scenario, follow projections provided by the Ministry for the Environment as part of the 2024 government agency projections.

Macroeconomic modelling of scenarios in C-PLAN

This section discusses the macroeconomic modelling of our reference scenario, our four scenarios to 2050 and the EB4 demonstration path in C-PLAN.

Our four scenarios to 2050 are named Low technology and low systems change (LTLS), High technology and low systems change (HTLS), Low technology and high systems change (LTHS), and High technology and high systems change (HTHS).

More information on the definitions of our modelled scenarios and pathways can be found in *Chapter 4: Developing the path to the fourth emissions budget*.

The macroeconomic impacts are estimated with the C-PLAN model. In both the reference scenario and in our scenarios, as many as possible of the inputs are outputs from ENZ or are the same as inputs to ENZ. However, there are key differences between the two models; not all mitigation options in ENZ are included in C-PLAN, and C-PLAN takes account of interactions within the economy that ENZ does not.

Reference scenario

In C-PLAN, the reference scenario is used to calibrate some of the parameters in the model. **Table 4** below sets out the data used for this exercise.

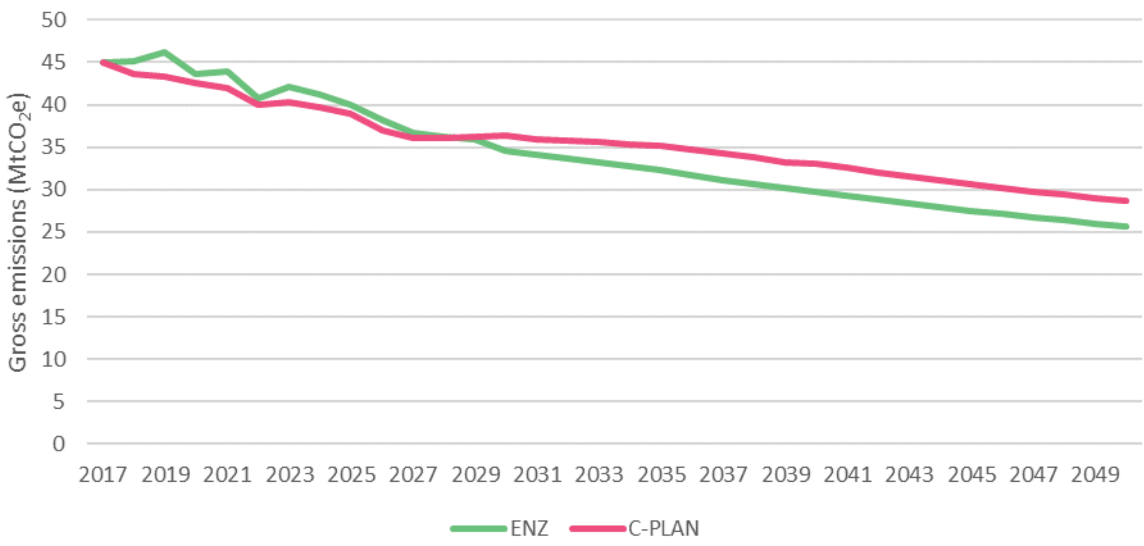
Table 4: *Selected data used in the reference scenario for calibrating C-PLAN*

	New Zealand	Rest of world
GDP	ENZ/WEM (with smoothing for COVID-related fluctuations)	OECD
Labour force growth	Estimated from ENZ population	Calculated in model
Electricity generation	ENZ	IEA
2014 emissions data	New Zealand's Greenhouse Gas Inventory, supplemented with GTAP and other data	GTAP11
Land use	ENZ	Calculated in model
Agricultural productivity	ENZ	Calculated in model
Removals	ENZ	N/A
Waste emissions	ENZ	Calculated in model
Proportion EVs	ENZ	Calculated in model
Land transport output	Calibrated to match ENZ results	Calculated in model
Emissions prices	ENZ/WEM	OECD
Global oil price	NA	ENZ

There are some differences between the emissions from C-PLAN in the reference scenario and ENZ, as shown in **Figures 6** to **8** below. For greenhouse gases other than biogenic methane (both gross and net), the emissions values in C-PLAN are not high enough to incentivise the use of biomass for process heat, whereas in ENZ biomass uptake for process heat is a result of regulation mandating the phase-out of coal boilers in low to medium temperature applications. For biogenic methane, C-PLAN has simpler assumptions than ENZ about how emissions change when other aspects of agriculture change, such as land area used.

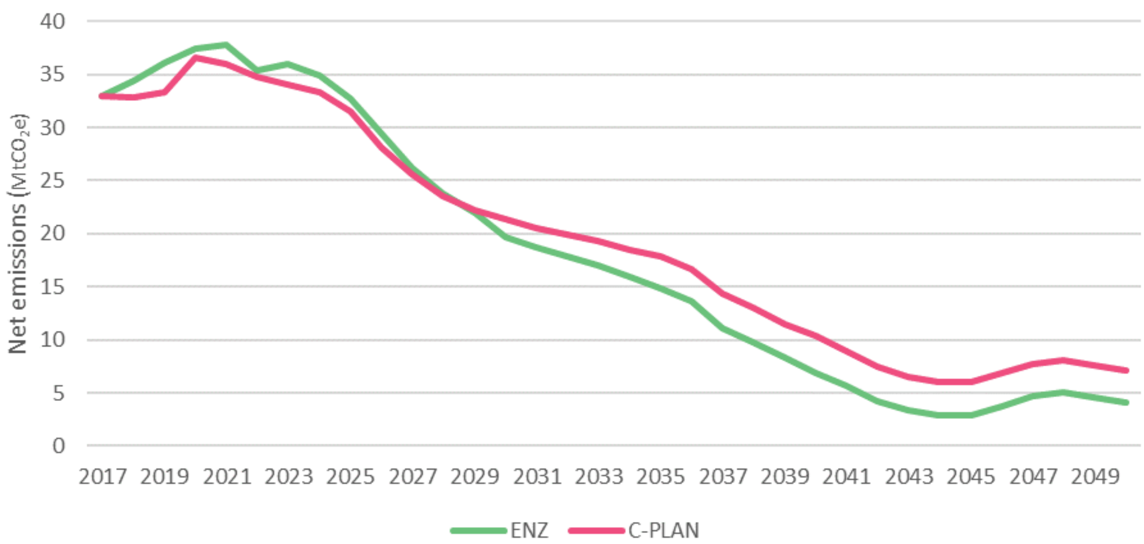
Note that GDP inputs and emissions removals from forestry are the same as those in ENZ because they are inputs to the model for the reference scenario.

Figure 6: *Gross emissions of greenhouse gases other than biogenic methane under the reference scenario in ENZ compared to C-PLAN*



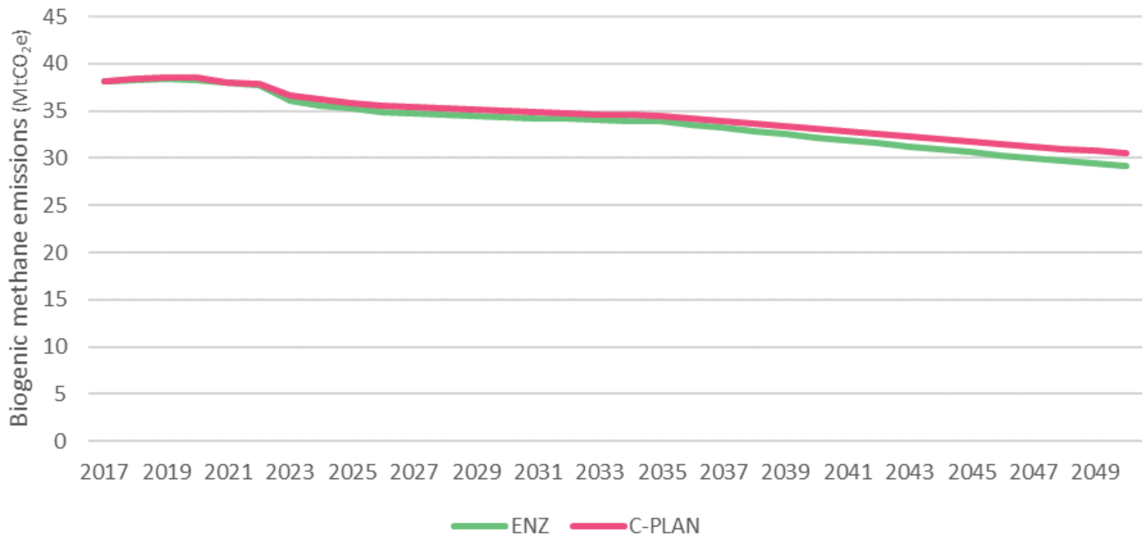
Source: Commission analysis

Figure 7: *Net emissions of greenhouse gases other than biogenic methane under the reference scenario in ENZ compared to C-PLAN*



Source: Commission analysis

Figure 8: *Biogenic methane emissions under the reference scenario in ENZ compared to C-PLAN*



Source: Commission analysis

Our scenarios

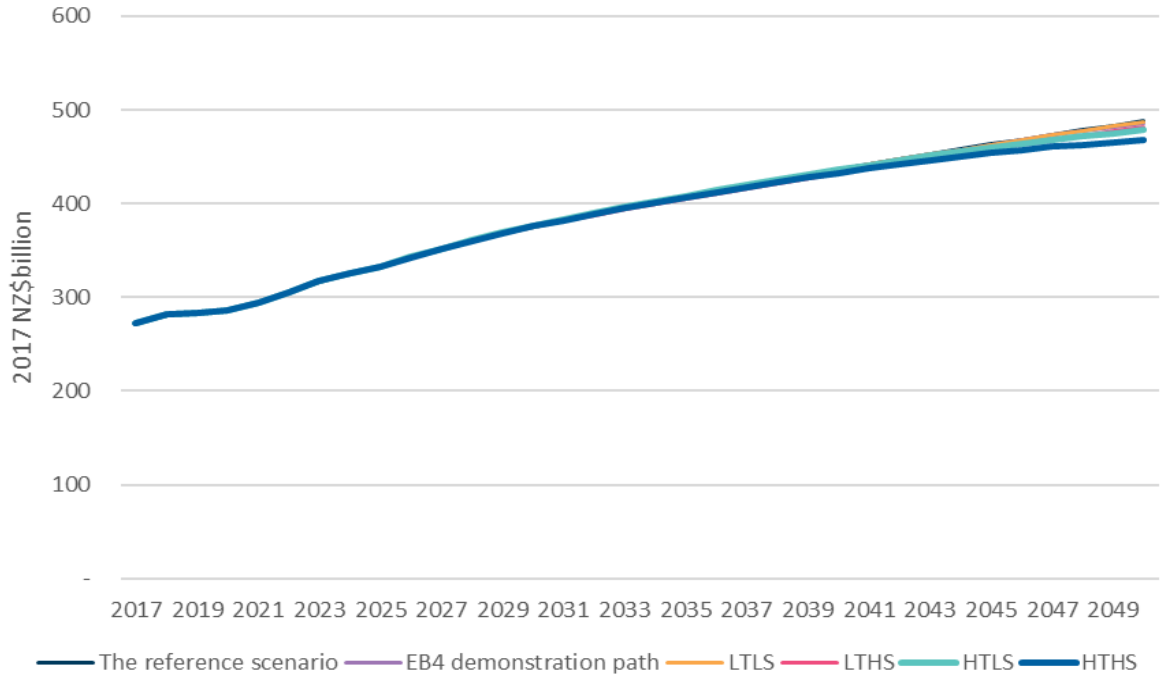
Some of the settings for our scenarios in C-PLAN come directly from ENZ results. These include emissions constraints for greenhouse gases other than biogenic methane, biogenic methane, removals, land use, agricultural productivity, the proportion of EVs, and biomass available for process heat applications. The following table details the scenario settings used in C-PLAN.

Table 5: *Scenario settings used in C-PLAN*

	Settings
From ENZ	emissions constraints for greenhouse gases other than biogenic methane and biogenic methane, removals, land use, agricultural productivity, proportion of EVs, and biomass available for process heat applications
Same as in reference scenario	Labour force growth, 2014 emissions, Rest of World emissions prices, sector constraints
Calculated in model	GDP, electricity, waste emissions, land transport output, NZ emissions prices (from 2022), global oil prices
Additional technologies (turned on if also used in ENZ)	Methane-reducing technologies for agriculture (vaccine, inhibitor), EAF and green hydrogen for steel-making, green hydrogen for ammonia/urea, zero carbon anodes for aluminium, N_2O inhibitor for dairy farming, improved genetics for sheep and cattle, CCS for geothermal electricity, biomass and electrification for process heat (excluding for non-metallic minerals, e.g. cement)

As shown in **Figure 9** below, in all scenarios GDP continues to grow in all years and is around 50% (or more) higher in 2050 than in 2022. The results show the impacts on GDP are relatively small until the 2040s, after which impacts increase significantly. This is caused by the model having to increase emissions values to meet the emissions reduction constraint as there is no further modelled abatement options available and therefore emissions reductions can only be achieved by reducing production. These results are an artifact of C-PLAN not including the full range of mitigations that are available in ENZ, albeit by design. As a macroeconomic model, including the level of sector and technological detail from ENZ into C-PLAN would make C-PLAN too complex and computationally unwieldy. In practice, we expect that higher emissions prices would encourage further development of new technologies which are not currently included in C-PLAN, which would reduce the expected impacts on output for any given emissions cap.

Figure 9: *GDP under the four scenarios, the EB4 demonstration path, and the reference scenario*



Source: Commission analysis

In C-PLAN, GDP impacts are determined by how tight the emissions constraint is. The emissions constraint is tighter if fewer emissions are allowed compared to the reference scenario, or if there are insufficient technologies or other mitigations to reduce emissions (which then results in sectors reducing production). If technologies in the model are not changed, each megatonne by which the emissions constraint is tightened will have a larger impact on GDP than the previous megatonne did.

Emissions resulting from international shipping and aviation

Estimating shipping emissions using our recommended approach

As part of our advice on international shipping and aviation, we recommend a different approach to quantifying emissions from aviation compared to the approach for shipping, discussed in *Chapter 7: How international shipping and aviation emissions could be included* in our report: *Review of the 2050 emissions target including whether emissions from international shipping and aviation should be included*. This section provides additional detail on our estimate of shipping emissions.

We recommended the government use an approach that accounts for 50% of the emissions to/from the next overseas port by all international operators and 100% of their emissions travelling between ports in Aotearoa New Zealand and while docked (50% of to/from next port).

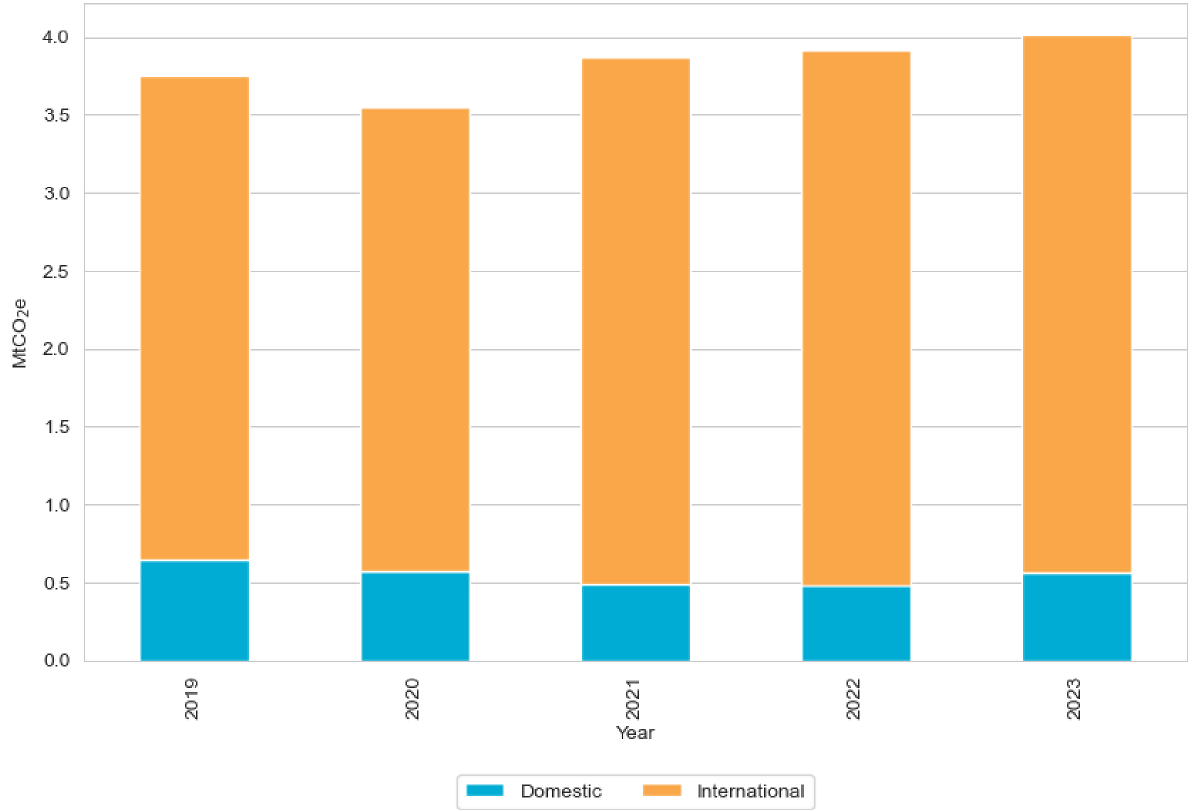
To support this recommendation, we estimate those emissions of 50% of to/from next port. This estimate was developed using datasets from Customs New Zealand about vessels entering and leaving New Zealand, the average weight by vessel type from the Ministry of Transport and average emissions values by vessel type and weight from the International Maritime Organization.

The Customs dataset provided information on the last port of departure and arrival for vessels travelling to or from international ports and between domestic ports. Using the location of each port and SeaRoute, a tool for estimating the likely sea route between two ports, we were able to estimate the emissions for commercial vessels travelling to and from New Zealand.

The results of the 50% of to/from next port emissions for shipping for 2019 – 2023, over the 5 years estimated emissions were between 3.5 MtCO2e and 4 MtCO2e, with the lowest value occurring in 2020, and the highest occurring in 2023. The share of emissions from international vessels travelling between domestic ports was typically around 0.5 MtCO2e or a little above 12%, as illustrated by the blue area of the columns in **Figure 10**.

With further refinement and validation, this method could be used as the basis for a government calculation of shipping emissions. However, measuring based on reporting from vessels that visit New Zealand may obtain more accurate results.

Figure 10: *Emissions from international shipping using the 50% of to/from next port approach*



Source: Commission analysis

Scenario modelling for aviation and shipping

To support our review on whether emissions from international shipping and aviation should be included in the 2050 target, and if so how, we modelled emissions based on our proposed measures of bunker fuels for aviation and 50% of to/from last port for shipping. There is further discussion of the scenarios in Chapter 7 in our report: *Review of the 2050 emissions target including whether emissions from international shipping and aviation should be included*.

The projected emissions in these scenarios do not include the emissions involved in the production of low-carbon liquid fuels. Under current accounting practices, these would be accounted for within other sectors if produced domestically.

This section provides further details of the scenario results for both shipping and aviation.

Scenario results

In our reference scenario, emissions from international aviation bunkering will grow by 43%, going from pre-COVID-19 levels of 3.9 Mt CO_2e in 2019 to 5.6 Mt CO_2e in 2050 (**Figure 11**). This reflects growth in underlying demand for travel from New Zealand, with passenger kilometres (PKM) increasing from 51 billion in 2019 to 121 PKM in 2050. This is an increase in PKM of 136%. Reference scenario demand was based on the central projection in modelling carried out by the Ministry of Transport.

In the reference scenario, shipping emissions grow slowly from 3.9 Mt CO_2e in 2022 to 4.1 Mt CO_2e in 2050. The underlying demand for international marine transport grows 50% by 2050 in the reference scenario, offset by 1% per annum annual efficiency improvements. Demand for international transport was based on growth in international trade from the C-PLAN model.

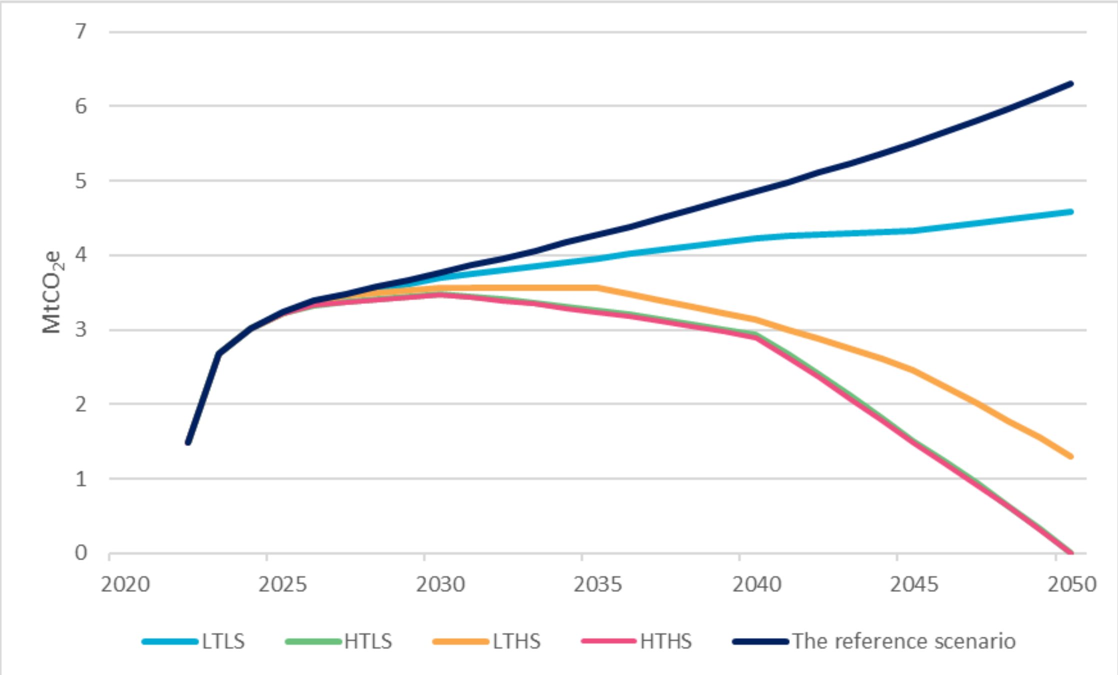
By 2050, emissions from aviation are reduced by between 27% in the LTLS scenario and 100% in the HTLS and HTHS scenarios. These reductions are achieved through a combination of enhanced efficiency measures, demand reduction, and the use of low-carbon liquid fuels.

In the LTHS scenario, a 20% reduction in demand for international aviation fuels is assumed based on the IEA net zero pathway.[12] HTHS demand reduction is due to the elasticity of demand in response to fuel prices. An elasticity of 0.69[13] was used and it was assumed that 30% of the cost of the ticket price relates to fuel. The result was a reduction of 7% in demand compared with the reference scenario by 2050.

Low carbon liquid fuels are used in all scenarios except the reference. We assume that:

- In both high technology scenarios, alternative fuel uptake is 100%, in line with high ambition scenarios in global models.
- In a low technology, low systems change scenario alternative fuel uptake is 22%.
- In a low technology, high systems change scenario alternative fuel uptake is 70%, in line with medium ambition scenarios in global models which is assumed to occur due to consumer behaviour change.

Figure 11: *Emissions from international aviation bunker emissions in reference and LTLS, LTHS, HTLS and HTHS scenarios**



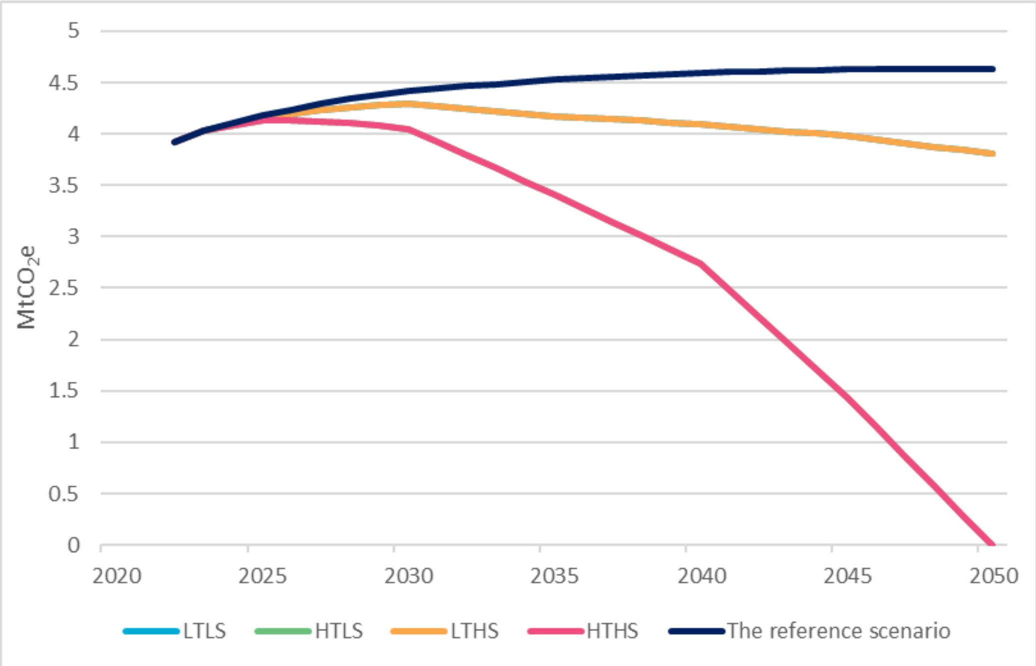
* Note: As mentioned above, alternative fuel uptake reaches 100% in 2050 in both high-technology scenarios, so the HTLS line in this chart is obscured by the HTHS line.

Source: Commission analysis

Using the proposed measure, marine emissions decline in all scenarios except the reference. In low-technology scenarios, emissions are reduced by 21% compared with the reference scenario, and in high-tech scenarios, emissions are reduced to zero (**Figure 12**).

In the LTLS scenario, the per-year efficiency improvement is 25% greater than in the reference scenario, with low carbon liquid fuel uptake of 12% by 2050. In the high-tech scenarios, the per-year efficiency improvement is 50% greater than in the reference scenario, and low-carbon liquid fuels entirely replace conventional fuel by 2050.

*__Figure 12:__ International marine bunker emissions in reference, LTLS, LTHS, HTLS, and HTHS scenarios**

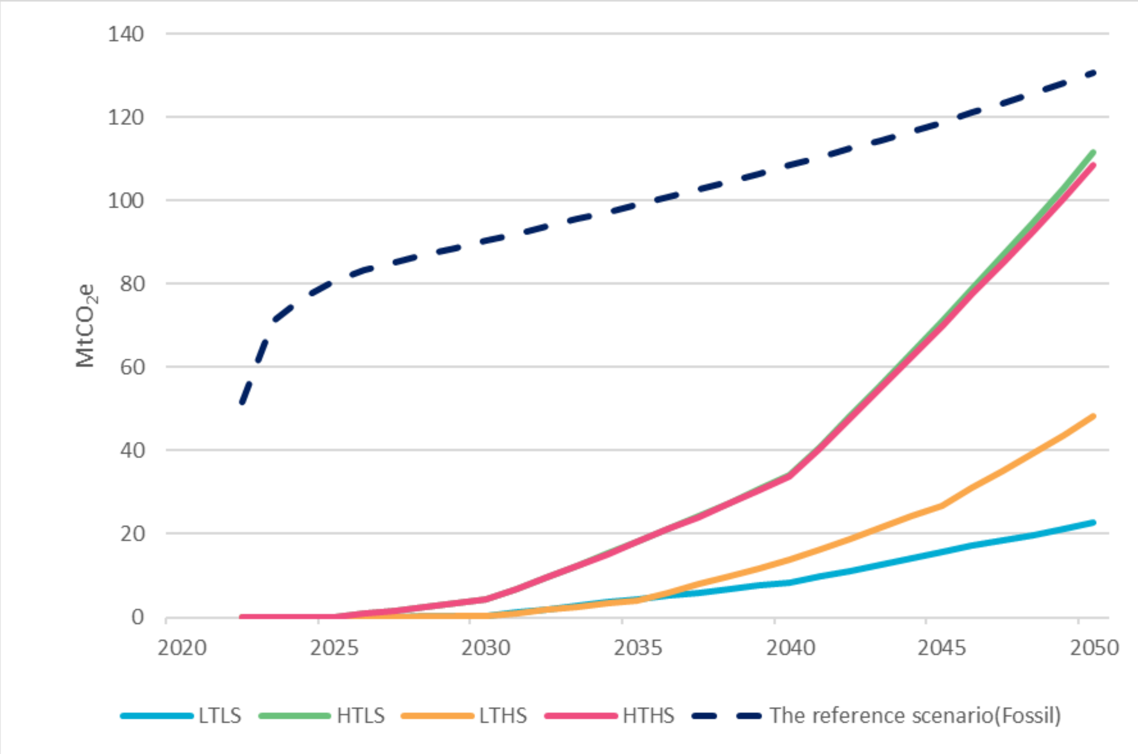


* Note: No systems change assumptions were made for international shipping so high systems change scenarios are obscured in the chart

Source: Commission analysis

By 2050, international transport will be the largest consumer of low-carbon liquid fuels in our scenarios. Achieving a high degree of decarbonisation in these sectors will require the use of low-carbon liquid fuels as there are limited alternative mitigation technologies. In 2050, between 22 and 108 PJ of low-carbon liquid fuels will be used in the scenarios to displace fossil fuels for international aviation and shipping (**Figure 13**).

Figure 13: *Low-carbon liquid fuels used in international aviation in reference and LTLS, LTHS, HTLS, and HTHS scenarios*



Source: Commission analysis

Temperature response modelling

As part of our *Review of the 2050 emissions reduction target,* we have modelled the warming from the country's past and possible future emissions and how that contributes to global efforts to limit warming to 1.5°C. This was to provide a range of perspectives on how Aotearoa New Zealand's efforts contribute to limiting warming.

Temperature response modelling uses a simplified climate model to convert emissions of greenhouse gases into concentrations, and then to the temperature effect directly. This allows us to compare the warming outcome from different targets and pathways and accurately reflect how emissions of each gas contribute to warming.

Key results and what it means for Aotearoa New Zealand's contribution to global efforts to limit warming can be found in *Chapter 3: Important context for our review of the 2050 target* and *Chapter 6: The implications of our recommended 2050 target* of our report *Review of the 2050 emissions target including whether emissions from international shipping and aviation should be included*.

This section provides further information on results, how the modelling was undertaken, as well as important assumptions and parameters used so the analysis can be reproduced.

Key results

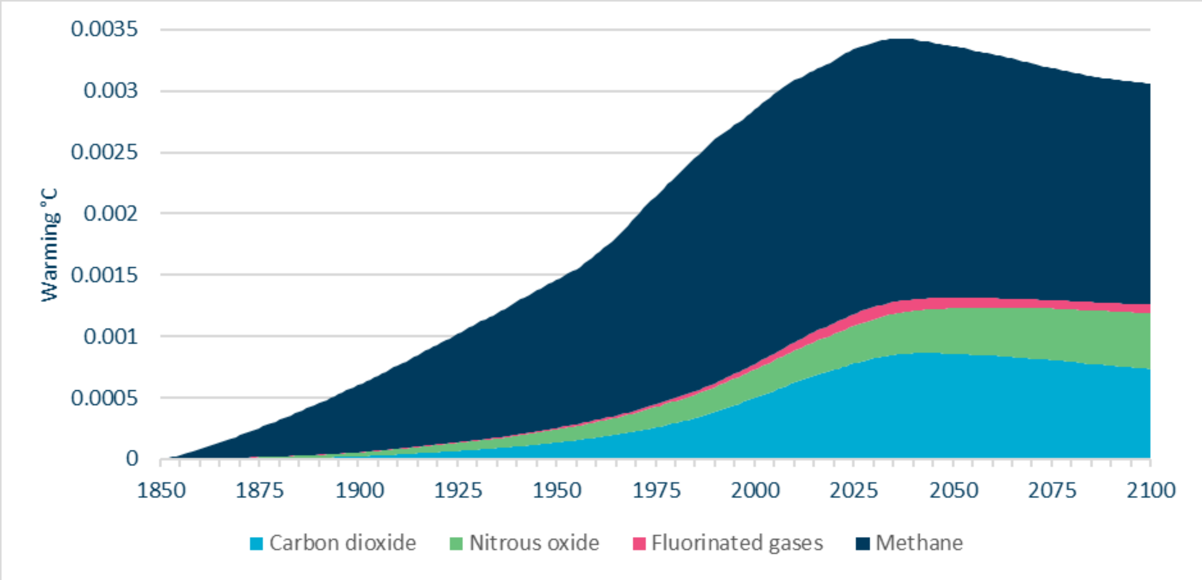
To assess the current target, the future projections are based on the LTLS scenario developed for the advice on Aotearoa New Zealand's fourth emissions budget. This is one possible pathway that meets the current target and can be used to draw insight into how much warming Aotearoa New Zealand would contribute if the country achieved the current target.

The results show that:

- warming is mainly from methane, carbon dioxide, and nitrous oxide
- most warming comes from methane emissions
- warming peaks in 2037 at 0.0034°C
- Aotearoa New Zealand contributes 0.0034°C in 2050 and below that at 0.0031°C in 2100.

Looking at the temperature response or 'warming' in this way allows us to understand total warming from different greenhouse gases without the use of metrics that equate other greenhouse gases to carbon dioxide.

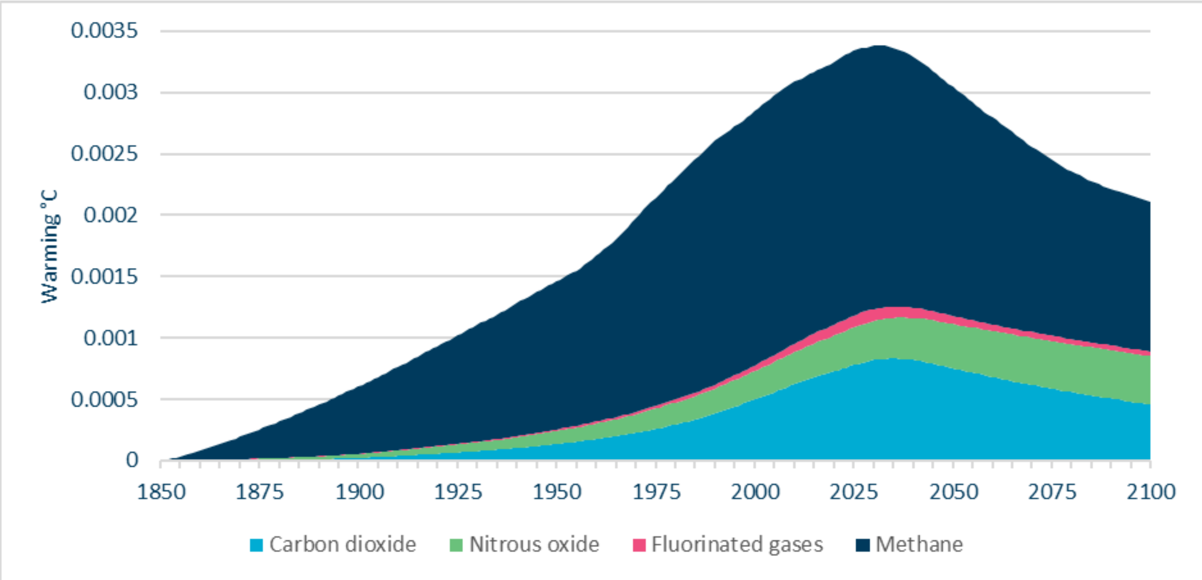
Figure 14: *Warming from Aotearoa New Zealand's emissions 1850–2100 under the LTLS scenario*



Source: Commission analysis

Under the HTHS scenario which we use to understand potential warming from an emissions pathway that meets the recommended target, warming from Aotearoa New Zealand's emissions declines further following the peak, as shown in **Figure 15** below.

Figure 15: *Warming by gas from Aotearoa New Zealand emissions 1850–2100 under the HTHS scenario*



Source: Commission analysis

How the temperature response modelling was done

FaIR

The Commission used the FaIR model (Finite-amplitude Impulse Response simple climate model). Simple climate models like FaIR are designed to emulate more complex full earth system models. FaIR has been developed by a team of UK researchers and has been shown in the IPCC Sixth Assessment Report to satisfactorily simulate the global temperature change modelled by complex earth system models over the 21st century. It includes the effect of non-CO_2 greenhouse gases and short-lived climate forcers such as aerosols.

FaIR takes an emissions time series for the world, and can be used to simulate the warming effect of emissions from Aotearoa New Zealand based on the global warming outcome with and without Aotearoa New Zealand's emissions. This allows us to estimate the warming attributable to emissions from Aotearoa New Zealand.

FaIR does not rely on any emissions metric, rather it models the temperature response of each gas separately based on the atmospheric lifetime and radiative efficacy of each gas.

The FaIR model is publicly available on PyPI. You can read more about the FaIR model at:
https://homepages.see.leeds.ac.uk/~mencsm/fair.htm

The papers providing the official description of the model are:

- Leach, N. J., Jenkins, S., Nicholls, Z., Smith, C. J., Lynch, J., Cain, M., Walsh, T., Wu, B., Tsutsui, J., and Allen, M. R. (2021): FaIRv2.0.0: a generalized impulse response model for climate uncertainty and future scenario exploration. Geosci. Model Dev., 14, 3007–3036, https://doi.org/10.5194/gmd-14-3007-2021
- Smith, C. (2024). FaIR calibration data (Version 1.4.2) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.13142999

For the IPCC assessment of emulators of complex climate models, see Cross-chapter Box 7.1 in:

- Forster, P.M. et al. (2021) 'Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity', in V. Masson-Delmotte et al. (eds) Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Oxford, UK: Cambridge University Press.

Input assumptions and caveats

For this exercise, we used FaIR version 2.1.3. We used version 1.4.2 of the calibration data. Version v1.4.0 was used by the IPCC for projections stemming from IPCC Sixth Assessment Report, v1.4.2 differs from v1.4.0 as follows:

- Volcanic efficacy (the temperature response per unit radiative forcing compared to CO_2) is set to 1.0 rather than 0.6. As this is a natural forcer, this will make little difference in comparing anthropogenic drivers.
- Contrails are excluded from this calibration set. They are unlikely to affect the relative differences between scenarios where aviation activity is not varied, such as in this analysis.
- A very small linear trend change in solar forcing, inclusion or exclusion of this factor makes no practical difference to the results.

The net effect of implementing the v1.4.2 calibration is to change the median warming of the baseline SSP1-2.6 scenario projection slightly. SSP1-2.6 is used as a baseline scenario to evaluate New Zealand's influence against, so these differences do not affect the results of New Zealand's warming contribution from anthropogenically emitted greenhouse gases. Therefore, there is little issue using calibration v1.4.2 in place of v1.4.0.

It is important to note that this exercise excluded historic deforestation emissions, i.e. emissions associated with land clearing since human settlement until 1990, and replanting prior to 1990.

Other relevant input assumptions include:

- SSP1-2.6 as global background scenario
- Emissions from Aotearoa New Zealand are based on:
  - Estimated historical emissions from 1850 to 1989 (see below for details)
  - Net target accounting emissions based on the GHG Inventory from 1990 to 2021
  - Various scenarios for future net target accounting emissions, assuming constant emissions from 2075 onwards
- We used reported activity data for agriculture from the 1930s to the present. We used linear scaling from 0 in 1840 to the known activity data from the 1930s.
- For fossil CO_2, we used existing published estimates from 1860, and a linear scale from 0 in 1840 to 1860.
- To estimate the proportion of fossil methane vs biogenic methane for historical data, we assumed fossil methane emissions to be proportional to fossil CO_2 emissions, using the ratio in 1990 (1990 being the earliest year for which GHG Inventory data is available)
- For f-gases, HFCs use is assumed to be zero before 1990. This is consistent with GHG Inventory data that showed zero use up until 1992.
- For PFCs and SF6, we assumed 0 use in 1950, increasing linearly to reach the emissions levels reported in 1990 by the GHG Inventory.

Pathways modelled

We ran the model using six of the scenarios from the final advice on Aotearoa New Zealand's fourthemissions budget, and the updated demonstration path used for that analysis (EB4 demonstration path).

The six scenarios ran were:

- Low technology and low systems change (LTLS)
- High technology and low systems change (HTLS)
- Low technology and high systems change (LTHS)
- High technology and high systems change (HTHS)
- The demonstration path for the fourth emissions budget (EB4 demonstration path)
- The reference scenario (fourth emissions budget analysis)

Outputs

For each scenario, three sets of results were produced:

- Total warming by gas 1750-2300 (across the four categories of CO_2, CH_4, N_2O, and other which encompasses fluorinated gases)
- Warming by gas split into warming from emissions up until 1990, and from emissions occurring after 1990
- Warming by gas split into warming from emissions up until 2023, and from emissions occurring after 2023

Estimates of warming from pre and post-2023 emissions show how past and future emissions contribute to warming. Estimates of warming from pre and post 1990 emissions informed assessments of Aotearoa's New Zealand's target under a responsibility approach.

Full results are available on our website and can be found here: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/preparing-advice-on-emissions-budgets/advice-on-the-fourth-emissions-budget/modelling-and-data-final-report

Review and quality assurance

The modelling for this draft advice was done by Dr Andy Reisinger[viii] using the FaIR model. The process and outputs were independently reviewed by FaIR developer Dr Chris Smith. He was able to reproduce the outputs of the analysis and confirmed that the work was done correctly. His conclusion was as follows:

> I conclude that FaIR is an appropriate tool for the analysis which has been conducted correctly

Revisions to budgets

As part of our advice on Aotearoa New Zealand's fourth emissions budget, we must consider whether revisions are needed to the first three emissions budgets to account for methodological or significant change. Our analysis and recommendations are set out in C*hapter 7: Recommended changes to the first, second and third emissions budgets of* the document. This section provides further details on:

- the procedure used to incorporate methodological improvements to New Zealand's Greenhouse Gas Inventory.
- our detailed initial assessments of significant change.

Methodological improvements to the GHG Inventory

Approach

Under section 5ZE of the Act, emissions budgets may be revised where there have been methodological improvements to the way that emissions are measured and reported. Changes to the GHG Inventory are summarised annually by MfE[14][15][16]. Our method to assess the impact of methodological improvements on the emissions budgets involved the following steps:

1. We took the ENZ model used to create the demonstration path in *Ināia tonu nei* and adjusted it for the changes made when the Government set the emissions budgets. This constituted a single change to the level of exotic afforestation.
2. The ENZ model was updated to be based upon GWP_{100} AR5 global warming potentials.
3. We took this modified model and revised the GHG Inventory data using the 2024 version. We only revised the GHG Inventory data for the years 1990–2019, since this is the original timeframe used at the time the emissions budgets were set. Direct GHG Inventory data from 2020 to 2022 would include changes made other than for methodological improvements, so were not applied.
4. Some of the specific updates to the ENZ model included:
    a. transport – VFEM estimations for 1990-2019 and liquid fuel efficiency of vehicles 1990–2019. Reassignment of liquid fuel emissions to the non-transport energy sector.
    b. non-transport energy – reassignment of liquid fuel emissions from the transport sector. Fugitive emissions from gas distribution networks.
    c. agriculture – regional land area, emissions per head, stocking rate and dairy kgMS/head, improvements to liveweight estimates and beef cattle population, changes to nitrogen leaching fractions.
    d. HFCs – The 2020 Verum study[17] provided updated basis for phasedown scenarios of HFC
    e. forests – MPI 2024 projections data containing multiple updates aligned with the 2024 edition of the GHG Inventory. This included revised carbon yields for exotic and native

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[viii] Dr Andy Reisinger undertook this work as an independent expert and not as part of his role as a Commissioner on the Climate Change Commission.

forests, incorporating an additional yield table, changes to production pine. Biomass and soil carbon values were also revised.

5. Land area splits between land use categories for 2024 were not available at the time the report was prepared and have been excluded from the update.
6. The revised model was run to get a new demonstration path and a projection of emissions through to 2050.
7. The revised emissions budgets due to methodological improvements were assessed as the cumulative emissions occurring between 2022–2025 (for the first emissions budget), 2026–2030 (for the second emissions budget) and 2031–2035 (for the third emissions budget).

Impact of changes on sectoral emissions

The impacts of the methodological changes are shown in the main report. The impacts of the changes on the pathway for sector emissions are shown in **Figure 16**.

Transport

For transport emissions, methodological changes were greatest in the first budget period. By 2050 the difference between the set budgets and revised with methodological changes was small due to the shift away from fossil fuel use. The majority of the difference could be accounted for due to the reassignment of liquid fuel use to the residential sector.

IPPU

The change in IPPU emissions is almost entirely due to methodological improvements to the HFC data, and revised projections for the phasedown of HFCs.

Non-transport energy

The non-transport energy sector has seen an increase in the projected emissions. The increase in emissions is due predominantly to the reallocation of liquid fuel use from the transport sector. The magnitude of the increase is less than the corresponding decrease observed in transport emissions due to other changes occurring in the non-transport energy sector. For example, reductions in coal emissions within food processing, a reduction in liquid fuel emissions from mining and quarrying, and changes to assumptions on natural gas fugitive emissions.

Agriculture

Methodological changes to the agriculture sector result in higher emissions across the first to third budget periods. The changes arise from the inclusion of non-pasture feed in the inventory model, changes to the fraction of nitrogen that is leached, improvements to beef cattle population and liveweight estimate, and accounting rules for agricultural lime.

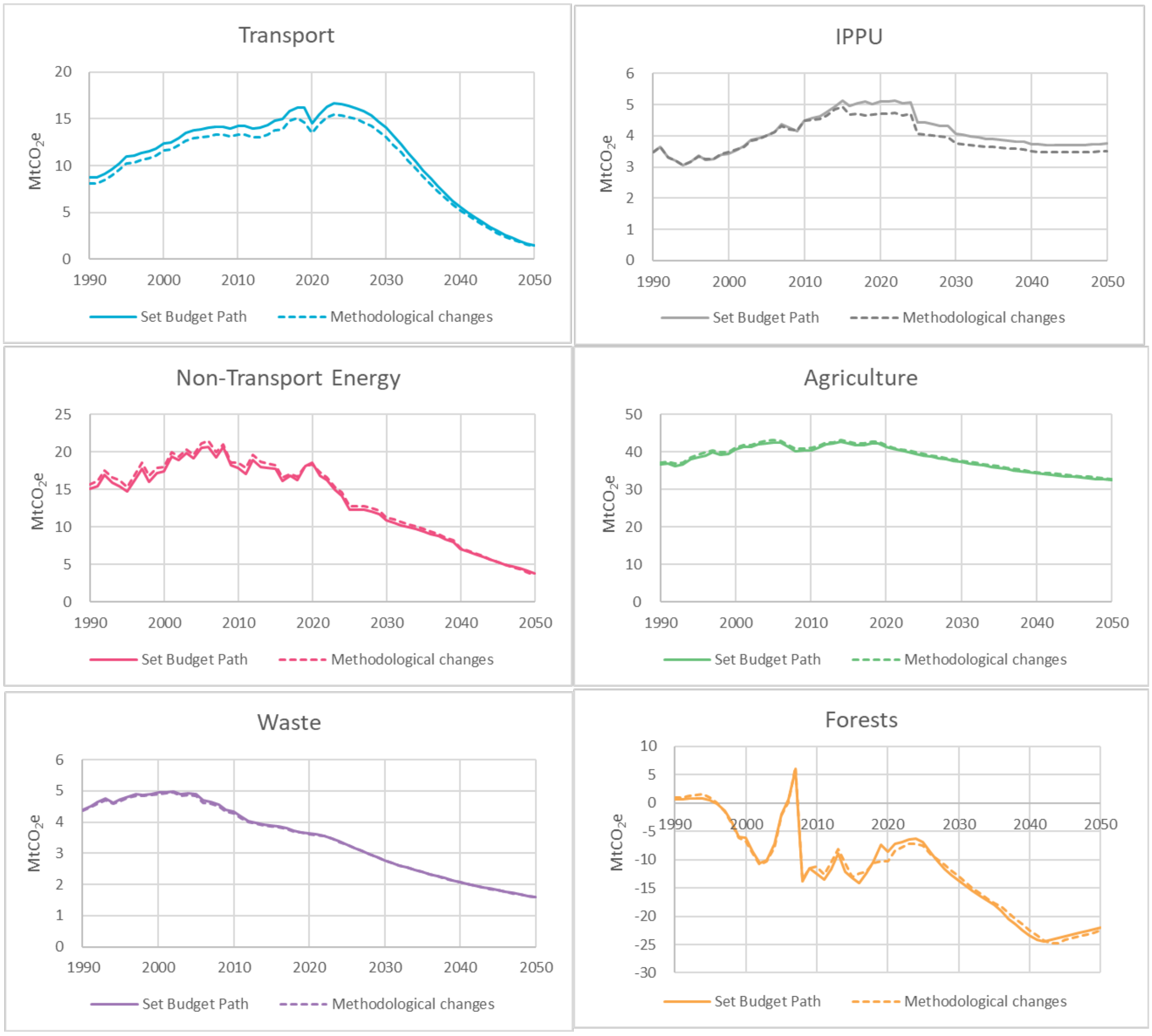
Waste

There were no methodological improvements in waste that contributed substantially to a change in projections.

Forests

A number of methodological changes in forest emissions [18][19] occurred, which were incorporated in WEM datasets supplied by MPI as well as the GHG Inventory.

***Figure 16:** Summary of impact on pathway profile of methodological changes (2024 vs 2021) by sector*



Source: Commission analysis

Significant change

Approach

A change can be recommended to set emissions budgets if there has been revisions made because of one or more significant changes affecting the considerations listed in section 5ZC(2) of the Act, on which an emissions budget was based. The purpose of making changes under section 5ZC(2) is to ensure that the Commission's advice on emissions budgets continues to be technically, socially, and economically achievable, while remaining ambitious.

There are similarities to assessing significant change in relation to our review of the 2050 target. However, there are sufficient differences between these provisions of the Act that the test we have developed for emissions budgets is separate to our review of the 2050 target. In our approach we have chosen not to apply a bright line test to assess significance. There are considerations under section 5ZC(2) that collectively contribute to a significant change and in some cases the change may not be quantifiable precisely.

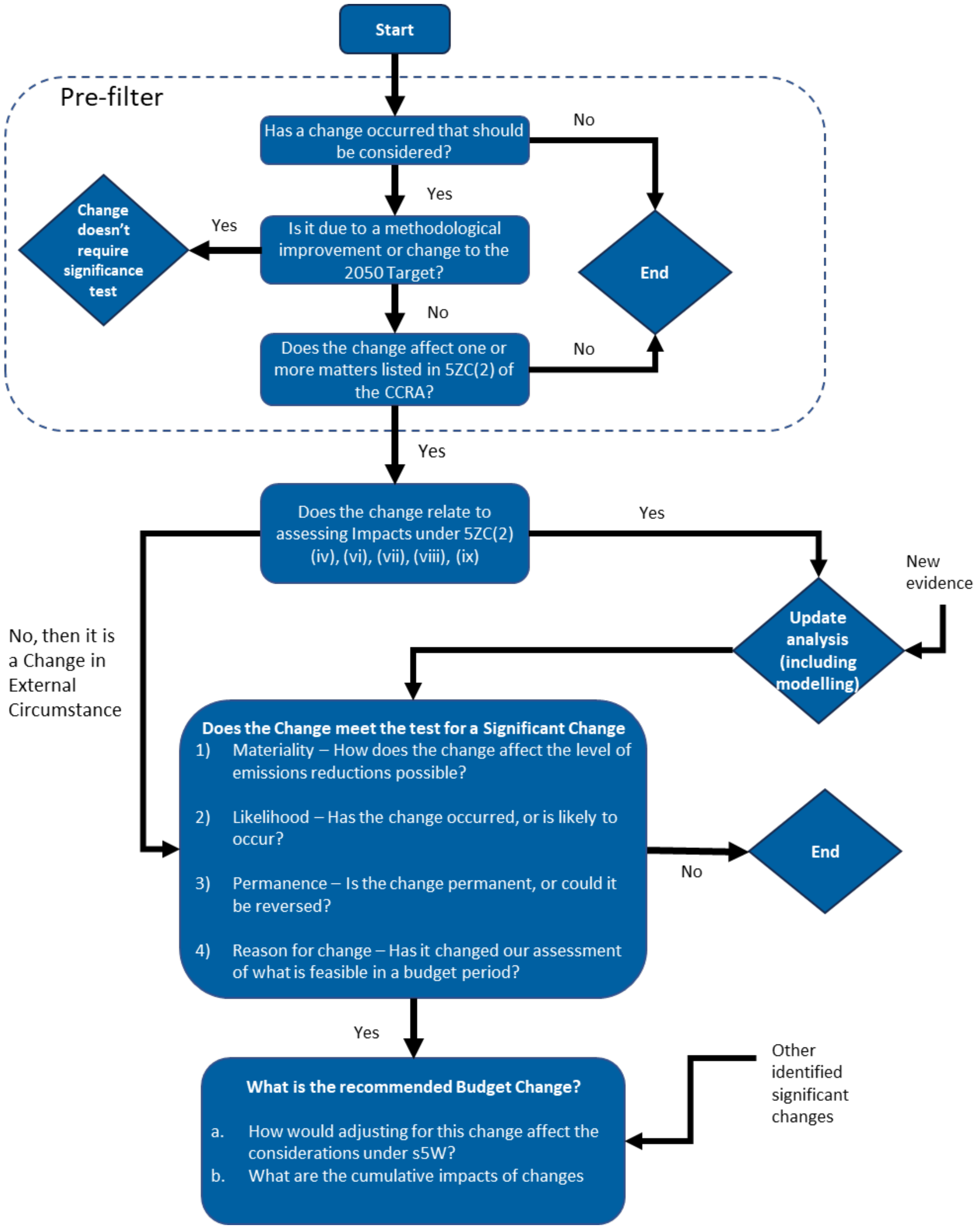
A framework was developed so that criteria could be applied consistently when changes are identified and evaluated.

Process flow diagram

The framework for evaluating significant change in the context of emissions budgets is described in *Chapter 7: Recommended changes to the first, second and third emissions budgets*. We have developed a separate test for significant change related to the 2050 target, which is detailed in Chapter 4 of our report *Review of the 2050 emissions target including whether emissions from international shipping and aviation should be included.*

Figure 17 summarises the process for evaluating significant change in the form of a process flow diagram.

Figure 17: *Process flow chart for assessing changes to emissions budgets*

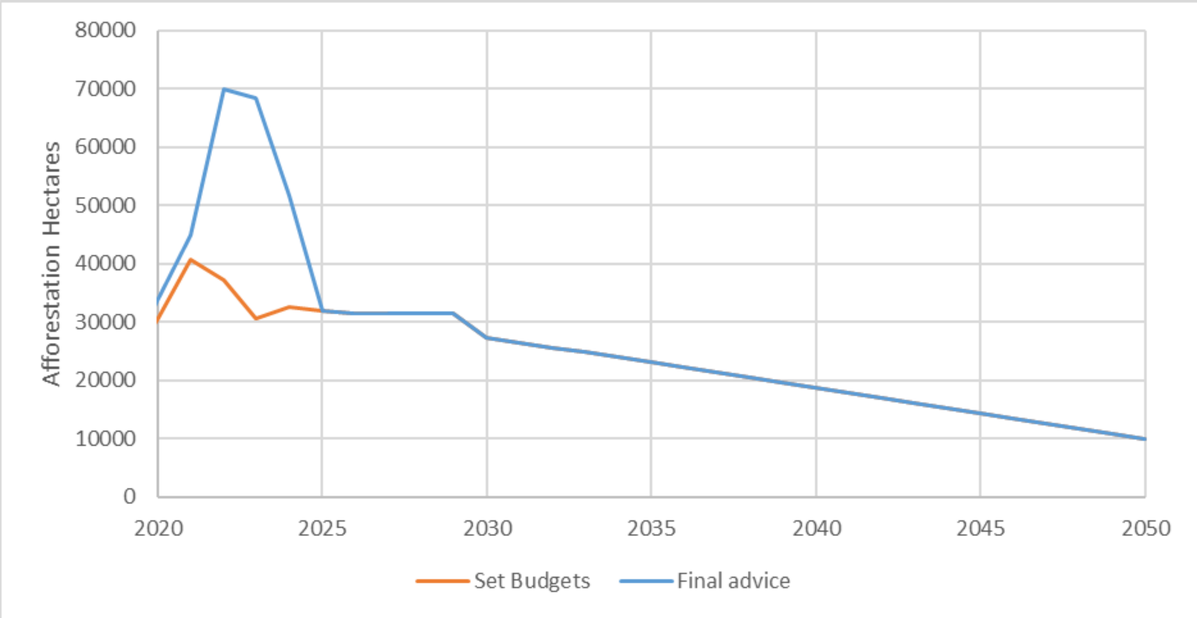


Source: Commission analysis

Afforestation as a significant change

Afforestation was identified as the only significant change, meeting the criteria as outlined in *Chapter 7: Recommended changes to the first, second, and third emissions budgets.* The significant change was modelled by taking the actual afforestation occurring in 2020–2024 then reverting back to the set budgets path for 2025–2050 (**Figure 18**).

Figure 18: *Afforestation of exotics due to significant change and set budgets 2020–2050*



Source: Commission analysis

Dashboard summaries of significance tests

In this section we present dashboard summaries of our assessments of each of the changes that were analysed through the significant change framework. This includes the increase in afforestation that was assessed to be significant and changes set out in Table 7.2 of *Chapter 7: Recommended changes to the first, second and third emissions budgets* that were assessed to be not significant.

Our analysis of significant change evaluates changes that have occurred since the first three emissions budgets were set by the government in 2022. In many of the dashboards that follow we discuss changes relative to assumptions documented in *Ināia tonu nei* because these assumptions closely align with those that underpin set budgets.

<table>
<tr><th colspan="6">1. Increase in afforestation</th></tr>
<tr><td>Change assessed:</td><td colspan="3">Exotic afforestation between 2020 and 2024 was substantially higher (Figure 18) than projected in the set emissions budgets. While set budgets incorporated forestry data published by MfE in 2022[20] which updated the Commission's advice in Ināia tonu nei. These rates of afforestation were still lower than what has been observed recently. We have modelled the higher exotic afforestation rates having occurred since budgets were set, i.e. actual afforestation from 2020 to 2024.[21] We then revert to set budget projections for hectares afforested from 2025 to 2050.</td><td>CCRA Criteria</td><td>5ZC 2b(i) the emission and removal of greenhouse gases projected for the emissions budget period</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td>1. Material impact: How does the change affect the level of emissions reductions possible?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:
Significant Change</td></tr>
<tr><td>Findings:</td><td>The difference between the afforestation projections in Ināia tonu nei and the actual afforestation (2020–2022 and estimated for 2023–2024) results in substantial changes in the second and third emissions budgets, of –14 MtCO2e (AR5) and –18 MtCO2e (AR5), respectively<table><tr><th>EB1</th><th>EB2</th><th>EB3</th></tr><tr><td>–1Mt</td><td>–14 Mt</td><td>–18 Mt</td></tr></table></td><td>The higher afforestation amount has already occurred and the impact of this will result in ongoing removals through 2050.

Although future afforestation rate projections are uncertain, the actual afforestation (2020-2024) is highly likely to achieve the reductions.</td><td>There is a high degree of confidence that this change is permanent (durable), and incentives are unlikely to reverse and lead to deforestation.</td><td>The higher rates of afforestation will increase what is feasible in the second and third emission budget periods. Earlier planting has an enduring impact on emission reductions.</td><td>There has been a far higher rate of afforestation than projected in the government emissions budgets. This is likely to have a permanent effect and increases what is feasible. We recommend that the actual afforestation activity, resulting in more carbon removals than anticipated in the second and third emissions budgets, be taken into account.</td></tr>
<tr><td>Alignment with the Act</td><td colspan="2">Consistency with purpose of budgets. How would adjusting for this change affect the considerations under section 5W of the Act?</td><td colspan="3">Higher afforestation activity from 2022 to 2024 will make it easier to achieve set budgets. Adjusting the budgets down would ensure the focus remains on incentives to reduce gross emissions. By adjusting budgets for this change, cumulative net emissions to 2050 will be lower, which increases Aotearoa New Zealand's contribution to global efforts to keep the temperature increase below 1.5° Celsius compared to pre-industrial levels.</td></tr>
</table>

2. EV uptake rate higher than predicted					
Change being assessed:	There has been an increase in the uptake rate of electric vehicles over that predicted in the *Ināia tonu nei* modelling. Since 2021 the Government has introduced a suite of policies to incentivise the uptake of low emissions vehicles. In the *Ināia tonu nei* demonstration path, by 2023, 4% of vehicles entering the fleet were assumed to be electric. In September 2023 EVs were 17% of new vehicle registrations.[22] Following changes to policy settings for EVs, the share of light vehicle registrations between January and August 2024 has fallen to 4%.			**CCRA Criteria**	5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand
Qualitative Test for Significant Change:	1. **Material impact**: How does the change affect the level of emissions reductions possible?	2. **Likelihood**: What is the likelihood that the impact on budgets will be realised?	3. **Permanence**: Is the change permanent, or could it be reversed?	4. **Reason for change**: Has it changed our assessment of what is feasible in a budget period?	**Decision:** **Not a Significant Change**
Findings:	EVs made up 17% of new registrations in Sep 2023. If these levels had been maintained the impact could have been materially impactful for budgets. **EB1**: - **EB2**: - **EB3**: -	Uptake projections are inherently uncertain and changing policy settings could have significant effects on the share of EV's entering the fleet.	The proportion of New Zealand's vehicle fleet that is electric is very unlikely to ever decline in the coming decades. The difference over the original projections are unlikely to be permanent. The rate of further uptake will change over time but the share of the total vehicle fleet is very unlikely to reverse.	It does not represent a fundamental change in what is feasible in the budget periods.	Since 2021 the Government introduced a suite of policies to incentivise the uptake of low emissions vehicles, however some of these policies were revoked in 2024. Uptake projections are inherently uncertain and changing policy settings could have significant effects on the share of EVs entering the fleet in future.

<table>
<tr><th colspan="6">3. Change in vehicle kilometres travelled (VKT) projections</th></tr>
<tr><td>Change being assessed:</td><td colspan="3">The projections for vehicle kilometers travelled (VKT) have changed since Ināia tonu nei. Although Covid resulted in a reduction in VKT, the 2023 VKT projections showed substantial changes, as the anticipated rebound in VKT following covid has not been as strong as predicted.</td><td>CCRA Criteria</td><td>5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td>1. Material impact: How does the change affect the level of emissions reductions possible?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:
Not a Significant Change</td></tr>
<tr><td>Findings:</td><td>The quantified change is reasonably large as estimated net emissions reduction for the first emissions budget (–1.7%) and the second emissions budget (–1.3%). The difference is smaller for the third budget (–0.3%).<table><tr><th>EB1</th><th>EB2</th><th>EB3</th></tr><tr><td>-4.6</td><td>-3.9</td><td>-0.7</td></tr></table></td><td>There is low confidence that the VKT will remain low.

Travel demand was considered within Ināia tonu nei as a mitigation, so these changes may be factored in and could just be occurring earlier than anticipated.</td><td>VKT can be expected to fluctuate in future projections from MoT, the change described here may reflect a fundamentally different assessment of future VKT, but equally the VKT could return to the pre-covid trend in future projection updates. The change is equally likely to not be permanent and could be reversed.</td><td>The projected VKT reduction has increased what is feasible in a budget period, if it were to occur.</td><td>VKT forms the basis of emissions estimates in the ENZ model which is used to derive the level of emission budgets. Light vehicles’ VKT is now estimated to be lower than that projected under Ināia tonu nei through to the third emissions budget. For heavy vehicles the VKT projections have increased, but have a smaller total VKT than light vehicles. These projections linked to demand can be harder to accurately predict than single discrete events, such as an industrial process change. This makes it an uncertain change which may not be permanent. It does not represent a significant change.</td></tr>
</table>

<table>
<tr><th colspan="8">4. Biofuels mandate</th></tr>
<tr><td>Change being assessed:</td><td colspan="5">In January 2021, the Government agreed in principle to implement a biofuels mandate. In June 2021 the consultation on the sustainable Biofuels Mandate was announced. The Sustainable Biofuels Obligation Bill was introduced to Parliament in November 2022. On 8 February 2023, it was announced the biofuels mandate would be discontinued, as part of the Government's policy refocus.[23]</td><td>CCRA Criteria</td><td>5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td colspan="3">1. Material impact: How does the change affect the level of emissions reductions possible?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:
Not a Significant Change</td></tr>
<tr><td rowspan="3">Findings:</td><td colspan="3">The Government's first emissions reduction plan had a target to reduce the emissions intensity of transport fuel by 10% by 2035. The Ināia tonu nei demonstration path assumed the use of low carbon fuels to provide 5% of total liquid fuel demand by 2035.</td><td rowspan="3">The discontinuation of the biofuels mandate has occurred.</td><td rowspan="3">It is possible that it could be reversed, or a different mechanism established to promote biofuels.</td><td rowspan="3">The Biofuels Mandate was a policy option to incentivise the uptake of biofuels in Aotearoa New Zealand for decarbonisation of the transport sector. Alternative mechanisms to incentivise biofuels uptake could be implemented in the future, given biofuels were, and remain, a key consideration in the first emissions reduction plan.</td><td rowspan="3">Biofuels are part of the Ināia tonu nei demonstration path and the first emissions reduction plan. The biofuels mandate is a specific policy used to incentivise uptake. Biofuels remain a realistic tool for hard to abate sectors such as heavy freight and aviation. Therefore, the fact this policy is discontinued does not mean alternative mechanisms will not emerge, or that alternative paths cannot be sought, as is the purpose of the emissions budgets.</td></tr>
<tr><td>EB1</td><td>EB2</td><td>EB3</td></tr>
<tr><td>-</td><td>-</td><td>-</td></tr>
</table>

5. New Zealand Steel EAF funded					
Change being assessed:	In May 2023, New Zealand Steel announced a $300M co-investment with government for an electric arc furnace at Glenbrook[24] to reduce greenhouse gas emissions. It is intended to be built within the next three years (from 2027). This was not modelled as part of the original *Ināia tonu nei* demonstration path.			**CCRA Criteria**	5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand
Qualitative Test for Significant Change:	**1. Material impact**: How does the change affect the level of emissions reductions possible?	**2. Likelihood**: What is the likelihood that the impact on budgets will be realised?	**3. Permanence**: Is the change permanent, or could it be reversed?	4. **Reason for change**: Has it changed our assessment of what is feasible in a budget period?	**Decision:** **Not a Significant Change**
Findings:	It is estimated that 0.8 $MtCO_2e$/year[25] (1% of New Zealand's total emissions) will be eliminated. **EB1**: – / **EB2**[ix]: –3 Mt / **EB3**: –5 Mt	It is currently an announcement and likely to occur. The introduction within a three-year timescale could experience delays, but is still likely.	Yes, this is a process change that will permanently change the emissions profile.	This co-investment is a policy intervention by the Government to meet future emissions budgets as established. It represents an alternative decarbonization pathway than evaluated in *Ināia tonu nei*.	The EAF is a change in technology and carbon emissions that was not considered in *Ināia tonu nei*. The EAF is considered one of the main initiatives for the Government to achieve the second and third emissions budgets. It is a policy response to the emission budgets being in place. The EAF is not representative of a new technological breakthrough for the industry but represents a different path for decarbonization.

EB1	EB2[ix]	EB3
–	–3 Mt	–5 Mt

[ix] This estimate of impact was from modelling changes within the ENZ model. Values may differ from the NZ Steel estimate of 0.8 $MtCO_2e$/year, partly since it is assumed to be operational from 2027, but also ENZ includes an assessment of how the changes flow through to other sectors of the economy.

<table>
<tr><th colspan="6">6. Fonterra receiving GIDI funding to reduce process heat</th></tr>
<tr><td>Change being assessed:</td><td colspan="3">The Government has committed to co-fund up to $90 million from the GIDI fund to cut coal use at Fonterra dairy factories.[26] This was not identified in Ināia tonu nei. It is forecast to cut coal use at six Fonterra dairy factories, halving Fonterra’s manufacturing emissions by 2030. Fonterra is anticipating a combination of energy efficiency, biomass, existing heat pump technology, and newer innovative solutions will deliver these reductions.

Note: the GIDI fund has been discontinued since this was first drafted, but committed funding will go ahead.</td><td>CCRA Criteria</td><td>5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td>1. Material impact: How does the change affect the level of emissions reductions possible?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:

Not a Significant Change</td></tr>
<tr><td>Findings:</td><td>This is estimated to deliver 1.2 MtCO_2e reductions between 2026-2030. It will deliver a similar level of reductions in the third emissions budget (2031–2035). This is materially significant.<table><tr><th>EB1</th><th>EB2</th><th>EB3</th></tr><tr><td>–</td><td>−1.2 Mt</td><td>−1.2 Mt</td></tr></table></td><td>There is high likelihood that the change will occur, and within the second emissions budget period.</td><td>The changes are likely to be permanent, and if installed, the technologies are unlikely to be reversed.</td><td>The GIDI fund is a policy response to meet the emission budgets through abatement of process heat. A reduction in process heat emissions was considered in the original Ināia tonu nei pathway. This represents an alternative approach to achieve the same mitigation potential and is not an increase in what is feasible.</td><td>This initiative is a policy response by the Government as a means to achieve budget reductions. Although this particular initiative was not modelled in Ināia tonu nei, the move away from coal for process heat was considered at the time. the demonstration pathway in Ināia tonu nei saw an approximately 50% reduction in food processing emissions, and about 70% reduction in coal use by 2030 relative to 2018. Coal use was modelled to be phased out by 2037. Our understanding of what is feasible is unchanged, and it should not represent a significant change.</td></tr>
</table>

7. Heat pumps that can deliver heat >100°C

Change being assessed:	High-temperature heat pump technologies for supply of temperatures >100 °C is an emerging technology.[27] The development and commercialization of high temperature heat pumps will enable decarbonization through electrification of process heat applications. In *Ināia tonu nei*, technologies such as this were not assumed to be available until after 2035. It is now likely that high temperature heat pumps for industrial processes will be available within the second emissions budget period (2026–2030)			**CCRA Criteria**	5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand
Qualitative Test for Significant Change:	**1. Material impact**: How does the change affect the level of emissions reductions possible?	**2. Likelihood**: What is the likelihood that the impact on budgets will be realised?	**3. Permanence**: Is the change permanent, or could it be reversed?	4. **Reason for change**: Has it changed our assessment of what is feasible in a budget period?	**Decision:** **Not a Significant Change**
Findings:	This is difficult to quantify with certainty, however similar process heat reduction (maximum) potentials are in the region of 1.2 $MtCO_2e$ annually. This would be materially impactful. **EB1**: - / **EB2**: - / **EB3**: -	There are a number of uncertainties associated with new technologies that could affect the uptake rate. The Heat Pump Centre's report in 2023[28] suggests these technologies will be available within the second emissions budget period, whereas it was only assumed to become available after 2035 in *Ināia tonu nei*. Whether they are adopted in NZ will depend on how they compare to competing decarbonisation routes	The cause of the change is likely to be permanent.	It has not changed our assessment of what is feasible. The benefits that the technology brings were anticipated to occur through other means, it represents an alternative decarbonisation pathway.	This is an emerging technology which has continued to develop since *Ināia tonu nei* was published. It is likely to be an option for electrification of process heat within the second emissions budget period. Decarbonisation of process heat, through transition from coal, has been addressed in a recent GIDI fund awarded to Fonterra. The same emission source is already being addressed and is a competing pathway to decarbonisation for the sector. This represents an alternative decarbonisation pathway and is not sufficient justification to represent a significant change.

<table>
<tr><th colspan="6">8. Potential for carbon capture and storage (CCS)</th></tr>
<tr><td>Change being assessed:</td><td colspan="3">CCS is a process in which a relatively pure stream of CO_2 from industrial and energy-related sources is separated (captured) at or near a point source, conditioned, compressed, and transported to a permanent storage location for long-term isolation from the atmosphere. Permanent storage is generally geological (underground geologic formations, rocks, minerals). Geothermal CO_2 reinjection during electricity generation is one application where the likelihood of implementation is greater than when assessed in Ināia tonu nei. CCS on natural gas production, and CCS on downstream uses of gas such as electricity generation are also applications for the technology. Government have indicated their interest in exploring further CCS on gas production.[29, 30]</td><td>CCRA Criteria</td><td>5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand.

5ZC 2b(v) the results of public consultation on an emissions budget.</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td>1. Material impact: How does the change affect the level of emissions reductions possible?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:

Not a Significant Change</td></tr>
<tr><td>Findings:</td><td>Geothermal CO_2 reinjection would be estimated to have a material impact in the second and third emissions budgets. For CCS on gas production initial estimates are less than 1 $MtCO_2e$ reduction. Estimates of magnitude provided below.<table><tr><th>EB1</th><th>EB2</th><th>EB3</th></tr><tr><td>0</td><td>–2Mt</td><td>–3Mt</td></tr></table></td><td>Geothermal CO_2 reinjection has reasonable likelihood. CCS on gas production still has a high level of uncertainty around its economic viability and likelihood.</td><td>Geothermal reinjection of CO_2 is not necessarily permanent and may be released in future, but this may be a feature of accounting. CCS on gas production will have to go through an assessment of potential for leakage and procedures developed for monitoring.</td><td>Although geothermal reinjection of CO_2 was not featured in Ināia tonu nei, it represents an alternative technology to meeting the emissions budgets, and decarbonizing electricity generation. It does not necessarily change our assessment of what was feasible.</td><td>The geothermal reinjection of CO2 has more likelihood than previously assessed. However, it represents an alternative path to decarbonizing electricity generation and isn't a significant change.
The use of CCS in gas production has greater potential than was assessed in Ināia tonu nei. However, the economic viability remains uncertain, and doesn't reduce emissions from consumer combustion, resulting in limited potential savings.</td></tr>
</table>

9. Fossil gas reserves and supply have declined					
Change being assessed:	A faster than expected decline in natural gas production volumes was seen in 2023 and 2024.[31] This is below that modelled for the demonstration path in *Ināia tonu nei*. The impacts could include the early closure of Methanex,[32] higher amounts of coal in electricity production, greater rates of renewables build, higher electrification (or biomass) use in process heat, as well as higher gas and electricity prices. Repeal of the exploration ban on oil and gas, may impact future supply, but the timing is unlikely to affect the second and third emissions budgets, and likelihood of success is currently uncertain. CCS could come online sooner, and mitigate emissions, but this is also uncertain. Gas was assumed to have an ongoing role in *Ināia tonu nei* during the transition.			**CCRA Criteria**	5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand. 5ZC 2b(viii) economic circumstances and the likely impact of the Minister's decision on taxation, public spending, and public borrowing. 5ZC 2b(v) the results of public consultation on an emissions budget.
Qualitative Test for Significant Change:	**1. Material impact**: How does the change affect the level of emissions reductions possible?	**2. Likelihood**: What is the likelihood that the impact on budgets will be realised?	**3. Permanence**: Is the change permanent, or could it be reversed?	4. **Reason for change**: Has it changed our assessment of what is feasible in a budget period?	**Decision:** **Not a Significant Change**
Findings:	The estimates are 3 to 7 $MtCO_2e$ decrease in emissions in the second and third emissions budget periods from reduced gas supply. The estimates are highly uncertain, depending on the response path chosen. **EB1**: - **EB2**: – **EB3**: –	The status is too uncertain to know what the impact on budgets will be. Whatever the solution, it is likely to be at a higher cost than is currently modelled.	If we adjusted budgets now for a shortfall in gas this could be reversed in future if gas exploration and extraction occur again in future. Alternatively, a decision to speed up electrification could make the displacement of gas permanent. It is too early to understand the consequences.	The lower gas supply should reduce emissions. There could be an argument to lower budgets in response so that the same effort is maintained across sectors. Equally it could be treated no differently to a reduction achieved purposely through policy. The uncertainty in the impacts is too high.	The lower gas supply is a physical constraint that deviates from the assumptions used in *Ināia tonu nei*. The impact is likely to be moderate in terms of emission budgets but it is highly uncertain to know at this stage, given the range of feasible responses (more gas exploration, renewables, imports of LNG, CCS, electrification and biomass). The costs may be higher with the different options. It doesn't, at this stage, necessitate a change in emission budgets, and existing budgets remain achievable.

10. Methane inhibitor 3-NOP					
Change being assessed:	In 2023, the Environmental Protection Authority (EPA) approved 3-nitrooxypropanol (3-NOP or trade name Bovaer®) for import or manufacture,[33] as a feed additive to reduce methane emissions in livestock.			**CCRA Criteria**	5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand.
Qualitative Test for Significant Change:	1. **Material impact**: How does the change affect the level of emissions reductions possible?	2. **Likelihood**: What is the likelihood that the impact on budgets will be realised?	3. **Permanence**: Is the change permanent, or could it be reversed?	4. **Reason for change**: Has it changed our assessment of what is feasible in a budget period?	**Decision:** **Not a Significant Change**
Findings:	Emissions savings would depend upon the uptake rate and speed of adoption which are currently unknown. *Ināia tonu nei* set out that if widely adopted, feeding 3NOP to dairy cattle could reduce emissions by ~5% (by 2030). **EB1** | **EB2** | **EB3** - | - | -	In *Ināia tonu nei* methane inhibitors were not considered to be available under the demonstration path within the first to third emissions budget periods. The EPA approval may make it more likely to occur in this time period, potentially from the second emissions budget period.	To our knowledge, there is no change yet in how effectively 3-NOP could reduce emissions, how barriers that exist can be overcome (e.g. applicability to pastoral farming), or the costs to implement across Aotearoa New Zealand. This gives us low confidence regarding the change. There are a number of uncertainties. There is not a high degree of confidence that the cause of the change is permanent.	This mitigation would increase what is feasible within a budget period.	The likelihood that a methane inhibitor will be available in Aotearoa New Zealand by 2025–2030 period (the second emissions budget) has increased since the notified budgets. However, there is no change yet to the knowledge of how effectively they could reduce emissions, barriers that may exist, or the costs to implement across the country. The uncertainties remain too large to recommend this be a significant change.

<table>
<tr><th colspan="6">11. Lower afforestation rates anticipated in forthcoming years</th></tr>
<tr><td>Change assessed:</td><td colspan="3">Afforestation rates have been substantially higher between 2020 and 2024 (Figure 18) than anticipated when budgets were previously set. However, the 2023 Afforestation and Deforestation Intentions Survey (ADS) released in 2024 indicates a substantial decline in exotic afforestation over the next few years.</td><td>CCRA Criteria</td><td>5ZC 2b(iii) Existing technology and anticipated technological developments, including the costs and benefits of early adoption of these in New Zealand

5ZC 2b(v) the results of public consultation on an emissions budget</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td>1. Material impact: How does the change affect the level of emissions reductions possible?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:

Not a Significant Change</td></tr>
<tr><td>Findings:</td><td>Applying the ADS survey estimates 2025–2030 (2025: 17700ha; 2026: 15800ha; 2027: 11300ha; 2028: 8500ha; 2029: 8000ha; 2030: 8000ha) results in an increase in net emissions in the second and third emissions budgets compared to set budgets.

EB1: 0 Mt | EB2: 1 Mt | EB3: 15 Mt</td><td>The ADS survey is likely to be a good approximation for the next couple of years, with more uncertainty beyond that to 2030. The afforestation rate and magnitude of the impact are uncertain.</td><td>If afforestation were to decline, the impact of the change on the second and third emissions budget is unlikely to reverse, but subsequent budgets could change if afforestation rates increase again.</td><td>This change would impact our assessment of what is feasible in budget periods.</td><td>Forecasts of future planting rates for new forests are inherently uncertain, which limits their ability to be used as evidence for significant change.</td></tr>
</table>

EB1	EB2	EB3
0 Mt	1 Mt	15 Mt

<table>
<tr><th colspan="6">12. Implication of land-use changes on communities</th></tr>
<tr><td>Change being assessed:</td><td colspan="3">Since budgets were set, the rate of exotic afforestation has been higher than projected. The implications of land-use changes (LUC) on communities was explicitly discussed in Ināia tonu nei, which recognised that large-scale conversions to forestry could affect communities. Notable increases in net stocked area of exotic forest have occurred in the Tasman and Marlborough Districts.[34, 35]</td><td>CCRA Criteria</td><td>5ZC 2b(ix) The implications, or potential implications, of land-use change for communities</td></tr>
<tr><td>Qualitative Test for Significant Change:</td><td>1. Material impact: How does the change affect the assessment of impacts?</td><td>2. Likelihood: What is the likelihood that the impact on budgets will be realised?</td><td>3. Permanence: Is the change permanent, or could it be reversed?</td><td>4. Reason for change: Has it changed our assessment of what is feasible in a budget period?</td><td>Decision:
Not a Significant Change</td></tr>
<tr><td>Findings:</td><td>While afforestation has been higher than anticipated when budgets were previously set and this afforestation has been focused in the Tasman and Marlborough Districts, the implications of the observed land use change are broadly in line with our understanding of the potential implications when budgets were previously set.

EB1 | EB2 | EB3
- | - | -</td><td>N/A</td><td>Social and economic impacts on communities, such as changes to employment, can be influenced by a range of factors including the policy response and the overall intensity of land use change.</td><td>N/A</td><td>Since budgets were set, afforestation has been higher than projected. How this progresses in the next few years could dictate the impacts on communities. There is a limited body of literature addressing the social impacts of land-use changes, and these studies were available at the time the budgets were set. No further climate policies have been announced or introduced that are likely to significantly influence land-use change and impact rural communities.</td></tr>
</table>

13. Changes to New Zealand obligations under international agreements

Methodology for assessment of changes to NZ obligations under international agreements	We have identified three criteria which we consider should all be met for a change to Aotearoa New Zealand's obligations to justify a change to one or more emissions budgets. The change to the obligations should be: 1. **Binding**. Many agreements, initiatives and decisions (referred to in this document as agreements) that Aotearoa New Zealand has been a party to are not enforceable. Some are agreements in principle only, while others may be precursors to future binding agreements. Unless an agreement is binding it is unlikely to have a material effect on Aotearoa New Zealand's emissions. 2. **Relevant to the 2050 target**. The agreements that Aotearoa New Zealand is party to have varying levels of relevance to the 2050 target or the NDC. 3. **Sizable**. Could it contribute to a notable, important and consequential change? If it is materially significant, then it is likely that it will affect at least one other matter listed in section 5ZC. The agreement must have been agreed, or updated, in the period following the current emissions budgets being published.	**CCRA Criteria**	5ZC 2b(xi) Aotearoa New Zealand's relevant obligations under international agreements.

International agreement assessed	**Is it binding?**	**Is it relevant to the 2050 target?**	**Is it notable, important or consequential. Does it affect another matter in 5ZC?**	**Decision**	**Justification**
Net zero Government Initiative	×	✓	×	**Not Significant**	This example does not meet the criteria because while it has some relation to the 2050 target, it is not binding and it currently presents no important, notable, consequential change.
EU Free Trade Agreement	×	✓	×	**Not Significant**	This agreement is not binding yet but will be once it comes into force. It includes a range of climate and environmental obligations with direct reference to the Paris Agreement and has a substantial nexus with the 2050 target. As this agreement has yet to be ratified, it presents no important, notable, consequential changes at this time although it is possible that it could in the future.

UK Free Trade Agreement	✓	✓	×	Not Significant	This agreement is binding and includes a disputes resolution process, it differs from the FTA with the EU as it does not include an option to use trade sanctions against a signatory if that signatory does not fulfil an obligation. This agreement has a high nexus with the 2050 target as many of its obligations cover a wide range of policy interventions that will enable Aotearoa New Zealand to meet emissions budgets and reach the 2050 target. No matters stemming from this agreement with the UK could cause or contribute to important, notable, consequential changes to emissions budgets at this time. However, because this agreement is binding and has strong nexus with the 2050 target, it is possible that it could cause or contribute to such a change in the future.
UNCLOS Marine Diversity	✓	×	×	Not Significant	An advisory opinion update to UNCLOS was made in May 2024. UNCLOS now includes a definition of pollution to include biodiversity loss and ecosystem degradation attributable to climate change. UNCLOS is binding and enforceable, but the advisory opinion is not binding (although could be submitted in evidence). The Agreement still has a low nexus with the 2050 target as it does not include parts that set emission reductions targets or budgets. No part of the Ocean Treaty could cause or contribute to important, notable, consequential changes to emissions budgets at this time.
Friends of Fossil Fuel Subsidy Reform	×	×	×	Not Significant	The Statement was not binding and has a low nexus with the 2050 target. The Glasgow Climate Pact, to which it refers, was agreed in 2021, and could therefore have been considered when the current budgets were set. The Statement could not cause or contribute to important, notable, or consequential changes to emissions budgets at this time.
Food and Agriculture for Sustainable Transformation Initiative	×	×	×	Not Significant	The Initiative is not binding and has a low nexus with the 2050 target because of its narrow scope and focus on 2030. The Initiative could not cause or contribute to important, notable, consequential changes to emissions budgets at this time.

Article 6 Implementation Partnership	×	×	×	**Not Significant**	The Partnership is not binding and has a low nexus with the 2050 target. The Partnership could not cause or contribute to important, notable, consequential changes to emissions budgets at this time.
Sharm el-Sheikh Implementation Plan	×	✓	×	**Not Significant**	None of these decisions are binding. They have a generally low nexus with the 2050 target, with references to 2030 NDC targets having the strongest nexus. None of these decisions could cause or contribute to important, notable, or consequential changes to emissions budgets at this time.

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