

Aotearoa New Zealand's first emissions reduction plan: Technical information annex



Ministry for the
Environment
Manatū Mō Te Taiao



Te Kāwanatanga o Aotearoa
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Introduction

This appendix contains:

- sector-specific and economy-wide emissions estimates reflecting the anticipated abatement from key policies and measures in the emissions reduction plan
- a comparison of projected emissions levels, including the anticipated abatement from emissions reduction plan policies and measures to the first three emissions budgets
- supporting information for the approach and methodology with which these estimates were calculated, including modelling limitations and uncertainties.

Emissions estimates

The figures presented below reflect our best estimates of future emissions levels in New Zealand, including the anticipated abatement impact of quantified policies and measures in our first emissions reduction plan. Our estimates are based on emissions projections and the modelled impact of quantified policies and measures across important sectors of the economy. These estimates reflect our best understanding of our future emissions levels, including the anticipated future impact of quantified policies. However, they are subject to significant levels of uncertainty.

Estimated emissions abatement

To reflect the impact of elements of uncertainty on our estimates, table 1 presents modelled emissions abatement impact from quantified policies and measures across sectors as a range from low to high policy impact over the first three emissions budgets except for the forestry sector (see [table 1a](#)). Importantly, the figures in table 1 do not include the impact of any uncertainties regarding the underlying greenhouse gas (GHG) emissions projections nor do they include the impacts of policies and measures in the emissions reduction plan that have not been quantified.

The forestry policy impact ranges are presented in [table 1a](#).

Table 1: Estimated emissions abatement from policies and measures by sector

Emissions abatement from policies and measures (AR5 Mt CO ₂ -e)		1st Budget 2022–25	2nd Budget 2026–30	3rd Budget 2031–35
Transport				
1.	Low impact estimate	-1.7	-5.9	-8.3
2.	High impact estimate	-1.9	-6.8	-10.6
Energy and Industry¹				
3.	Low impact estimate	-2.7	-16.1	-19.3
4.	High impact estimate	-6.2	-27.6	-33.2
Waste				
5.	Low impact estimate	-0.2	-1.9	-3.8
6.	High impact estimate	-0.4	-2.7	-4.5
Fluorinated gases				
7.	Low impact estimate	-0.1	-0.3	-0.9
8.	High impact estimate	-0.5	-1.0	-1.7
Agriculture				
9.	Low impact estimate	-0.3	-3.8	-19.1
10.	High impact estimate	-2.7	-53.8	-64.1

¹ Energy and Industry comprises non-transport energy plus industrial processes and product use less fluorinated gases.

Emissions abatement from policies and measures (AR5 Mt CO ₂ -e)		1st Budget 2022–25	2nd Budget 2026–30	3rd Budget 2031–35
Forestry²				
11.	Low impact estimate	-0.3	-2.8	-7.1
12.	High impact estimate	-0.3	-2.8	-7.1
Total from all sectors				
13.	Low impact estimate	-5.4	-30.9	-58.4
14.	High impact estimate	-11.9	-94.7	-121.3

Note: AR5 = Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, 2014; Mt CO₂-e = million tonnes of carbon dioxide equivalent.

Each sector has modelled a low and high policy impact scenario. In reality, it is likely that actual abatement in some sectors is more aligned to a ‘high policy impact’ scenario while the actual abatement in other sectors may be more aligned to a ‘low policy impact’ scenario. It is therefore unlikely that actual total abatement falls at either the low or the high end of the modelled range. In fact, it is more likely to fall somewhere in the middle.

Benchmarking to New Zealand’s Greenhouse Gas Inventory

The GHG projections and policy impact estimates that inform [table 1](#), [table 1a](#) and [table 2](#) are largely benchmarked to New Zealand’s Greenhouse Gas Inventory (GHG Inventory). The GHG projections and policy impact estimates are benchmarked to the previous version of the GHG Inventory 1990–2019, published in April 2021. A more recent GHG Inventory (1990–2020) was published in April 2022 but has not been incorporated into the GHG projections and policy impact estimates due to its recent release.

Uncertainty in forestry sector estimates

The uncertainty range around policy impact estimates for the forestry sector (6.5 million tonnes (Mt)) is very high relative to other sectors. This is primarily due to the uncertainties around deforestation, which can have high emissions impacts. To mitigate the impact of this significant range on the aggregate estimates, we have used a central estimate for abatement in the forestry sector for all considered scenarios in [table 1](#) and [table 2](#). The full range of estimates for the forestry sector, including the ‘low’ and ‘high’ policy impact scenarios, is captured in the sub-table below. This table presents the full range of modelled forestry estimates under two forestry scenarios: one including a proposed restriction to registering exotic forestry in the new Permanent Post-1989 Emissions Trading Scheme (ETS) category and the other allowing for registration of exotic forestry in this category. Policy decisions in this area are yet to be made. Given the large scale of the potential impact of these policy decisions on the abatement estimates from the forestry sector, we have presented both scenarios in [table 1a](#).

² Provides the central estimate of the total impact of forestry policies while assuming exotic forests are restricted from registering in the Permanent Post-1989 ETS category. High and low ranges and a scenario excluding this policy are included in [table 1a](#).

Table 1a: Incorporating low and high forestry policy impact ranges

Emissions abatement from policies and measures (AR5 Mt CO ₂ -e)		1st Budget	2nd Budget	3rd Budget
Impact of forestry policies – assuming exotics are restricted from registering in the Permanent Post-1989 ETS category				
15.	Low impact estimate	3.5	2.8	7.8
16.	Central impact estimate	-0.3	-2.8	-7.1
17.	High impact estimate	-2.9	-9.7	-24.7
Total from all sectors				
18.	Low impact estimate	-1.6	-25.3	-43.6
19.	High impact estimate	-14.5	-101.6	-138.8
Impact of forestry policies, assuming exotics are not restricted from registering in the Permanent Post-1989 ETS category				
20.	Low impact estimate	3.7	0.8	-13.5
21.	Central impact estimate	0.1	-6.2	-48.5
22.	High impact estimate	-2.3	-15.3	-83.4
Total from all sectors				
23.	Low impact estimate	-1.4	-27.3	-64.8
24.	High impact estimate	-14.0	-107.2	-197.5

Estimated emissions levels against emissions budgets

Table 2 provides a comparison of projected emissions levels for each of the first three emissions budgets, taking the range of potential abatement anticipated from quantified emissions reduction plan policies and measures, as reflected in [table 1](#), into account. These estimates are provided for a scenario in which the New Zealand’s Aluminium Smelter at Tiwai Point closes in 2024 and for a scenario in which it remains open after this date, reflecting the impact of this specific uncertainty on the overall estimates.

Table 2: Comparison of estimated emissions levels against emissions budgets³

Comparison of estimated emissions levels against emissions budgets (AR5 Mt CO ₂ -e)	1st Budget 2022–25	2nd Budget 2026–30	3rd Budget 2013–35
Projected emissions without emissions reduction plan abatement measures (counterfactual)	299.1	339.2	310.7
Projected emissions with emissions reduction plan abatement measures – low impact estimate	293.7	308.3	252.3
Projected emissions with emissions reduction plan abatement measures – high impact estimate	287.2	244.5	189.5
Emissions budgets	290.0	305.0	240.0

³ Assumes exotic forests are restricted from registering in the Permanent Post-1989 ETS category.

Comparison of estimated emissions levels against emissions budgets (AR5 Mt CO ₂ -e)	1st Budget 2022–25	2nd Budget 2026–30	3rd Budget 2013–35
If New Zealand’s Aluminium Smelter was assumed to remain open beyond 2024:			
Projected emissions without emissions reduction plan abatement measures (counterfactual)	301.5	348.5	313.7
Projected emissions with emissions reduction plan abatement measures – low impact estimate	296.1	317.6	255.3
Projected emissions with emissions reduction plan abatement measures – high impact estimate	289.6	253.8	192.5
Emissions budgets	290.0	305.0	240.0

Approach

Greenhouse gas emissions projections

The emissions reduction plan uses New Zealand's GHG emissions projections as its starting point. These provide a business-as-usual projection of our anticipated future emissions levels that can help us understand the additional emissions reductions required to meet the emissions budgets. These projections provide an estimate of the counterfactual (or baseline scenario) of a world in which there was no emissions reduction plan; in other words, what would be expected to occur if no further actions were undertaken to reduce domestic emissions other than those policies and measures already in place.⁴

The Climate Change Commission (the Commission) took a similar approach in modelling its 'Current Policy Reference' case projections. These were largely aligned to the latest Government GHG projections available at the time (May 2021) although differed in some areas. These differences are described in more detail in the '[Differences from the Climate Change Commission's analysis](#)' section.

The projections used to support the modelling of emissions reduction plan policies as presented in [table 1](#) and [table 2](#) are based on the latest GHG projections finalised by the Government in June 2021 and published by the Ministry for the Environment in March 2022.⁵ The June 2021 Government projections included assumptions about two large industrial emitters that have material implications for New Zealand's anticipated emissions trajectory: Refining New Zealand (the oil refinery at Marsden Point) and New Zealand's Aluminium Smelter. For our analysis to support the development of the emissions reduction plan, we have adjusted the June 2021 Government projections, as described below.

Refining New Zealand announced and subsequently began the oil refinery's transition to an import-only terminal on 1 April 2022. The June 2021 Government's GHG projections have previously assumed the refinery would continue to operate indefinitely. The estimated impact of the closure of the refinery is to reduce projected emissions by 3 Mt CO₂-e in emissions budget 1 (EB1) and by 4.25 Mt CO₂-e in each future emissions budget period (including, and beyond, EB2 and EB3). In response to the refinery's announcement, we have adjusted our emissions projections downwards, to account for this estimated impact. The June 2021 Government's projections assumed New Zealand's Aluminium Smelter would close at the end of 2024. Since the Government's projections were finalised in June 2021, expectations around future aluminium prices have increased and the outlook for the smelter has changed. A significant chance exists that it will close in 2024; however, the likelihood it will continue to operate has substantially increased. Due to the uncertainty around the continued operation of the smelter, we have considered a scenario in which the smelter closes (reflecting our underlying assumption) alongside a scenario in which the smelter remains open beyond 2024. The estimated impact of the continued operation of the smelter beyond 2024 is to increase our projected emissions levels by 2.4 Mt CO₂-e in EB1, by 9.3 Mt CO₂-e in EB2 and 3 Mt CO₂-e in EB3.

⁴ We refer to this approach as calculation on a with existing measures (WEM) basis, which encompasses only policies and measures that have been implemented and adopted at the point in time that the projections are made.

⁵ These projections are benchmarked to the GHG Inventory 1990–2019 published in April 2021 and will be updated again later in 2022.

Using the GHG emissions projections to support emissions reduction plan policy modelling

The Government's GHG projections, with the amendments referenced above, provide a base case. Upon the base case, we can consider the anticipated impact of quantified emissions reduction plan policies and measures and compare New Zealand's anticipated future emissions levels under the impact of quantified emissions reduction plan policies and measures with the emissions budgets. The quantification of the abatement impact of emissions reduction plan policies and measures was undertaken by agencies, including the Ministry for the Environment (MfE), Ministry of Business, Innovation and Employment (MBIE), Ministry of Transport (MoT), Ministry for Primary Industries (MPI) and Energy Efficiency and Conservation Authority (EECA), with a focus on policies and measures in their respective sectors.

Differences from the Climate Change Commission's analysis

While differences exist between the Commission's and the Government's evidence bases and models, the data used to support the Government's GHG emissions projections and the Commission's advice were broadly aligned at the time of the publication of the Commission's May 2021 advice: 'Ināia tonu nei: a low emissions future for Aotearoa'⁶. However, since the Commission's final advice was delivered, several updates have been made to the evidence base used to support their analysis.

Significant revisions to the Government's GHG projections that were undertaken following the Commission's final advice are as follows.

- New survey information was received that led to a significant revision of the June 2021 Government GHG projections for the forestry sector. The impact of these revisions was that the gap between these projections and the Commission's recommended first emissions budget was widened by 1.5 Mt CO₂-e, and narrowed for the second and third emissions budgets by 5.0 Mt CO₂-e and 10.7 Mt CO₂-e respectively. This revision indicated that EB1 is more difficult to achieve and EB2 and EB3 are less difficult to achieve than the Commission's analysis suggested.
- The June 2021 Government projections for the agriculture sector were also revised substantively, widening the gap between these projections and the Commission's recommended first and second emissions budgets by 2.4 Mt CO₂-e and 1.6 Mt CO₂-e respectively, and narrowing the gap between these projections and the third emissions budget by 0.2 Mt CO₂-e. This revision indicated that EB1 and EB2 are more difficult to achieve and EB3 is less difficult to achieve than the Commission's analysis suggested.
- As noted in the section above, Refining New Zealand announced and subsequently began the oil refinery's transition to an import-only terminal. The impact of this transition is estimated to reduce emissions by 3 Mt CO₂-e in EB1 and by 4.25 Mt CO₂-e in each future budget period (including, and beyond, each of EB2 and EB3). This has resulted in EB1, EB2 and EB3 being less difficult to achieve than the Commission's analysis suggested.
- Also as noted in the section above, New Zealand's Aluminium Smelter was assumed to close at the end of 2024. Since the time of publication of the Commission's advice, the likelihood of the smelter continuing to operate beyond 2024 has greatly increased.

⁶ www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/

The estimated impact of the smelter remaining open is an increase in emissions of 2.4 Mt CO₂-e in EB1, 9.3 Mt CO₂-e in EB2 and 3 Mt CO₂-e in EB3. If the aluminium smelter were to continue to operate indefinitely, it would result in EB1, EB2 and EB3 being more difficult to achieve than the Commission’s analysis suggested.

- The collective impact of the differences noted above (assuming the smelter remains open) is that achieving the first emissions budget, as recommended by the Commission, would require an additional 3.3 Mt CO₂-e of emissions reductions.

Emissions budgets

Emissions budgets are our ‘stepping stones’ between where we are now and our long-term 2050 targets. At the end of each emissions budget period, we will compare our emissions levels to our emissions budget to measure our progress. Once set by the Minister of Climate Change, the ability to revise emissions budgets is limited. Any revision must take place following a recommendation from the Commission. Only emissions budgets for future periods can be revised.

The Commission recommended emissions budgets of 290 Mt, 312 Mt⁷ and 253 Mt for EB1, EB2 and EB3 respectively. The emissions budgets set by the Minister of Climate Change differ from the Commission’s recommendations, to take account of information from the latest Afforestation and Deforestation Intentions Survey published in June 2021 (table 3). This information was not available to the Commission when it delivered its final advice in May 2021. This adjustment was made only for the new information on afforestation, which meant the emissions budgets set are 7 Mt CO₂-e and 13 Mt CO₂-e lower in EB2 and EB3 respectively. The emissions budget set for EB1 is the same as the Commission’s recommendation.

Table 3 Comparison of the Climate Change Commission’s recommended emissions budgets with the emissions budgets as set by the Minister of Climate Change

AR5 Mt CO ₂ -e	Emissions budget 1	Emissions budget 2	Emissions budget 3
Commission’s recommended budgets	290.0	312.0	253.0
Emissions budgets	290.0	305.0	240.0

⁷ The second emissions budget is greater than the first because the first emissions budget covers four years, 2022–25, whereas the second emissions budget and all future budgets are for five years.

Modelling limitations and uncertainty

All emissions estimates and projections are subject to both modelling limitations and uncertainty. Our emissions models, like all models, are simplified imperfect versions of the real world and, for this reason, are limited in their ability to predict the future.

Modelling limitations

All emissions estimates and projections are subject to the limitations of the models and methods used to produce those estimates. These limitations mean the emissions impacts of some policy initiatives, indirect emissions reduction plan-related actions and unforeseen events have not been incorporated into the GHG projections or accounted for in the modelling.

Examples of these limitations are summarised below.

- **Some emissions reduction plan policies have not been quantified:** An example of this is the impact the ETS price corridor increase will have on refrigerants (or hydrofluorocarbons (HFCs)). HFCs are relatively sensitive to the ETS price and this initiative is expected to contribute to significant emissions reductions. However, quantified impacts of this policy were not able to be modelled, largely due to a lack of robust data.
- **Some emissions reduction plan policies have only been partially quantified in the emissions reduction plan:** An example is the impact of the ETS setting changes that increased the price corridor. Estimates of the impact of this policy change were able to be calculated for areas such as process heat, transport and forestry. Estimates were not able to be calculated for fluorinated gases even though they would be expected to be significantly affected by higher NZ ETS prices.
- **Indirect emissions reduction plan-related impacts:** An example of this is that the increasing publicity on climate change will lead to more individuals, businesses and local government taking abatement action that otherwise would not have occurred. This is not represented in the projections or estimates.
- **Recent events not included:** An example of this is that the latest GHG emissions projections are nine months old. While we have been living with the COVID-19 pandemic for two years, the impact of its spread and restrictions are only just being captured in our GHG inventory estimates. Other events that may have significant impacts on emissions have happened since the June 2021 Government projections and include the increasing carbon price and recent oil price hikes. These impacts have not been included in the modelling.
- **Limited data or assumptions:** An example of this is in the waste sector where we do not have a good indicator of the tonnage of waste going into farm fills. We apply assumptions to extrapolate farm fill waste volumes as an indicator of tonnage. The impact is that actual waste tonnage to landfill and the subsequent emissions are likely to be significantly different.
- **Model design is a simplification of the real world:** An example of design uncertainty is from the ETS policy modelling where the model assumes that an emitter will convert to

renewable energy sources once the carbon price reaches a certain level. However, the real world is more complicated than this. An emitter may choose to convert early or delay conversion for reasons that cannot be predicted or used in the model. The emitter may find a different solution not defined in the model that affects their emissions. Often, adjustments are made within the models to attempt to moderate the impact of this type of limitation.

Uncertainty

All emissions estimates and projections are subject to varying degrees of uncertainty. Low levels of uncertainty suggest we can be confident in our emissions estimates, high levels of uncertainty suggest we should be less confident in our emissions estimates. If our projections or estimates of policy impacts change significantly then this has implications for our understanding of whether our quantified policy actions and measures put us on a trajectory that will achieve our emissions budgets.

An example of the potential impact uncertainties can have on our GHG projections is given in table 4. This table compares the magnitude of the revision to the June 2021 Government GHG projections published in March 2022 from the projections published in January 2021 to the abatement required from additional policies and measures to achieve the first three emissions budgets. For the first emissions budget, the projections have been revised upward by an amount that is significantly greater than the level of emissions reductions estimated to be required to meet the first emissions budget (15.5 Mt compared with 11.5 Mt). Table 4 shows the degree to which uncertainty can influence our quantified estimates and have material implications for the level of abatement required to meet our emissions budgets.

Table 4: How uncertainty influences the level of abatement required to meet emissions budgets

AR5 Mt CO ₂ -e	Emissions budget 1	Emissions budget 2	Emissions budget 3
Revision to projections between January 2021 and March 2022 ⁸	15.5	9.4	11.7
Required emissions reductions to meet emissions budgets ⁹	11.5	43.5	73.7

Uncertainty impacts our estimates in many ways. Some uncertainties relate to the historical estimates, the emissions models, policy implementation, and others are unforeseen events. Further descriptions of different types of uncertainties are summarised below.

Measurement and reporting uncertainties

A risk is that the achievement of emissions budgets could be affected by improvements to emissions reporting during the budget period.

The GHG Inventory represents our best estimate of actual historical emissions. The methods and emissions factors in the GHG Inventory have been used to help set the emissions budgets, and future inventory reports will also be used to evaluate whether emissions budgets have been met. However, an entire emissions time series can change from year to year as

⁸ The revision between these two sets of GHG projections was large, compared with historic revisions, but provides a good example of the potential impact of uncertainty on the emissions estimates in [table 1](#) and [table 2](#).

⁹ This is the gap between the projections used in the emissions reduction plan and the emissions budgets

improvements to the accuracy of the GHG Inventory are implemented. These changes have implications for both our GHG projections and policy impact modelling. It is possible changes to the GHG Inventory may end up being one of the main reasons why an emissions budget is achieved or not achieved, rather than due to specific emissions reduction actions. If Inventory changes were to significantly affect the achievement of emissions budgets then the Commission noted in its final report that ‘this could then be factored into the Commission’s advice and commentary on the adequacy of the emissions reduction plan’.¹⁰

An example of this is improvements to the agriculture estimates implemented as part of the 2021 GHG Inventory. These improvements increased the entire historical and projected agriculture emissions time series by four per cent to five per cent, which corresponds to an increase in projected emissions in the EB1 period of around 7 Mt CO₂-e.

Input data and assumption uncertainties

Emissions projections and the impacts of policy measures are estimated using emissions models that use input data and assumptions to provide insight into what may happen in the future. However, as noted, none of these models are explicitly predictive. How closely a model is able to represent the future is partially affected by modelling choices on how to represent reality and significantly influenced by uncertainty inherent in the input data and assumptions.

The uncertainties in our input data and assumptions in our models lead to uncertainties in our modelling estimates. An example is the use of the Stats NZ population projections in the GHG projections. These population projections are inherently uncertain, which adds to the broader uncertainties of the GHG projections. Another example is policy efficacy relating to assumptions made about how effective policies are at changing behaviour, such as electric vehicle (EV) uptake, recycling materials or reducing farming emissions.

Implementation uncertainties

Implementation uncertainties stem from differences between the policy scenario that was modelled and how and when the policy is actually implemented. The emissions modelling often occurs ahead of final policy decisions and changes to the policy, for example, resourcing, implementation and timing affect how much abatement an initiative achieves. If the modelled implementation assumptions differ from what is actually implemented then the modelled estimates will be inconsistent to a certain extent. An example of this is a policy that is modelled to reduce emissions by 100 kilotonnes (Kt) per year and is due to be implemented in 2023, however, subsequent to the modelling, the policy was delayed until 2024 so instead of reducing emissions in EB1 by 300 Kt (three years by 100 Kt) it reduces them by 200 Kt (two years by 100 Kt).

Unforeseen uncertainties

Unforeseen uncertainties are those that cannot be modelled because they are unforeseen and not able to be predicted. An example is the effect that the COVID-19 pandemic has had on emissions over the past couple of years. These are often referred to as ‘black swans’ or ‘unknown unknowns’.

¹⁰ Climate Change Commission (May 2021) *Ināia tonu nei: a low emissions future for Aotearoa*, p 206. See <https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa.pdf>

Accounting approach and global warming potentials

Accounting approach

Emissions can be accounted for by applying a range of approaches; the different approaches determine the types of emissions that are within scope. Two approaches are described below, although variations can then be applied within them (particularly the production approach).

- The production approach records emissions at the point at which emissions pass from human activity to the environment. It has two variations: the territory-based approach (used by MfE's GHG Inventory) and the residency-based approach (used by Stats NZ's System of Environmental-Economic Accounting or SEEA framework).
- Consumption-based emissions estimates show the emissions resulting from the economic activity required to meet a nation's demand for goods and services. They reflect the carbon footprint of a nation's consumption and lifestyle choices.

The different approaches have different strengths and weaknesses. However, no international standard exists for measuring consumption-based emissions and it is subject to greater uncertainties given the use of modelling assumptions. National GHG inventories that are submitted to the United Nations Framework Convention on Climate Change apply the production approach and they are the only source of emissions data mandated internationally for use against targets. New Zealand applies the production approach for its international GHG reporting under the United Nations Framework Convention on Climate Change, which it began in 1995, and for its emission reduction target accounting since 2008. The GHG Inventory, GHG projections and emissions budgets are all based on the territory-based production approach.

New Zealand inventories its human-induced GHG emissions annually, going back to 1990, in the GHG Inventory. These emissions are reported within five sectors: energy, industrial processes and product use, agriculture, waste, and land use, land-use change and forestry. When all five sectors are considered, these make up New Zealand's net emissions. The first four sectors listed make up New Zealand's gross emissions. When it comes to accounting for targets, historically, under the Kyoto Protocol, at least, the land sector is treated differently.

The approach that has been communicated for New Zealand's first Nationally Determined Contribution under the Paris Agreement builds on the accounting rules of the Kyoto Protocol, which were used for New Zealand's 2008–12 Kyoto Protocol target and its 2013–20 target. Target accounting uses gross emissions estimates from the national GHG Inventory but accounts for the land sector differently. The removals used for target accounting, a subset of net removals from the land sector, are also published in the GHG Inventory.

New Zealand has also communicated that it will apply a long-term average carbon stock ('averaging') approach to accounting for the emissions and removals from afforestation activities (that is, forests that have been established since 1990), as well as using a reference-level approach for accounting for pre-1990 forests. All emissions from deforestation activities are included in the accounting.

The Commission's advice applied a variation of these accounting rules to its recommended emissions budgets. They included afforestation (also applying the averaging approach) and deforestation only.

The Climate Change Response Act 2002 directs that accounting against the target for 2050 and for emissions budgets requires net accounting of emissions as reported in the New Zealand GHG Inventory. This means it will follow a production approach and that accounting against budgets will include emissions and removals from all five sectors (energy, industrial processes and product use, agriculture, waste, and land use, land-use change and forestry), as well as offshore mitigation.

Reducing emissions that are out of scope of the approach we are using is still beneficial, but they do not count towards the emissions budgets. Examples of where this is the case are as follows.

- Reducing amount of iron, steel and concrete that is used in construction: This will count towards meeting emissions budgets for the portion of these products that are domestically produced but not when the products are imports (although the action will contribute to global emissions reductions).
- Holidaying domestically rather than internationally. This will actually increase our domestic emissions although the overall global impact would likely be a reduction in emissions, so such an action is beneficial.

Global warming potentials

Global warming potentials (GWPs) are used when aggregating non-carbon dioxide (CO₂) GHGs because different GHGs have different warming impacts. It is important when comparing and/or aggregating emissions that a consistent set of GWPs is used, otherwise the comparisons can be misleading. New Zealand's GHG Inventory, projections, and emissions budgets all apply GWPs to calculate aggregate totals.

Emissions in the emissions reduction plan are calculated using GWPs (any exceptions will be clearly noted) from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, 2014 (AR5) based on a 100-year time horizon (warming impact over this period) relative to CO₂. New Zealand's emissions outputs are in the process of transitioning from using IPCC Fourth Assessment Report (AR4) GWPs, which are applied to the 2022 GHG Inventory (1990–2020) submission, to AR5, which will be applied to the 2023 submission onwards. The Commission's analysis was largely calculated and presented in AR4 terms. However, the Commission notably presented its final recommended emissions budgets in AR5.

Summary of methods and assumptions

The modelling exercise to quantify the emissions impacts of the emissions reduction plan policies and measures has been extensive and includes a large number of policies. Some policy impacts have been modelled individually whereas others have been modelled in groups of policies in a way that captures interactions between the policies.

This section provides information about the policies that have been quantified and included in [table 1](#) and [table 2](#), as well as summary information about the modelling of those policies. The modelling has been largely sector based and, for this reason, the information is grouped by sector.

Transport

The quantification of policy impacts for the transport sector was undertaken by the Ministry of Transport.

Policies and measures that have been quantified¹¹

- Clean vehicle standard and discount (including vehicle fuel economy labelling).
- Decarbonising all public transport buses by the end of 2035.¹²
- Light EV road user charge exemption.
- Sustainable biofuels obligation.
- More efficient rail locomotives and ferries as funded through Budget 21 (Future of Rail – rolling stock and ferries).
- Initial investments to improve safety and access to public transport and active modes.
- ETS price corridor increase.

Key policies and measures that have not been quantified

The following actions have not been explicitly quantified beyond the policy impact of the initial investments to improve safety and access to public transport and active modes:

- Action 1.1. Integrate land use planning, urban development and transport planning and investments to reduce transport emissions.
- Action 1.2. Support people to walk, cycle and use public transport.
- Action 1.3 Enable congestion charging and investigate other pricing and demand management tools to reduce transport emissions.

¹¹ Transport has also quantified emissions reductions for reaching its targets, but the targets are not separated into specific policies beyond what is listed below and are not included in table 1 and table 2.

¹² These estimates reflect the Government commitment to decarbonise the public transport bus fleet by 2035.

- Action 1.4. Require roadway expansion and investment in new highways to be consistent with transport targets.
- Action 1.5. Embed nature-based solutions as part of our response to reduce transport emissions and improve climate adaptation and biodiversity outcomes.

The following actions have not been explicitly quantified beyond what is covered by the Clean Vehicle Standard and Discount (including vehicle fuel economy labelling) and the Light EV road user charge exemption:

- Action 2.1. Accelerate the uptake of low-emission vehicles.
- Action 2.2 Make low-emissions vehicles more accessible for low-income and transport disadvantaged New Zealanders.
- Action 2.3. Support the roll out of EV charging infrastructure.

The following actions have not been explicitly quantified beyond what is covered by our estimates for the emissions impact of more efficient rail locomotives and ferries as funded through Budget 21 (Future of Rail – rolling stock and ferries):

- Action 3.1. Support the decarbonisation of freight.
- Action 3.3. Work to decarbonise aviation.
- Action 3.4. Progress the decarbonisation of maritime transport.

Key policies and measures already included in the baseline projections

- ETS impact before price corridor increase.
- Road user charge exemption for light EVs until 2021.
- Road user charge exemption for heavy EVs until 2025.

Emissions from producing electricity used in transport are captured in energy emissions and not transport emissions.

Summary details of modelling approach and key assumptions

Clean vehicle standard and discount (including vehicle fuel economy labelling)

- From the default scenario in the clean vehicle package cost benefit analysis based on March 2021 policy settings.
- Calculates emissions reductions from the change in vehicle imports due to the clean vehicle discount and the clean vehicle standard.
- Uses default assumptions around behavioural responses to vehicle price, to determine changes in imports by emission band.
- Accounts for changes in relative vehicle prices, supply and battery performance over time that would increase the uptake of EVs.
- Assumes electricity emissions are zero.

- Calculates changes in reference to a baseline import fleet projection from the Vehicle Fleet Emissions Model 2021 update, which uses the 1990–2019 GHG Inventory update, and under the conditions of an ETS price corridor increase.

Decarbonising all public transport buses by the end of 2035

- From the decarbonising the public transport bus fleet by 2035 climate implications of policy assessment.
- Three factors drive the change in electric bus numbers by 2035 in the high, central and low effort–impact scenarios:
 - i. public transport fleet growth
 - ii. business as usual electric public transport bus share of fleet
 - iii. scenario growth in electric public transport buses that is fixed to reach 100 per cent of the public transport fleet by the end of 2035.
- Public transport fleet growth.
- Business as usual electric public transport bus share of fleet.
- Scenario growth in electric public transport buses that is fixed to reach 100 per cent of the public transport fleet by the end of 2035.
- Calculates emissions using the projected number of electric and diesel public transport buses, annual average vehicle kilometres travelled (VKT) per public transport bus (this is higher than heavy buses on average), and the emissions per kilometre for public transport buses (this is higher than heavy buses on average).
- Assumes electricity emissions are zero.

Light EV road user charge exemption and discount

- From the Extending the EV exemption from road user charge cost benefit analysis.
- Calculates the effects of a road user charge exemption for light EVs and light plug-in hybrid electric vehicles from 2021 until 2024.
- Bases emissions reductions on how many EVs and plug-in hybrid electric vehicles would displace internal combustion engine purchases due to the exemption.
- Assumes electricity emissions are zero.
- Calculates changes in reference to a baseline import fleet projection from the Vehicle Fleet Emissions Model 2021 update (base-base scenario), which uses the 1990–2019 GHG Inventory update.

Sustainable biofuels obligation

- Applies the emissions reduction to two different projections for liquid fuel emissions to generate high and low estimates:
 - i. high impact estimate: fuel CO₂-e emissions from the no intervention base-base pathway from the Vehicle Fleet Emissions Model (2021 update, base-base scenario)
 - ii. low impact estimate: fuel CO₂-e emissions from the Ministry of Transport’s emissions reduction plan model, which includes the effects of the transport targets on liquid fuel use, excluding the biofuels target.

- All estimates include the effect of the quantified initial investments to improve safety and access to public transport and active modes.
- Assumes electricity emissions are zero in each of these projections.
- Averages the high and low impact estimates to get the central or mid-point impact estimate.
- Applies the mandated emissions reductions to rail and coastal shipping emissions from the 1990–2019 GHG Inventory result for 2019 for each year between 2022 and 2035.

More efficient rail locomotives and ferries as funded through Budget 21 (Future of Rail – rolling stock and ferries)

- From the Future of Rail 2021 budget bid for rolling stock and ferries climate implications of policy assessment.
- Counts the emissions reductions from replacing old rolling stock with newer more efficient rolling stock.
- Excludes the emissions effects of any potential mode shift from road to rail due to the newer rolling stock.

Initial investments to improve safety and access to public transport and active modes

- A range of emissions reductions resulting from VKT reductions.
- Applies percentage reductions to a projection for light fleet emissions that includes the effects of the ETS price corridor increase and the Clean Vehicle Standard and Clean Car Discount.
- The percentage reduction is derived from applying very low, low, and medium VKT reductions to different shares of national VKT representing the light vehicle VKT share of different urban areas as per the Ministry of Transport’s emissions reduction plan model.
- Calculates changes in reference to a baseline light vehicle fleet projection from the Vehicle Fleet Emissions Model 2021 update, which uses the 1990–2019 GHG Inventory update, and under the conditions of an ETS price corridor increase.

ETS price corridor increase

- Includes the impact of different ETS prices have on both EV uptake and VKT.
- The emissions change is mainly due to the change in EV uptake because the impact of VKT changes is very limited.
- Assumes the VKT change only affects the vehicle travel of light internal combustion engine vehicles (discretionary travel only).
- These estimates could overestimate the impact of ETS prices because:
 - i. there are other constraints on EV uptake (eg, supply constraints) and buyers may not proportionately react to the price changes as estimated
 - ii. of the feedback loop between policy settings and ETS prices, thereby resulting in potential double counting of effects.

- Calculates changes in reference to a baseline light vehicle fleet projection from the Vehicle Fleet Emissions Model 2021 update (base-base scenario), which uses the 1990–2019 GHG Inventory update.

Information about what has been quantified to estimate the impact of achieving the transport targets

The section below lists the interventions included in the transport modelling to estimate the impact of achieving the transport targets. Clean Vehicle Standard and Clean Car Discount (including vehicle fuel economy labelling):

- land use changes
- incentives for public transport use, for example, more services, a wider network and improved services
- parking pricing in urban environments
- congestion charging in Auckland and Wellington
- distance-based pricing nationally
- the increase in the public transport bus fleet to cater for mode shift
- electrification of the public transport bus fleet
- import restrictions for light internal combustion engine vehicles
- mode shift to rail and coastal shipping
- accelerated EV uptake for medium and heavy trucks
- logistics improvements, driver training, load maximisation, weight minimisation and vehicle design improvements (eg, aerodynamics and high efficiency tyres) for medium and heavy trucks
- biofuels for all remaining petrol and diesel use by light and heavy vehicles
- biofuel use in motorcycles, domestic shipping, domestic aviation and rail
- ETS price corridor increase.

The transport modelling did not explicitly include the following activities, but some might be needed to support achievement of the corresponding transport targets:

- incentives for walking and cycling not captured in land use changes
- regulations restricting parking availability
- other pricing options
- increase in the passenger rail frequency or carriages to cater for mode shift
- hydrogen uptake (any mode)
- incentives for light EV uptake outside of the Clean Vehicle Standard and Clean Car Discount and import restrictions on light internal combustion engine vehicles
- small vehicle electrification, for example, motorcycles
- import restrictions for heavy EVs
- domestic shipping, domestic aviation and rail electrification.

Emissions from producing electricity used in transport are captured in energy emissions and not transport emissions.

Information about key assumptions used in the modelling to estimate the impact of achieving the transport targets

The bulk of the policy impacts apply to a baseline¹³ that already has the effects of existing policies as well as the effects of an ETS price corridor increase.

An avoid, shift and improve framework underpins how we estimate the impacts of the transport targets on emissions. First, we adjust emissions for changes that avoid and shift GHG emissions for light and heavy road vehicles. Then we apply changes that improve transport fleet energy efficiency by electrifying light vehicle imports as well as changing the fleet mix for medium and heavy trucks to account for more EVs. Next, we apply biofuels emissions reductions to petrol and diesel emissions. Lastly, we account for biofuels-induced emissions reductions among motorcycles, trains, domestic flights and coastal shipping.

Energy and industry

The quantification of policy impacts for the energy and industry sector was undertaken by MBIE, EECA and MfE.

Policies and measures that have been quantified

- ETS price corridor increase impact (excluding industrial process emissions).
- National direction for industrial GHG emissions from existing Government Investment in Decarbonising Industry (GIDI) Fund.
- Expand and continue the roll out of the GIDI Fund.
- Provide grant funding for decarbonising commercial space and water heating.
- Provide grant funding for high efficiency electrical equipment.
- Expansion of EECA's business programmes.
- State Sector Decarbonisation Fund (Energy and Industry component).
- Improve energy efficiency products and services regulation.

Key policies and measures that have not been quantified

- EECA's Gen Less programme.
- ETS price corridor increase impact on industrial process emissions.

Key policies and measures already included in the baseline projections

- ETS impact before the price corridor increase.

¹³ The baseline is the base-base scenario from the Vehicle Fleet Emissions Model 2021 update (using the 1990–2019 GHG Inventory).

- Refining New Zealand's transition to an import-only terminal in April 2022.
- Closure of New Zealand's Aluminium Smelter in 2024.

Summary details of modelling approach and key assumptions

ETS price corridor increase impact (excluding industrial process emissions)

- Emissions reduction estimates are largely based on marginal abatement cost analysis. The model estimates the cost of using different fuels for meeting the same energy and heating requirement and then the model chooses the cheapest option.
- The rising ETS price corridor is based on the carbon price trajectory as suggested by the Commission in its demonstration path.
- Emissions reduction estimates are also adjusted to take account of the fact that it takes time for firms to switch to different technologies.
- The estimates do not take account of the fact that rising carbon prices could have a flow-on impact on economic growth and prices, which in turn affects energy demand.
- The projection does not model how additional demand for solid biomass is met.

National direction for industrial GHG emissions

- Emissions reduction estimates use a baseline that is adjusted for the impacts of the ETS and GIDI Fund to reduce the potential for double counting of impacts.
- The model assumes a percentage of new or re-consents will switch from fossil fuel to the cheapest renewable fuel when regulations come into effect, the percentage can be 100 per cent, if the regulation fully restricts a certain activity such as is the case for new coal consents.
- Consents are assumed to last 20 years, with other assumptions around economic growth, site entry and exit rates, and energy intensity improvement rates being specific to the industry and sector.

Government investment in Decarbonising Industry Fund

- Emissions reduction estimates are based on data from individual project funding applications, summed over relevant periods (five yearly emissions budgets).
- Estimates are reduced to account for logical overlaps with other policies (eg, ETS pricing, national direction for industrial GHG emissions).
- Emissions reduction estimates include pragmatic delivery and timeframe risks.
- Most projects have an effective life of 20 years.
- Many projects result in an increase in electricity consumption with a corresponding emissions increase that partially offsets an emissions reduction from fossil fuel use. The electricity emissions factors from the Commission's 'current policy reference' scenario were used for this calculation.

Expansion of EECA's business programmes

- Emissions reduction estimates are based on a scaling up of existing business programme reductions, along with assumptions relating to programme efficiency improvements and scale effects.
- Most interventions are assumed to have an effective life of 10 years.

State Sector Decarbonisation Fund

- Emissions reduction estimates are based on data from individual project funding applications from the first seven rounds, summed over relevant periods (five-yearly emissions budgets) and scaled for overall funding envelope.
- Emissions reduction estimates include pragmatic delivery and timeframe risks.
- Most projects have an effective life of 20 years.

Improve energy efficiency products and services regulation

- Regulatory changes are expected to result in a percentage increase in the effectiveness of EECA's existing regulatory programmes. This is applied as a multiplier against current emissions reduction projections for this programme.

Expand and continue the roll out of the GIDI Fund

- Emissions reductions are estimated using cost of emissions reduction derived from GIDI 1.0 projects, scaled for size of requested funding, and limited to available emissions potential for some fuels (specifically coal and LPG).
- Estimates are reduced to account for logical overlaps with other policies (eg, ETS pricing, National Environmental Standard and National Policy Statement on industrial GHG emissions).

Provide grant funding for decarbonising commercial space and water heating

- Emissions reductions are based on decarbonising space heating in the commercial sector through a mixture of co-funding projects for a portion of the market, followed by normalisation of low-carbon heating systems by suppliers and purchasers.

Provide grant funding for high efficiency electrical equipment

- Emissions reductions are estimated by dividing requested funding by known technology replacement costs for high potential end-uses, limited by available potential and assessed market readiness.
- Most emissions reductions are from electricity efficiency; the electricity emissions factors from the Commission's 'current policy reference' scenario were used for this calculation.

Building and construction

The quantification of policy impacts for the building and construction sector was undertaken by MBIE. The building and construction sector is not directly measured by the GHG Inventory

but has a substantive impact on emissions, particularly energy and industry. For this reason, the quantified impacts of the building and construction sector have been included in the energy and industry sector.

Policies and measures that have been quantified

- H1 code updates.
- Behaviour change programme.
- Implementation of data infrastructure.

Key policies and measures that have not been quantified

- Kainga Ora programmes.
- Concrete decarbonisation.
- Policies intended for implementation in future emissions budget periods that require further development, such as requirements to reduce operational and embodied carbon.

Key policies and measures already included in the baseline projections

- Healthy homes standard.
- Adoption of Homestar.

Summary details of modelling approach and key assumptions

Emissions modelling of the three quantified policies has been done in one integrated model

- The modelling accounts for reductions in emissions from new buildings.
- The modelling assumes two main drivers of emissions from new buildings:
 - i. the number of buildings that are built; projections of these are from the pipeline report, produced by BRANZ
 - ii. the amount of electricity used to operate the building; projections of these are from the energy markets team at MBIE. Note a driver of emissions from electricity is the proportion of electricity generated from low-emissions sources.
- Therefore, policies that reduce emissions in new buildings focus on two main areas:
 - i. lowering whole of life carbon emissions, that is, emissions from the materials used in construction, the construction process, construction waste, and the disposal of a building at the end of its life
 - ii. lowering operational emissions, that is, emissions from operating a building, space and water heating, using appliances.

More specific policy assumptions include:

H1 building code changes

- Assumes a 40 per cent reduction in energy use in new buildings operating from 2024.

Behaviour change programme

- Assumes a 10 per cent reduction of emissions across all new building stock operating from 2024.

Implementation of technical infrastructure

- Assumes a 10 per cent reduction of emissions across all new building stock operating from 2024.

Mandatory reporting and measurement requirements for whole of life carbon emissions

- This initiative has not been included in table 1 and table 2 because its settings require further definition throughout the first emissions budget period. Possible settings have been modelled as scenarios and included in 'Figure 12.2: Illustration of potential building and construction emissions reduction scenarios against baseline (operational and embodied emissions)' in the emissions reduction plan publication, to show possible impacts.
- The assumptions below have been included in 'Figure 12.2: Illustration of potential building and construction emissions reduction scenarios against baseline (operational and embodied emissions)' in the emissions reduction plan publication:
 - i. assumes three sets of progressively tightening requirements over 10 years for embodied carbon and operational emissions
 - ii. models three types of buildings: public, non-residential, residential (both for reporting and measurement requirements, and assumes different schedules and required levels of efficiency are in place for different building types)
 - iii. assumes reductions of embodied carbon of up to 60 per cent to 70 per cent are possible
 - iv. assumes three steps in required operational emissions levels over 10 years:
 - initial: 180 kilowatts per square metre per year (kWh/m₂/yr)
 - intermediate: 95 kWh/m₂/yr
 - final: 50 kWh/m₂/yr.

Waste

The quantification of policy impacts for the waste sector was undertaken by MfE. The waste emissions modelling was developed on a scenario basis whereby policies and policy outcomes were generally implicitly included in the development of scenarios rather than explicitly modelled.

Policies, measures and outcomes that have been quantified

- Organic waste reduction behaviour change programmes.
- Standardisation of residential kerbside collection - provision of food scraps collections.
- Requiring businesses to separate food waste.
- Investment in organic waste processing and resource recovery infrastructure to support an increase in food, garden, paper/cardboard and wood waste diversion from landfill.
- Limits and banning of organic waste to landfill by 2030.
- Improvement of landfill gas capture systems.
- Expansion of landfill gas capture systems to more landfills.

Key policies and measures that have not been quantified

- ETS price corridor increase.
- The direct impact of the expansion of the waste disposal levy on waste disposal has not been quantified.
- Upstream emissions reductions of supporting increased diversion of non-organic waste (eg, metals, plastic and glass) have not been quantified.

Key policies and measures already included in the baseline projections

- ETS impact before price corridor increase.
- National Environmental Standards for Air Quality requirement for some landfills to capture gas.

Summary details of modelling approach and key assumptions

The waste modelling was based on the models used for compiling the GHG Inventory and government emissions projections for waste. Key assumptions that considered the range of policies and outcomes above were applied to waste streams in the model to develop emissions reduction scenarios.

Standardisation of organic waste residential kerbside collection

- All territorial authorities are assumed to be able to implement effective organic kerbside collection schemes by 2030.
- The assumed diversion rate of residential food waste under a food waste kerbside collection scheme in the model is 35 per cent to 69 per cent.

Food and garden waste diversion assumptions

- Of the waste diverted from Class 1 landfills in the model, we assume 40 per cent of food waste is diverted to composting (20 per cent windrow and 20 per cent in-vessel composting) and 60 per cent to anaerobic digestion. It also assumes 100 per cent of

diverted garden waste to composting (60 per cent compost and 40 per cent in-vessel composting).

- Emissions factors for diversion activities are based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories¹⁴.

Limits and banning of organic waste to landfill by 2030

- Food, garden and paper/cardboard waste assumed to reach over 90 per cent diversion (which could include reduction) by 2030.
- Diversion assumed to increase over time at a relatively constant pace with different starting points for low and high estimates.

Reduction of wood waste to landfill

- Assumed that a 15 per cent to 25 per cent reduction of wood waste to Class 1 landfills could be achieved by 2030 through increased resource recovery and changes to building and construction practices.

Landfill gas capture assumptions

- Assumed that the average landfill gas capture efficiency could increase from 68 per cent to a range of 71.75 per cent to 73.5 per cent.
- Assumed 15 of the largest 'small' category Class 1 landfills that currently do not have landfill gas capture systems could be retrofitted for landfill gas capture (or organic waste diverted elsewhere).

Unmanaged or Class 2 to Class 5 landfills

- The modelling includes a scenario where key organic wastes are diverted from Class 2 to Class 5 landfills (equivalent to the 'ban' of organic material to Class 1 landfills scenario). This has been used as an indicative scenario only because the level of data uncertainty for these sites is very high.

Fluorinated gases

The quantification of policy impacts for the fluorinated gases sector was undertaken by MfE.

Policies and measures that have been quantified

- Regulated product stewardship.

Key policies and measures that have not been quantified

- Phase out schedule of HFC equipment and uses.
- ETS price corridor increase and flow on impact to the synthetic GHG levy.

¹⁴ Intergovernmental Panel on Climate Change (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, vol. 5. See: <https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html>

Key policies and measures already included in the baseline projections

- ETS and synthetic GHG levy impact before price corridor increase.
- HFC phasedown under Kigali Amendment to the Montreal Protocol.

Summary details of modelling approach and key assumptions

Regulated product stewardship

- The model uses historical and projected bulk gas and pre-charged HFC's import data along with assumptions around use, leakage, retirement and destruction, to estimate stocks and emissions of HFCs by gas and use type.
- Imports of HFCs (especially those with relatively high GWPs) are expected to reduce sharply over time, largely due to the phasedown under the Kigali Amendment to the Montreal Protocol (an existing policy), however, due to high levels of HFC stocks, emissions from HFCs decline at a much slower pace.
- Operational HFC leakage rates are assumed to reduce with the implementation of this policy, leakage rates reduce at different rates and the reduction increases over time depending on the refrigerant and its use.
- Recovery for destruction of HFCs when equipment is retired is expected to increase over time with the implementation of this policy. The assumed baseline recovery rates of HFCs are 11 per cent of total retired HFCs, this is assumed to increase to between 13 per cent and 20 per cent between 2023–29, 20 per cent and 30 per cent between 2030–39 and to 20 per cent and 35 per cent from 2040 onwards.

Agriculture

The quantification of policy impacts for the agriculture sector was undertaken by MPI.

Policies and measures that have been quantified

- ETS price corridor increase.
- Additional funding for research to develop agricultural emission mitigation technologies.

Key policies and measures already included in the baseline projections

- Freshwater policies on agriculture, including freshwater farm plans, and stock exclusion regulations (Essential Freshwater Package).
- ETS impact before price corridor increase.
- Implementation of agriculture emissions pricing.

Summary details of modelling approach and key assumptions

New policies and measures

ETS price corridor increase

- ETS has an indirect effect on agriculture emissions because it encourages afforestation on farmland. A higher carbon price is expected to encourage additional afforestation on agricultural land.

Additional funding for research to develop agricultural emission mitigation technologies

- Additional funding for mitigation research is expected to accelerate the roll out of mitigation technologies on farm. Estimates on the expected effect of different mitigation technologies were developed through consultation with subject-matter experts at MPI.
- A list of actions and technologies (eg, methane inhibitor) was compiled based on research and subject-matter expertise. Each action and technology was given an expected start date of implementation (assuming research funding is available), a date for peak adoption, uptake at peak adoption and effectiveness at reducing emissions (efficacy). These parameters were based on published data, the stocktake of technologies completed earlier this year and expert opinion. The uptake and efficacy parameters were assigned to the appropriate emissions categories to obtain estimates of emissions reductions by year.
- Adjustments were made to avoid double counting of emissions mitigations and to account for the expected extent to which extension activities would be undertaken without funding.

Key existing policies and measures

Essential Freshwater Package

- The Essential Freshwater Package introduces new rules and regulations to stop further degradation of New Zealand's freshwater resources and improve water quality.
- The expected land use change resulting from this package includes:
 - i. reductions in dairy area to reduce nitrogen pollution
 - ii. reductions in the use of nitrogen fertiliser
 - iii. land in setback from rivers related to the stock exclusion requirements.
- These actions are likely to reduce agricultural emissions.
- Some land use change to forestry in hill country sheep and beef farms could be a profitable approach towards mitigating sediment loss. However, sediment bottom lines could also be achieved through changing on-farm practices without land use change.

Emissions Trading Scheme

- The ETS has an indirect effect on agriculture emissions because it encourages afforestation on farmland. Assumptions for future ETS carbon prices were formed in the first half of 2020 in agreement with MfE and other government agencies.
- Any afforestation on agricultural land is expected to primarily occur on land used for sheep and beef farming.

Implementation of agriculture emissions pricing

- The base projections assume that pricing of agricultural emissions will begin in 2025. Emissions would be charged at a processor level at a 95 per cent discount rate. These assumptions are based on a 'backstop' policy measure to be implemented if the He Waka Eke Noa government–industry partnership does not deliver a cost-effective and implementable alternative pricing method.
- It has been assumed for the projection modelling that, irrespective of whether agriculture is incorporated through the ETS or an alternative farm-level pricing system, the unit price for carbon emissions will be the same as that for forestry under the ETS.

Forestry and other land use

The quantification of policy impacts for the forestry and other land use sector was undertaken by MPI.

Policies and measures that have been quantified

- ETS price corridor increase and exotic forests are restricted from registering in the Permanent Post-1989 ETS category (Focus areas 1 and 2).
- ETS price corridor increase and exotic forests are not restricted from registering in the Permanent Post-1989 ETS category (Focus areas 1 and 2).
- Maximising carbon storage: increasing natural sequestration to achieve New Zealand's future carbon goals Budget 2022 (Focus areas 2 and 3).
- Native afforestation initiative (Focus area 2).
- Woody biomass (Focus area 4).

Key policies and measures already included in the baseline projections

- ETS impact before price corridor increase.
- One Billion Trees Programme.¹⁵

Summary details of modelling approach and key assumptions

Forestry and other land use baseline projections (June 2021)

- Draws on New Zealand's approach to accounting for the forestry and other land use sector as defined in New Zealand's first Nationally Determined Contribution (www4.unfccc.int/sites/ndcstaging/PublishedDocuments/New%20Zealand%20First/New%20Zealand%20NDC%20November%202021.pdf).
- Projections for emissions budgets include sequestration from post-1989 forests up until their long-term average carbon stock and emissions from pre-1990 and post-1989

¹⁵ Ministry for Primary Industries. 2022. *One Billion Trees Programme*. Retrieved from www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme (10 May 2022).

deforestation activities. For production forests, the long-term average represents the average amount of carbon sequestered over harvesting and replanting cycles, while for permanent forests this represents the carbon sequestered at maturity.

- Emission factors, historical afforestation and deforestation activity data are sourced from the GHG Inventory 1990–2019. Biomass emissions resulting from deforestation are assumed to occur in the year of conversion. Establishing a new exotic forest will result in a slight source of cumulative emissions for the first four years after planting. This is due to the loss of the previous land use biomass and soil carbon changes. Following a land use change event, the previous land use biomass is emitted in the year of conversion, while soil carbon stocks are estimated to change from the previous land use value to the new land use value over a 20-year period. Native deforestation rates are based on historical trends, while the long-term average carbon stock is based on research completed by Scion in 2020 (*Reporting New Zealand's Nationally Determined Contribution under the Paris Agreement using Averaging Accounting for Post-1989 forests*, May 2020).
- The June 2021 base projections source future afforestation and exotic deforestation rates from the *Afforestation and Deforestation Intentions Survey Report 2020*. (www.mpi.govt.nz/dmsdocument/46564-Afforestation-and-Deforestation-Intentions-Survey-2020).

The June 2021 baseline projections do not reflect potential emissions reductions from policies that are currently under consideration. These policies are likely to affect land use decisions, including the scale and location of land use change, which also has strong interdependencies with emissions pricing.

Projections are by their nature uncertain. Lower, central and upper projection scenarios have been modelled to reflect this uncertainty.¹⁶ The upper removals scenario assumes average afforestation rates of around 44,000 hectares per year from 2020–50, and low deforestation rates. The central removal projection assumes average afforestation rates of around 35,000 hectares per year from 2020–50, and deforestation rates declining to around 750 hectares per year by 2050. The lower removals scenario assumes average afforestation rates around 24,000 hectares per year from 2020–50, and higher deforestation rates.

ETS price corridor increase and exotic forests are restricted from registering in the Permanent Post-1989 ETS category

- As in the first three bullets of the '[Forestry and other land use baseline projections \(June 2021\)](#)' section above.
- Assumes new policy to restrict exotic forests registering in the Permanent Post-1989 ETS category from 2023 (ie, no exceptions are made for exotic species¹⁷ and natives are included).
- Assumes the ETS price corridor and an increased carbon price incentive to establish exotic production and native forests. The impact of the price corridor and higher carbon prices

¹⁶ The range of afforestation reported in the 2020 *Afforestation and Deforestation Intentions Survey* reflects uncertainty in people's decision making (eg, around land availability and price, seedling and labour availability, requirement for Overseas Investment Office approval, government and local council regulation).

¹⁷ Final decisions on this policy are not yet made. While this modelling scenario assumes there are no exceptions for exotic species, this may not reflect the final policy decision. The Government is yet to decide whether the permanent post-1989 category will be restricted and whether there will be exceptions for some exotic species if the category is restricted.

on afforestation rates is drawn from the 2021 *Afforestation Economic Modelling Report* (www.mpi.govt.nz/dmsdocument/50302-Afforestation-Economic-Modelling-Report).

- Depending on the carbon price, exotic afforestation rates potentially ranging between 0.76 million hectares to 1.6 million hectares over 2022–50.
- Depending on the carbon price and whether a start-up grant is available, native forest establishment rates are projected to range between 330,000 hectares to 430,000 hectares over 2022–50. Assumes deforestation levels as per base projection scenarios.
- The 2021 *Afforestation Economic Modelling Report* notes that, given the economic assumptions, the modelling is likely skewed towards greater rates of native afforestation, and the forecasts are likely to systematically over-estimate the native afforestation response to the carbon price. The modelling also does not consider the complex interaction between supply and demand for New Zealand Units, which will affect the future carbon price and, therefore, afforestation response. The modelling assumes land owners make the most economically rational decisions, and no constraints exist to afforestation (seedlings, planting crews, land-owner preference etc).

ETS price corridor increase and exotics are not restricted from registering in the Permanent Post-1989 ETS category

- As in the first three bullets of the ‘[Forestry and other land use baseline projections \(June 2021\)](#)’ section above.
- Exotic forests are not restricted from registering in the Permanent Post-1989 ETS category from 2023.
- Assumes the ETS price corridor and an increased carbon price incentive to establish exotic permanent, production and native forests. The impact of the price corridor and higher carbon prices on afforestation rates is drawn from the 2021 *Afforestation Economic Modelling Report* (www.mpi.govt.nz/dmsdocument/50302-Afforestation-Economic-Modelling-Report).
- Depending on the carbon price, exotic afforestation rates potentially ranging between 2.0 million hectares to 3.1 million hectares over 2022–50 with most managed as permanent exotic forest.
- As with the last two bullets of the ‘[ETS price corridor increase and permanent exotic forests are restricted into the Post-1989 Permanent ETS category](#)’ section above.

Maximising carbon storage: increasing natural sequestration to achieve New Zealand’s future carbon goals

- This budget initiative is anticipated to drive sequestration through two responses in post-1989 forest:
 - i. the first is increasing the incentive to establish indigenous forest, particularly regeneration, by increasing the net present value because carbon stocks are assumed to be around 20 per cent higher in any year. This is projected to result in an average of 1690 hectares of indigenous forest established each year
 - ii. the second is encouraging the management of indigenous forest towards ‘tall forest’ (eg, totara, broadleaf/podocarp and beech forest) by recognising the increased carbon stocks in tall forests that will continue to store carbon at higher rates (around 10 tonnes per year) after the current tables ‘tail off’. This results in greater income from carbon compared with that for regenerating forest. This is projected to promote

an average of 2200 hectares per year of indigenous forest being managed to become tall forest within the ETS. With an average of 1000 hectares per year projected of additional afforestation outside the ETS (eg, on public conservation land).

- This budget initiative also assumes the carbon stock change that results from improved pest and browser management can be counted towards emissions budgets and targets. The bid assumes around 100,000 hectares of treated indigenous pre-1990 forest each year, and 1 million hectares of forest overall (after 10 years). It assumes the carbon stock increase from reduced pests can be credited against our targets by around 1 tonne per hectare per year.

Native afforestation initiative

- This budget initiative focuses on the deployment and uptake of automated propagation capacity to begin to apply proven technologies and tools, developed for production forestry, to the propagation of native plants to reduce costs and time to delivery, and increase survival rates.
- The initiative's contribution to meeting emissions budgets assumes an increase in seedling production beginning in 2025/26, reaching a level sufficient to establish around 12,500 hectares of indigenous forest per year from 2026/27.
- This is around half the difference needed to meet the Commission's average indigenous afforestation levels under its Demonstration pathway. The indigenous forest sequestration rates used were sourced from the GHG Inventory 1990–2019.

Woody biomass

- This budget initiative will directly increase biomass supply and aims to stimulate private sector investment to create further supply. Additional biomass supply is needed to alleviate shortages projected to eventuate around 2030 as biomass is increasingly used to replace coal and other fossil-based fuels. Action is needed now to stimulate biomass production and provide certainty to a developing industry that will play a critical role in the just transition to a low emissions economy.
- The budget initiative assumes total planting of around 10,000 hectares of exotic species across multiple blocks at different places around New Zealand, and targeted research and development.
- The central projection assumes that half of the trees will be harvested at age 10–12 years, and half at age 13–15 years. It assumes the forest crop is replanted following harvest and carbon sequestration rates are based on the long-term average carbon stock.