He Pou a Rangi
Climate Change Commission

Advice on NZ ETS unit limits and price control settings for 2023-2027

Technical Annex 2: ENZ Modelling

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1. Purpose and contents

This document sets out further information on the modelling undertaken using the *Energy and Emissions in New Zealand* (ENZ) model for the Commission's advice on New Zealand Emissions Trading Scheme (NZ ETS) unit limits and price control settings for 2023-2027.

We used ENZ to analyse the potential range of NZ ETS prices required to meet Aotearoa New Zealand's emissions budgets, subject to uncertainty around baseline emissions, mitigation costs, and non-NZ ETS policies. This analysis informed our recommended price control settings, alongside other considerations. A summary of our modelling approach and key results is presented in Appendix 1 in the main report.

We also used ENZ emissions scenarios as an input into calculating NZ ETS unit limits. We updated the model and our scenarios to incorporate new source data and information released since the Commission's advice on emissions budgets, *Ināia Tonu Nei*, was published in June 2021[1]. This includes the latest national greenhouse gas inventory, updated agriculture and forestry projections from the Ministry for Primary Industries, and decisions or announcements affecting future industrial activity.

2. Modelling the range of potential NZ ETS prices required to meet emissions budgets

2.1 Method

We conducted two separate modelling exercises using ENZ to address the following categories of uncertainty affecting emissions prices:

- Uncertainty in the emissions baseline and mitigation costs
- Uncertainty in the impact of other policies on emissions in NZ ETS sectors.

We followed a common process in both exercises:

1. We set a target level for gross emissions covered by the NZ ETS as part of meeting the overall emissions budgets from 2022–2035. Consistent with our approach to allocating the emissions budget set out in the main report, we set this target level based on sector emissions in the Commission's demonstration path. We refer to this level throughout this annex as the target emissions level.
2. We developed a pair of scenarios to test the bounds of uncertainty for the category in question. We created these by identifying a set of relevant drivers in the model and varying the assumptions used from the demonstration path, holding everything else the same. We describe the scenarios in section 2.2.
3. For each scenario, we ran the model with a series of different emissions price paths to test the impact on emissions. Section 2.2 describes how we designed the emissions price paths.
4. From the results, we determined the price level required to match the target level of gross NZ ETS emissions as closely as possible. Results and analysis are presented in section 2.3.

[1] (He Pou a Rangi, Climate Change Commission, 2021)

Emissions pricing in ENZ

An emissions price path is a variable we input into the ENZ model. Figure 1 below illustrates how emission pricing drives the uptake of some mitigation actions, while for others the uptake is specified by other scenario assumptions.

Choices around the electricity generation, transport, and heating technologies are modelled based on costs, including the input emissions price (i.e., uptake is *endogenous*). These are represented in orange in Figure 1. Uptake may also be subject to assumed rate constraints and resource constraints, and other factors related to feasibility. The model seeks to represent diversity in use cases (e.g., variation across how vehicles are used) and other situational factors which lead to a range of cost outcomes for a given technology switch.

For other technologies and behaviour changes, we specify the uptake as an input assumption (i.e., uptake is exogenous). We do this for choices that ENZ does not model, and where emissions pricing is unlikely to be a primary driver of uptake or abatement costs are highly uncertain. In this analysis we have continued to use the input assumptions from our 2021 *Ināia Tonu Nei* advice. These were built from available evidence on the likely costs and benefits of different options, and on achievable rates of change under supportive policies.[2]

The emissions price within the model should generally be interpreted as a shadow emissions price – a price which reflects the marginal cost of the mitigation outcomes, rather than an explicit price in the NZ ETS. However, in the context of this analysis, we use the emissions price in the model to inform us of the potential range of emissions prices that may be needed in the NZ ETS for Aotearoa to meet emissions budgets.

Caveats around the representation of emissions pricing in ENZ are discussed later in this annex.

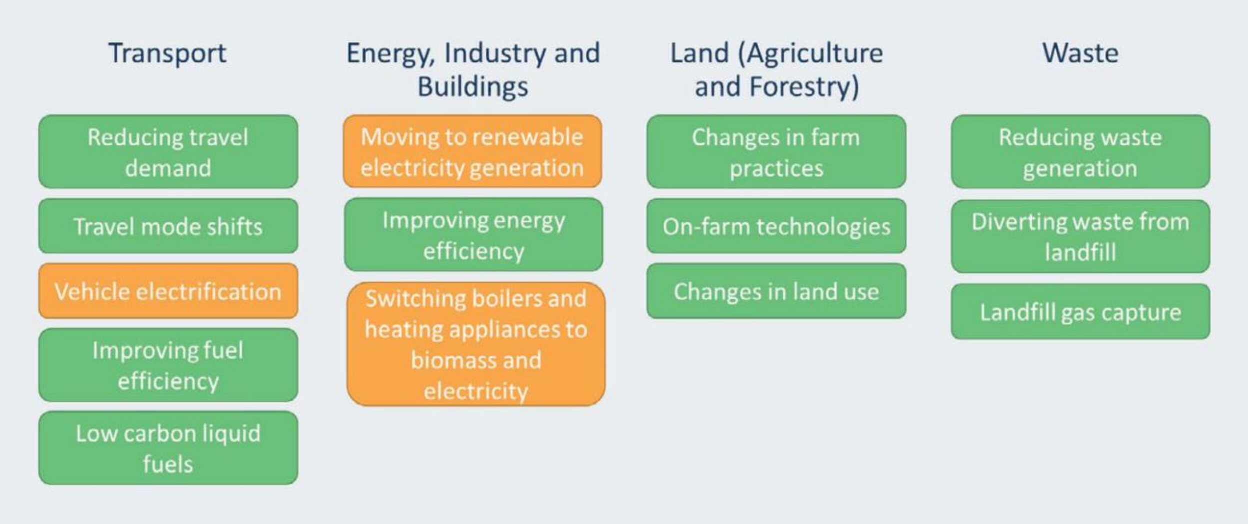

Figure 1: Key emissions reduction options represented in the ENZ model. For the options in orange boxes, the model simulates their uptake in each year based on costs (including emissions pricing), available resources, and other factors. For the options in green boxes, we specify their uptake as an input assumption.

[2] This evidence was presented in the "Supporting evidence" chapters accompanying the *Ināia Tonu Nei* report (parts 2 and 3).

2.2 Scenario design and assumptions

Emissions price paths

We used a fixed 3% rate of increase (or *discount rate*) across the emissions price paths. We varied only the starting point for the price from 2022 to 2023. This reflects a one-off equilibrium adjustment to the different scenario assumptions. The 3% discount rate is in line with a conservative cost of capital assumption used in the price control analysis.

As the ENZ model 'looks forward' at future emissions prices when determining whether abatement is cost-effective (assuming perfect foresight), using a higher discount rate risks understating the actual emissions prices required.

Testing uncertainty in the baseline and mitigation costs

In the model we undertook an exercise to test the combined impact of a higher or lower emissions baseline, and higher or lower mitigation costs, compared with the core assumptions used in the demonstration path. This builds on the sensitivity analysis undertaken for *Ināia Tonu Nei*.[3]

The baseline growth in emitting activities, such as energy and vehicle use, affects the quantity of abatement required to meet emission budgets. These activities are driven by factors such as population and economic growth. The costs of abatement depend on assumed energy and technology prices and, for some measures, resource availability.

We created a pair of scenarios to test uncertainty around the demonstration path. First, we identified a set of key drivers relating to the baseline and mitigation costs (listed as 'variables' in Table 1 below). We then adjusted their assumed values to make the budgets either easier to achieve ('Low baseline and mitigation costs' scenario) or harder to achieve ('High baseline and mitigation costs' scenario).[4] All other assumptions were unchanged from the demonstration path. Table 1 below shows the factors varied and the assumptions used.

Table 1: Assumptions in the "High/Low baseline and mitigation costs" scenarios compared with the demonstration path

Variable	Assumptions by scenario		
	Demonstration path	Low baseline and mitigation costs	High baseline and mitigation costs
Population (average growth rate 2020-2035)	1.0%	0.5%	1.4%

[3] See Section 7.10 in *Ināia Tonu Nei*. Factors involving large industrial closures were excluded in this analysis on the grounds that these may lead to an adjustment to emissions budgets and, or NZ ETS volume settings. Factors involving forestry were excluded from the scope of this analysis. Finally, the dryer or wetter hydro years sensitivity was excluded as this was calculated outside of the ENZ model, which assumes average hydro flows.

[4] Except for two variables relating to resource constraints, which we do not change in 'Low baseline and mitigation costs' but assume a tighter constraint in 'High baseline and mitigation costs'.

Variable	Assumptions by scenario		
	Demonstration path	Low baseline and mitigation costs	High baseline and mitigation costs
GDP (average real growth rate 2020-2035)	2.4%	2.1%	2.7%
Oil price (2030 value) (per barrel of crude oil, bbl)	60 USD/bbl	90 USD/bbl	35 USD/bbl
New renewable generation costs (annual capital cost reduction)	Wind 0.8% Solar 3.0% Geothermal 0.1%	Wind 1.2% Solar 4.5% Geothermal 0.15%	Wind 0.5% Solar 2.0% Geothermal 0.07%
EV costs (year light passenger EVs reach purchase price parity with ICE, excluding subsidies)	2031	2028	2035
Used EV supply constraint (EV share of used light passenger vehicle imports)	Can grow by up to 30% of prior year's value plus 1 percentage point each year	Same as demonstration path	Can grow by up to 15% of prior year's value plus 0.3 percentage points each year
Biomass price in delivered (gigajoules)	Residues $10/GJ Pulp chip $12.8/GJ	Residues $7.5/GJ Pulp chip $10.4/GJ	Residues $12/GJ Pulp chip $17.5/GJ
Biomass availability	50% of regional forestry residues and export pulp logs	Same as demonstration path	25% of regional forestry residues and export pulp logs

Testing uncertainty in other policies affecting NZ ETS sectors

This exercise tested the impact of weaker or stronger support from other policies alongside emissions pricing, compared with the assumptions in the demonstration path.

Other policies can drive direct emissions reductions that are unlikely to respond to an emissions price and thus reduce the quantity of abatement that the NZ ETS needs to deliver. They can also interact with emissions pricing to unlock further abatement in response to the emissions price by reducing other non-price barriers to a technology or behaviour change.

For this exercise we used the Headwinds and Tailwinds scenarios developed in *Ināia Tonu Nei*. These scenarios feature higher or lower barriers to action, and slower or faster uptake of mitigation technologies and behaviour changes, respectively. For example, we considered:

- Different levels of transport demand reduction and mode shift, which will depend on other transport and land-use policies
- Different rates of energy efficiency improvements, which could reflect targeted policies to overcome non-price barriers to uptake
- Different constraints on the rate at which EV uptake can grow, which could reflect targeted policies reducing barriers on the supply- and demand-side.

We use illustrative scenarios where supporting policies are either weak or under-performing, or strong or out-performing relative to the demonstration path. For clarity we relabel these as 'Weak support policies (Headwinds)' and 'Strong support policies (Tailwinds)'.

This exercise considers factors that can be controlled or influenced through climate policy, while the first exercise considers external factors beyond the government's control. However, we note there are some areas of overlap. Including these overlapping assumptions where appropriate gives a more complete assessment of uncertainty within each exercise.

Table 2 outlines the key differences in assumptions or modelled outcomes relating to NZ ETS sectors compared to the demonstration path. Note that for some variables listed the outcome is an aggregate of multiple assumptions (e.g., assumptions for travel demand reduction and mode shift affect total vehicle-kilometre travelled). The uptake of electric vehicles is not a direct assumption in the model – their uptake is determined endogenously subject to cost assumptions, including the emissions price, and other constraints.

Table 2: Assumptions and modelled outcomes in the "Weak support policies (Headwinds)" and "Strong support policies (Tailwinds)" scenarios compared with the demonstration path

Variable		Assumptions or modelled outcomes by scenario		
		Demonstration path	**Strong support policies (Tailwinds)**	**Weak support policies (Headwinds)**
Total vehicle-kilometre travelled in 2030	Light vehicles	51 million	49 million	53 million
	Heavy vehicles	3.5 million	3.3 million	3.5 million
EV share of vehicle	Light vehicles	67%	95%	33%

Variable		Assumptions or modelled outcomes by scenario		
		Demonstration path	Strong support policies (Tailwinds)	Weak support policies (Headwinds)
registrations in 2030†	Heavy vehicles	49%	74%	28%
EV share of fleet in 2030†	Light vehicles	14%	22%	9%
	Heavy vehicles	7%	9%	4%
Low carbon liquid fuels (in petajoules) (annual volume by 2035)		9.5 PJ (~270 million litres)	Same as demonstration path	None
Electric air travel (% of distance by 2035)		5%	10%	10%
Rail/shipping/aviation efficiency improvements (annual increase)		0.5%/1.25%/1.75%	0.75%/1.5%/2.25%	Same as demonstration path
New renewable generation costs (annual capital cost reduction)		Wind 0.8% Solar 3.0% Geothermal 0.1%	Same as demonstration path	Wind 0.5% Solar 2.0% Geothermal 0.07%
Biomass availability		50% of regional forestry residues and export pulp logs	Same as demonstration path	25% of regional forestry residues and export pulp logs
Food processing energy efficiency improvement (annual increase)		1.1%	1.3%	0.9%
Kinleith pulp mill conversion date to high efficiency recovery boiler		2030	2025	2035
Date for no fossil fuel heating in new buildings		2025	Same as demonstration path	2035-2040
	Existing	6%		2%

Variable		Assumptions or modelled outcomes by scenario		
		Demonstration path	Strong support policies (Tailwinds)	Weak support policies (Headwinds)
Heating demand reduction: residential buildings (by 2035)	New build	36%		27%
Heating demand reduction: commercial & public buildings (by 2035)	Existing	27%		16%
	New build	31%		27%
Hydrofluorocarbon (HFC) emissions reductions (2020–2030)		21%	30%	15%
Municipal waste emissions reductions (2020–2030)‡		30%	47%	19%

† Electric vehicle uptake dynamically responds to prices (including the emissions price) in the model. The numbers shown are illustrative and assume the same emissions values as in the demonstration path.

‡ Waste emissions are modelled based on assumed changes in waste generation, diversion from landfill, and increased landfill gas capture.

2.3 Results

Abatement-cost curves

The results when we apply different emissions prices to a given scenario can be visualised in the form of an abatement-cost curve. Figure 2 illustrates this concept using the demonstration path. The blue line shows the level of abatement in NZ ETS sectors (horizontal axis) as a function of emissions price (vertical axis). Abatement is the emissions reduction measured relative to a reference scenario. Here, we use a variation of the current policy reference scenario with a zero emissions price. For each model run, we calculate the cumulative abatement over the three emissions budget periods (2022 to 2035) and plot this against the emissions price in 2030.[5]

Meeting the target level of gross NZ ETS emissions for the period requires total abatement of 89 megatonnes of carbon dioxide equivalent (Mt CO_2e). Under the demonstration path, around 39 Mt CO_2e of abatement happens under a zero ($0) emissions price due to other scenario assumptions (*non-price-driven abatement*). This reflects emissions reductions likely to be driven by policies other than the NZ ETS. This leaves 50 Mt CO_2e of abatement to be achieved through the emissions price (*price-driven abatement*). As Figure 2 shows, the 2030 emissions price required to drive this level of abatement is close to $150.[6]

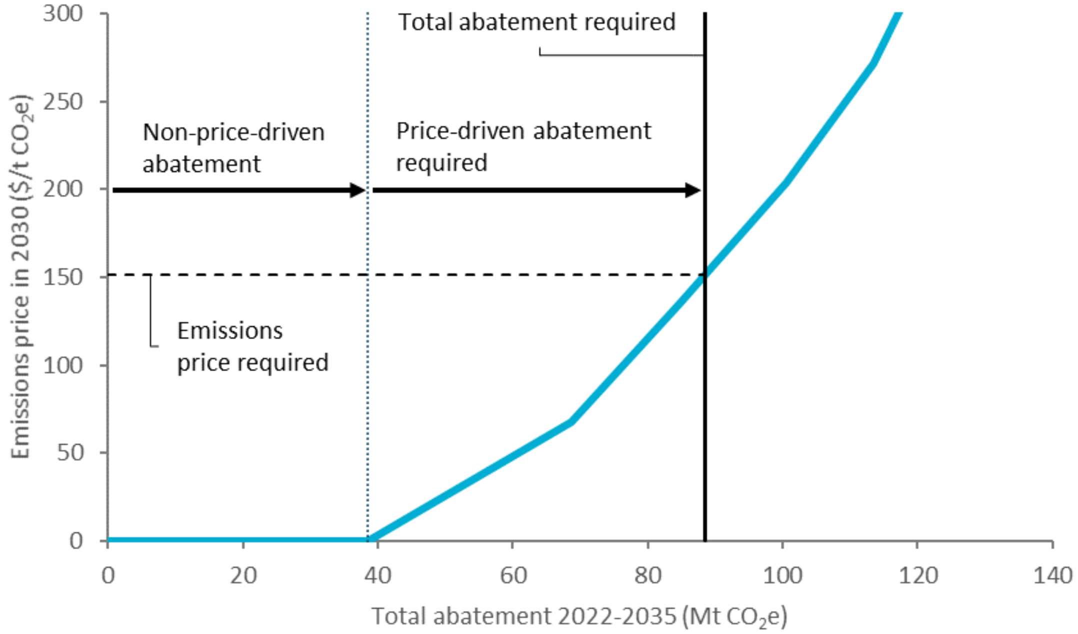

Figure 2: Abatement-cost curve for the demonstration path, showing the emissions price required to achieve the target emissions level and the contributions from price-driven and non-price-driven abatement

[5] This is close to the average emissions price over the period under the 3% discount rate used.
[6] Note emissions prices are reported in 2022 NZD unless specified otherwise.

Below in Figure 3, we show the abatement-cost curves for the 'High/Low baseline and mitigation costs' scenarios compared to the demonstration path. Under these scenarios, achieving the target emissions level requires minimum 2030 emissions prices of around $260 and $70 respectively.[7]

To show the curves for these scenarios simply on a single chart, we measure the abatement relative to the same reference scenario, even though these scenarios use different baseline assumptions.

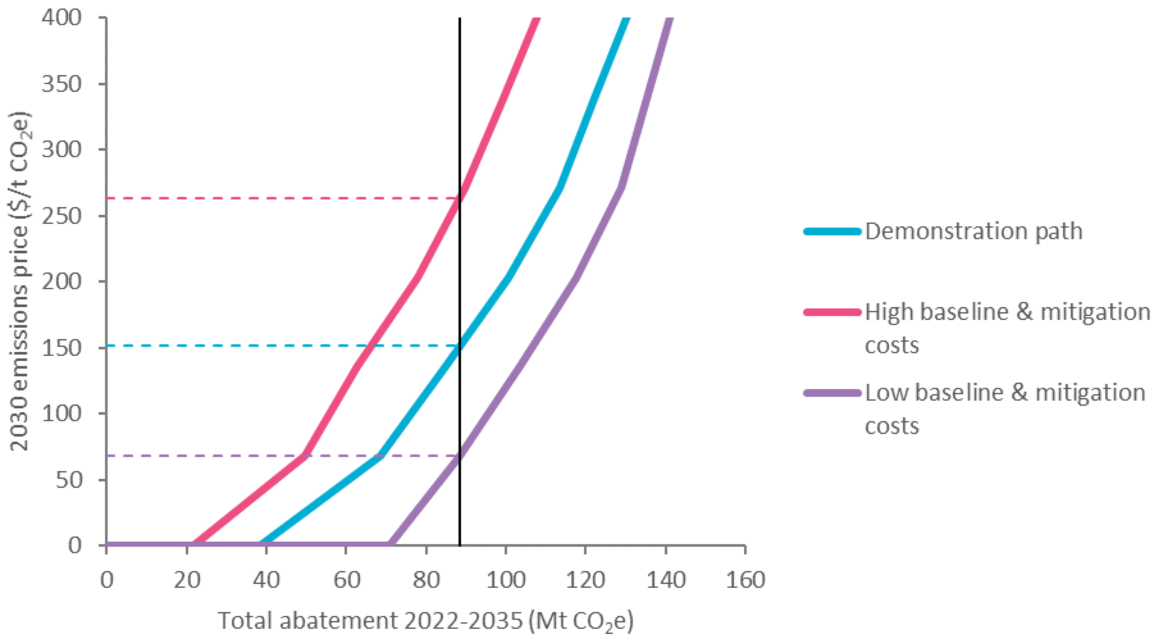

Figure 3: Abatement-cost curves for the 'High/Low baseline and mitigation costs' scenarios compared with the demonstration path

[7] In the main report we cite slightly higher minimum emissions prices in 2030 ($270 and $75). The reason for the difference is that a higher price path is required to meet the target level in all emission budget periods, rather than only the total for 2022–2035 (which allows for banking and borrowing between budget periods).

Figure 4 below shows the abatement-cost curves for the 'Weak/Strong support policies' scenarios compared to the demonstration path. Under these scenarios, achieving the target emissions level requires minimum 2030 emissions prices of around \$370 and \$70 respectively.

The figure shows that the different scenario assumptions affect not only the level of non-price-driven abatement, but also the shape or slope of the price-driven segment of the curve. The 'Weak support policies (Headwinds)' scenario curve (orange line) is steeper than the other scenarios, meaning higher emissions prices are needed to deliver the same quantity of abatement. This reflects how supporting policies can interact with emissions pricing to unlock further emissions reductions. Within the model, this is affected by assumptions such as constraints on EV uptake or how responsive consumer fuel-switching decisions are to cost factors.

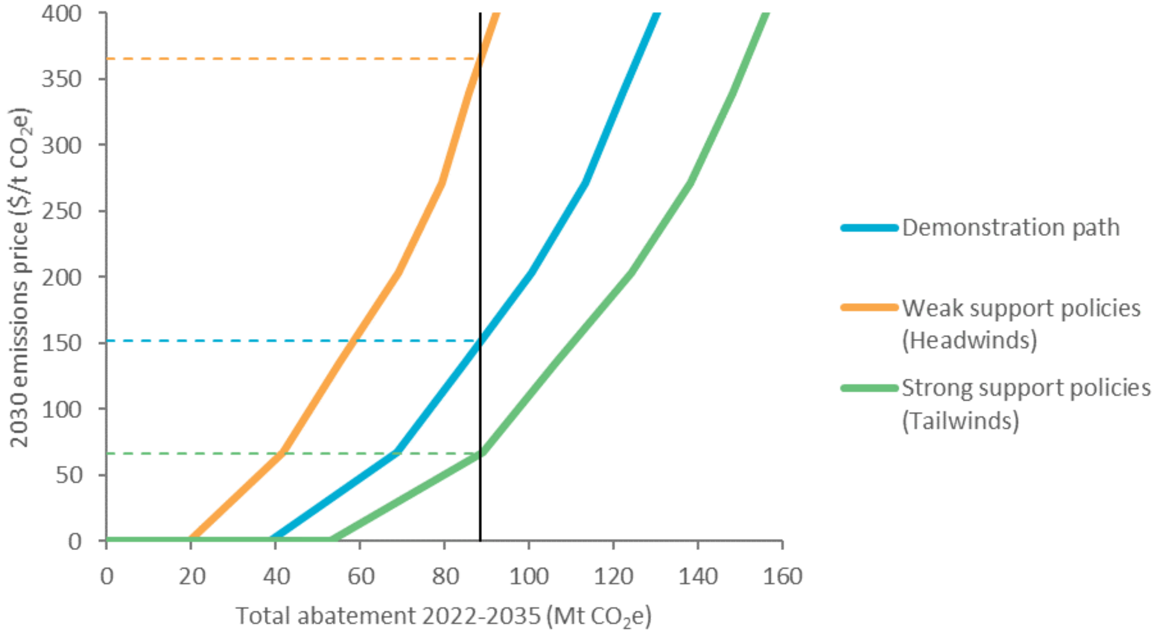

Figure 4: Abatement-cost curves for the 'Weak support policies (Headwinds)' and 'Strong support policies (Tailwinds)' scenarios compared with the demonstration path

Price paths consistent with meeting the target emissions levels

Above we identified the minimum 2030 emissions prices modelled to meet the target emissions level over 2022–2035 (defined in section 2.1) in each of the four scenarios ('High/Low baseline and mitigation costs', 'Weak/Strong support policies'). In Figure 5 we show full emissions price paths for these scenarios alongside the demonstration path.[8]

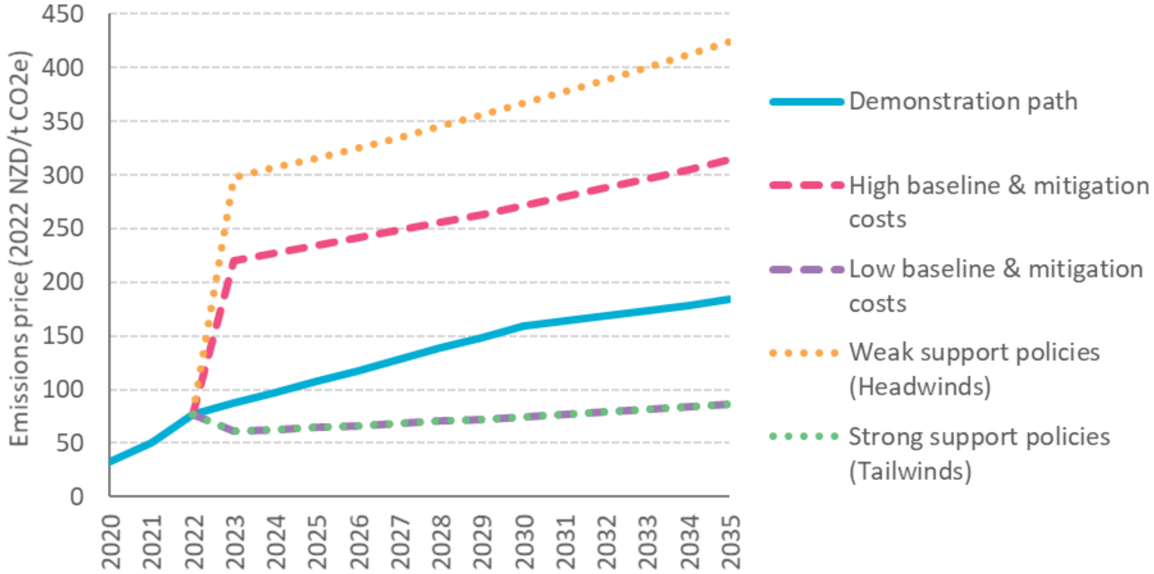

Figure 5: Emissions price paths consistent with achieving the NZ ETS target emissions level under the four scenarios, compared with the demonstration path emissions values. The 'Low baseline and mitigation costs' and 'Strong support policies (Tailwinds)' price paths are overlapping.

[8] Note the emissions price paths shown in Figure 5 are slightly higher than the minimum 2030 price levels identified above, as explained in footnote 8.

Emissions reductions by sector

Figure 6 shows how the different sectors contribute to the total abatement across the 2022-2035 period under the different scenarios.[9] Within the model, higher or lower emissions in transport and waste (from changes in baseline activity or the impact of non-NZ ETS policies) are balanced out by compensating changes in energy emissions. This is because the energy sector, particularly electricity generation and industrial process heat, are sensitive to the emissions price. The effect of the emissions price on transport is more muted.

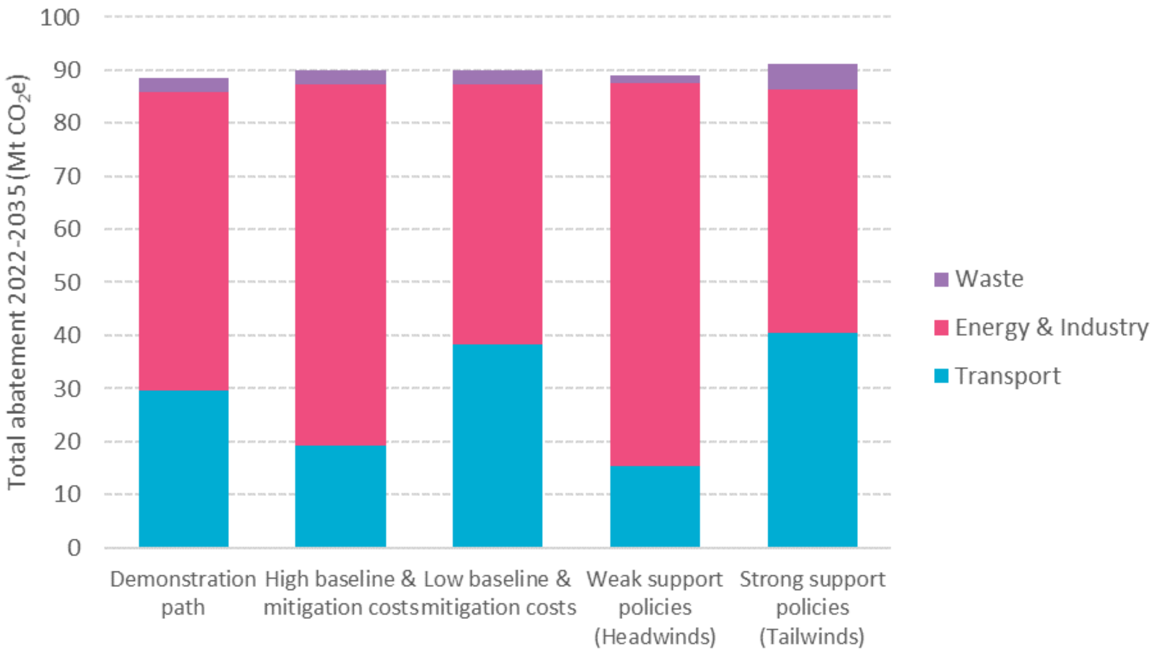

Figure 6: Total abatement from 2022-2035 broken down by sector under the different scenarios with the emissions price paths shown in Figure 5

Comparison to estimated policy impacts in the Government's emissions reduction plan

The Government's first emissions reduction plan (ERP) includes plans for implementing complementary policies alongside the NZ ETS and provides estimates of the emissions reductions expected to be achieved in each sector.

The ERP provides a policy impact assessment with low and high estimates of abatement potential for each sector. Due to the ERP being released late in our analysis, and the level of detail required to do so, we could not incorporate specific measures from the ERP into this analysis. Instead, using data provided by the Ministry for the Environment, we calculated the level of abatement within NZ ETS sectors from policies other than the

[9] Note again that we are measuring abatement relative to the same reference scenario even though the 'High/Low baseline and mitigation costs' scenarios use different baseline assumptions. In other words, some of what we are calling abatement here is due to higher or lower levels of baseline activity (e.g., vehicle travel).

NZ ETS.[10] In Figure 7 we compare the overall levels of emissions reductions that the government estimates non-NZ ETS policies could deliver to our own scenarios.

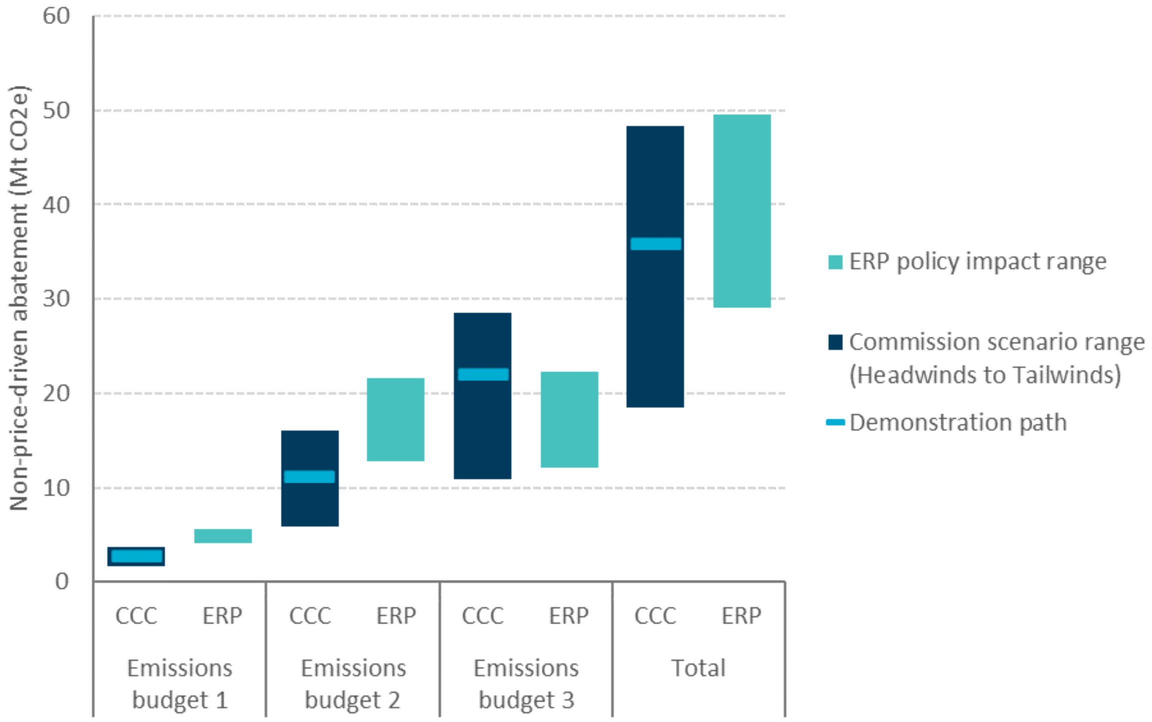

Figure 7: The level of non-price-driven abatement in NZ ETS sectors other than waste in the Government's ERP policy impact assessment compared with in the Commission's scenarios. This comparison excludes the waste sector as it was not possible to isolate the NZ ETS component in the ERP data.

The data from Figure 1 is taken directly from the Governments ERP and are not referenced as an assessment of the ERP's effectiveness. We compared the level of non-price-driven abatement in our own scenarios representing weak/strong support policies. This gives a high-level indication of the level of abatement that the NZ ETS would need to drive if the other quantified policies in the ERP are implemented, and their estimated emissions impacts are achieved.

Compared with the Commission's scenario range, the ERP policy impact range is towards or above the high end for emissions budgets 1 and 2, but towards the low end for emissions budget 3. In sum, over all three budget periods, the ERP estimates a range of 29 – 50 Mt CO_2e of abatement from policies other than the NZ ETS, while our scenarios give a range of 18 – 48 Mt CO_2e.

At face value this comparison could suggest that the emissions price range required in the NZ ETS may be lower under the package of policies in the ERP than our analysis indicates. It suggests the very high emissions price path seen in the 'Weak supporting policies (Headwinds)' scenario would be unlikely to be needed. However, we advise against drawing any strong conclusions from this high-level comparison. A key issue is that

[10] We calculated this by subtracting the emissions reduction impact attributed to the NZ ETS from the total estimated impact for the transport, energy, and industry sectors. Waste was excluded as it was not possible to isolate the component covered by the NZ ETS in the ERP data we received. We did not include additional emissions reductions impacts from the transport targets set out in the ERP.

some of the abatement attributed to other policies in the ERP (such as the Government Investment in Decarbonising Industry (GIDI) fund) is likely to be driven by the emissions price within our modelling. Where this overlap occurs, the abatement from the policy may not reduce the level of emissions price required.

Model limitations and caveats

All models have limitations. There are several limitations around how the ENZ model represents emissions pricing that are important to consider in interpreting the results.

ENZ models the areas we expect emissions pricing to make the biggest difference but does not fully capture the likely impact on mitigation actions. In ENZ, emissions prices have no impact on:

- energy and transport demand
- energy efficiency measures
- mitigation in the waste sector
- uptake of liquid biofuels
- assumptions affecting how fast EV uptake and household fuel switching can occur.

These assumptions are reasonable considering emissions prices seen to date, reflecting areas where the price is a small component of costs or savings or where other policies are expected to dominate. However, they are unlikely to hold at significantly higher emissions prices. As emissions prices increase, we would expect to see some growing influence in these areas. Much higher prices could also lead to reductions in industrial output.

Further, some technologies that are not represented in the model, such as use of hydrogen for high temperature process heat, could potentially become cost-effective at the higher prices considered in this modelling.

Conversely, the model assumes perfect foresight of future prices, which may drive faster uptake of the available mitigation options than we would expect in the real world where prices are uncertain.

Overall, we consider that these limitations mean ENZ is likely to understate the mitigation response to significantly higher emissions prices.

3. Modelling inputs for the unit limit settings

3.1 Updates to the ENZ model since Ināia Tonu Nei

Model improvements

Improvements have been made to the ENZ model since the release of *Ināia Tonu Nei* based on new information and internal review, as summarised in the box below. The overall impact of these improvements on emissions forecasts was very small at around 0.2% of net emissions from 2020–2050.

Industrial sectors	• For the cement and lime sector, a unique emissions factor has been added for the combustion of tyre-derived-fuel, and the estimation of biomass resource now better considers regional availability. • The price of coal for the food processing sector has been inflated to reflect 2019 prices. • For the agricultural and commercial sectors, the calculation of the abatement from the use of liquid biofuels has been revised. • Electricity consumption for the 'other chemicals' sector has been revised.
Transport sectors	• Revised the total historic vehicle-kilometres travelled (VKT) calculation to include plug-in hybrid vehicles.
Land sectors	• Updated the breakdown of emissions by gas for technologies applied to the sheep and beef sector. • Updated projection of wood harvest volumes to account for non-harvested exotic forest.

3.2 Updates to historical data sources

Since the release of *Ināia Tonu Nei* in June 2021 several of the key data sets used in the ENZ model have been updated. This section lists all updates to historical data sources used in the Commission's analysis.

2022 National greenhouse gas inventory report

The Ministry for the Environment (MfE) compiles and publishes the National Inventory Report (the 'national greenhouse gas inventory') which provides official estimates of greenhouse gas emissions by sector along with other official statistics related to emissions. We have updated ENZ to use the most recent national greenhouse gas inventory, published in April 2022[11], which includes emissions up to the calendar year 2020. This dataset forms the basis for the emissions projections in ENZ. We have updated the model base year for projections from 2019 to 2020.

The 2022 national greenhouse gas inventory included some significant methodological changes which affected the emissions projections. Most notably, approximately 1 Mt CO_2e of emissions from the combustion of liquid fuel were reallocated from road transport to recreational marine usage in the residential sector. This decreased total transport sector emissions in 2019 by 10% and increased residential sector emissions by 167%.

[11] (Ministry for the Environment, 2022)

There was also a methodological change around how emissions from the leakage of HFCs are estimated. This update reduced estimated HFC emissions for the 2019 calendar year by around 15%, or 0.25 Mt CO_2e.

Energy statistics

The Ministry of Business Innovation and Employment (MBIE) compile and publish national energy statistics on a quarterly and annual basis. We have updated ENZ with the latest oil, fossil gas, coal and biomass consumption and supply statistics from the Energy Balance Table, and electricity generation and consumption (including Installation Control Point (ICP) numbers) data from the Electricity Statistics Table. Natural gas field reserves have also been updated from the New Zealand Oil and Gas Reserves tables.

The latest energy statistics are complete for the calendar year of 2021, which is 12 months ahead of the latest national greenhouse gas inventory. The model estimates emissions for the 2021 calendar year based on the actual reported fuel consumption assuming consistent emission factors.

Other data source updates

Vehicle fleet statistics[12]	• Added 2020 vehicle entry and exit by type and fuel • Added 2020 New/used vehicle split by type and fuel
Vehicle fleet emission model base case 2022 update[13]	• Updated estimated historic road transport fleet emissions 2001 – 2020 • Updated VKT by vehicle type 2001 – 2020
GDP[14]	Added 2020 GDP
Oil price[15]	Added 2020 oil price
EV sales	EV registrations in 2021 and 2022 were added using motor vehicle register data up to April 2022[16]. Registrations in 2022 were forecast based on the average of the previous 12 months May 2021 - April 2022
Dairy statistics[17]	Added milking cow population and milk solids production for 2020 and 2021.

[12] (Ministry of Transport, 2021)
[13] (Ministry of Transport, 2022)
[14] (Te Tai Ōhanga, The Treasury, 2022)
[15] (US Energy Information Agency, 2022)
[16] (Waka Kotahi (NZ Transport Agency), 2022)
[17] (*New Zealand Dairy Statistics 2020-21*, 2021)

3.3 Updated current policy reference scenario assumptions

This section lists updates to the 'current policy reference' scenario (CPR) presented in *Ināia Tonu Nei*. It does not include measures detailed in the Government's first ERP or an update to model emissions values in line with recent changes in NZU price. The assumption updates detailed here also apply to the updated demonstration path scenario.

Updates to assumptions

Macro assumptions

Short-term GDP projection	Updated short-term GDP projection from 2021 to 2023 based on the Treasury's Budget 2022 forecast. From 2024, GDP reverts to the original projections.

Industrial activity

Aluminium smelting	We assume that Tiwai Point aluminium smelter continues to operate beyond 2024 at the conclusion of their main electricity supply contract. This is a change from our default assumption in *Ināia Tonu Nei* that the smelter would close at the end of 2024. The smelter consumes around 13% of national electricity and its future state has a considerable influence on the energy system. The change in assumption increases emissions due to: 1. Direct emissions from the smelting process 2. Indirect impact on the electricity system. More thermal generation runs for longer in the system if the smelter remains. 3. Impact on electricity prices. Wholesale electricity prices are higher if the smelter remains, which has impact on electrification rates primarily in industrial process heat. The smelter owners have signalled a desire to continue operation and as of July 2022 aluminium commodity prices remain high. High commodity prices are likely to increase the profitability of the smelter whereas the closure announcement coincided with a period of very low global aluminium prices. We note that the electricity system operator (Transpower) assumes continued operation in their current security of supply assessment and that their position was tested through public consultation.[18] The future operation of the smelter remains uncertain, but we have changed our default assumption based on this new evidence. This ensures our scenarios reflect the level of effort required to meet emissions budgets in the case that the smelter continues to operate.

[18] (Transpower, 2022)

Methanol production	We have increased our assumption of the future levels of methanol production by 43% so that plants operate at 95% capacity by 2023. We have not changed our assumptions on the timing of closure of the methanol producing trains at Motunui, or the restarting of the Waitara Valley train. Recent gas supply shortages are being alleviated through investment in upstream production and a reduction in baseload gas demand.[19]
Refining	The Marsden Point refinery converted to an import terminal in May 2022. We have incorporated this into the model projections. For *Ināia Tonu Nei* we had assumed that the refinery would continue operating.
Pulp production	Norske Skog's Tasman pulp mill closed in 2021. We have incorporated this into the model projections.

The methodology applied for projecting other industrial emissions has been improved. Previously ENZ used the most recent actual reported emissions as the starting point for projections. Because in 2020 many industries curtailed production due to the COVID-19 pandemic response, this approach was no longer appropriate and could underestimate emissions in future years. The new methodology uses the average of emissions over recent years as the projection basis. For sectors which are not constrained by plant capacity and activity has demonstrated robust trends in recent years, we project this trend to estimate future activity.

Energy prices

Oil price	Near-term oil prices have been updated using the U.S Energy Information Agency (EIA) short-term oil price outlook 2022-2023[20]. Prices gradually return to the 2030 values assumed in *Ināia Tonu Nei*.
Electricity prices	We have aligned our short-term wholesale electricity prices with our recent electricity market modelling (see Technical Annex 3). A dynamic has been introduced into the ENZ model which adjusts short-term prices based on emissions values/prices.
Gas prices	Wholesale prices have been increased for the 2021 and 2022 model years. Actual reported prices have been used for 2021. For 2022, we used the midpoint of the reported price and the model equilibrium price.
Coal prices	Huntly coal prices are elevated from 2022 to 2026.

[19] (Concept Consulting, 2021)
[20] (U.S. Energy Information Agency, 2022)

Agriculture and forestry

Updated MPI projections	MPI produced its most recent projections of agriculture and forestry activity and emissions in June 2021. The Government took these updated projections into account when setting the final emissions budgets. We use MPI's projections as the basis for our updated current policy reference scenario. We undertook a full update to incorporate these more recent projections. This includes projected land areas (including afforestation and deforestation), livestock populations, production metrics, and fertiliser use.
Provisional exotic afforestation estimates for 2021 and 2022	We have replaced projected levels of exotic afforestation in 2021 and 2022 with provisional estimates based on reported tree stock sales in 2021 and expected seedling sales in 2022.[21] We estimated a likely new planting area of approximately 60,000 ha in 2022, assuming a replanting area in line with the recent trend.

Other

Hydrofluorocarbons (HFCs)	The latest national greenhouse gas inventory updates the methodology used for estimating emissions of HFCs. This led to a misalignment between reported emissions and the emissions projected in *Ināia Tonu Nei*. The emissions projection used in *Ināia Tonu Nei* was based on standalone scenario modelling of HFC phaseout scenarios. We have reused these projections but have scaled the entire time series so that base year emissions align.

[21] *Provisional estimates of tree stock sales and forest planting in 2021* (Ministry for Primary Industries, 2021)

3.4 Impact of changes to current policy reference scenario Compared to Ināia Tonu Nei

In this section we compare the impact of the updated CPR to the previous iteration published in *Ināia Tonu Nei* and discuss the main changes.

Totalled across the first three emissions budgets, the combined effect of all updates results in a 2% decrease in net emissions in the CPR. Figures 8 to 11 compare the updated CPR to *Ināia Tonu Nei* with different splits by greenhouse gas and sector.

The updated forestry projections from MPI, with higher levels of both afforestation and deforestation, cause the largest difference in the CPR emissions projections. Net forestry emissions increase slightly in emissions budget 1 mainly due to the higher deforestation. However, during emissions budgets 2 and 3 the increase in CO_2 removals due to higher afforestation lowers net emissions substantially compared with *Ināia Tonu Nei* (Figure 8).

Note that the Government took these updated forestry projections into account when setting the emission budgets and made corresponding adjustments to the Commission's recommended budget levels. This means the increase in projected removals by forests has been absorbed into the final emissions budgets.

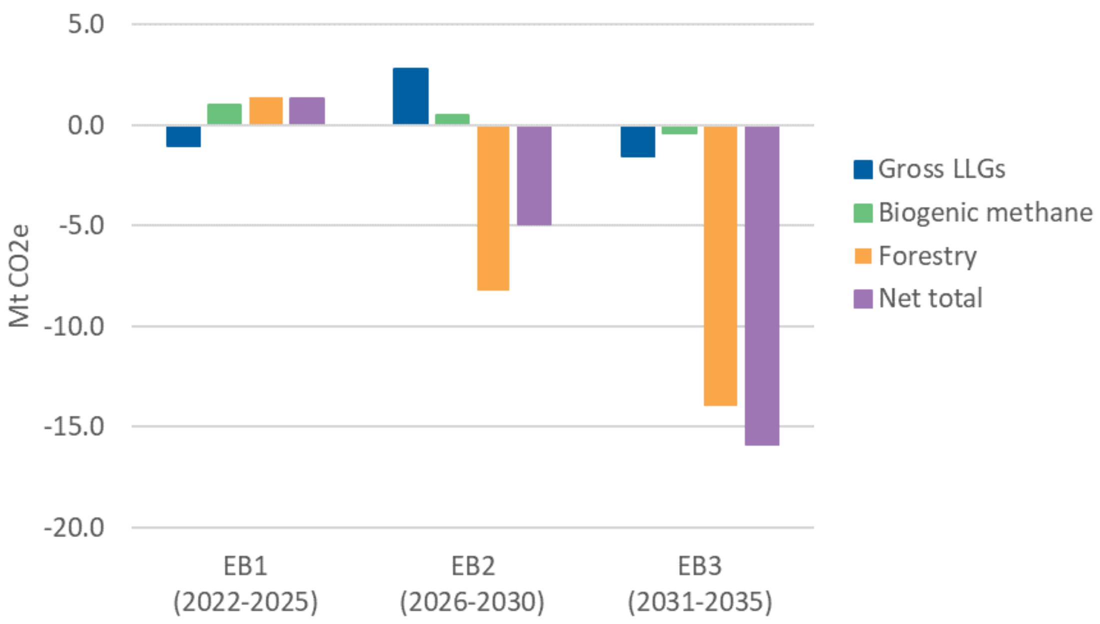

Figure 8: The difference between the updated CPR and Ināia Tonu Nei with gross long-lived gases (carbon dioxide, nitrous oxide, and HFCs), biogenic methane, and forestry removal totals (a positive value means the updated CPR emissions are higher)

The increased contribution of forestry removals persists beyond 2035, with net emissions falling further below those projected in *Ināia Tonu Nei*, while gross emissions are similar (Figure 9).

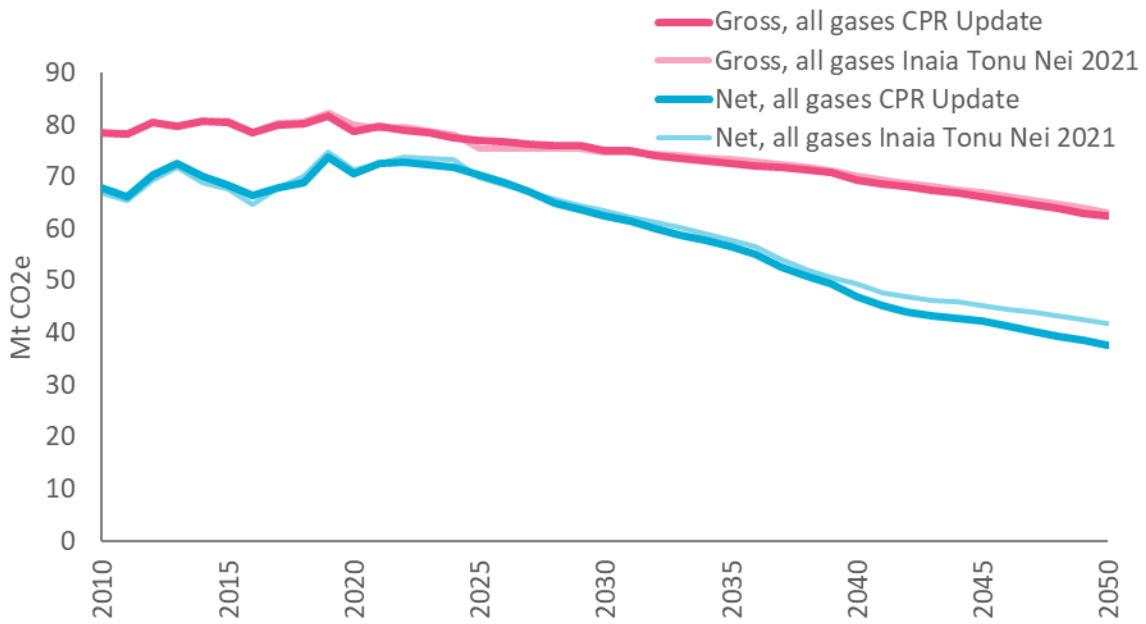

Figure 9: Gross and net emissions in the updated CPR compared with Ināia Tonu Nei

The assumed continued operation of the Tiwai Point aluminium smelter beyond 2024 has considerable impact in emissions budgets 2 and 3 and the final year of emissions budget 1. The smelter's continued operation causes an increase in industrial process (IPPU) emissions and electricity system emissions compared with *Ināia Tonu Nei*. However, this impact is offset by the conversion of the Marsden Point refinery to an import-only terminal in 2022 and the downwards revisions to HFC emissions in the latest national greenhouse gas inventory.

The updates to the CPR also result in a faster electrification of the vehicle fleet, due to the higher uptake seen in 2021 and 2022 and higher oil prices throughout the 2020s.

In agriculture, the updated projections from MPI feature a significantly higher baseline productivity assumption and a relative increase in land area for dairy farming, causing higher emissions. Emissions from sheep and beef farming are similar over emissions budget 1, but lower beyond that due to reduced land area from higher afforestation.

The combined effect of these changes by sector are shown in Figure 10. Note here we show energy and transport as a combined sector due to the national greenhouse gas inventory reallocation issue discussed below.

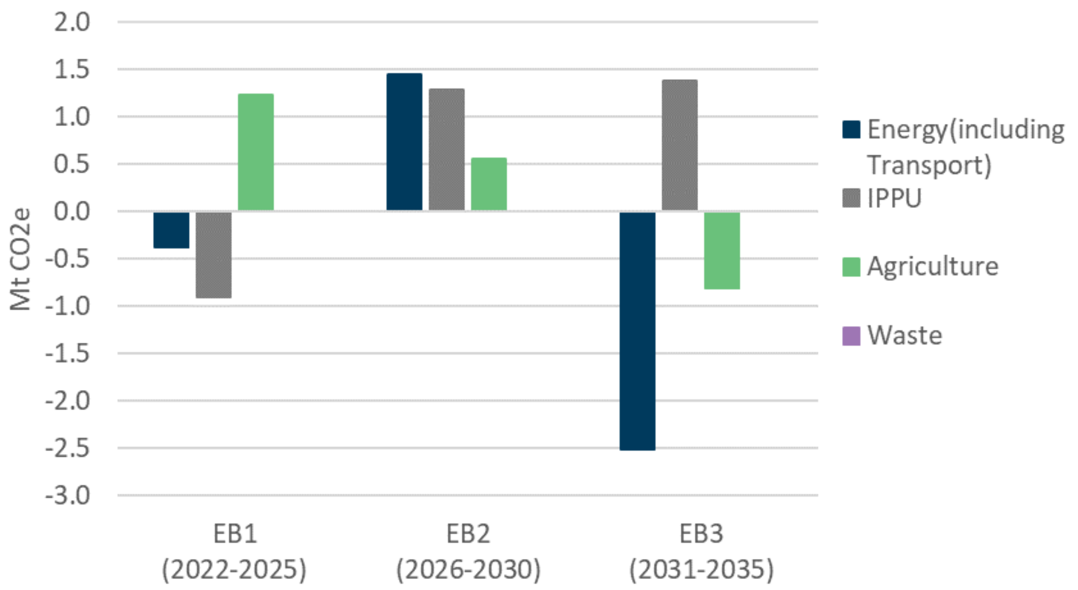

Figure 10: Differences by sector between the updated CPR and Ināia Tonu Nei (a positive value means updated CPR emissions are larger)

As mentioned, methodological changes in the 2022 national greenhouse gas inventory reallocated emissions between the transport and non-transport energy sectors. In the transport sector, inventory changes and faster electrification result in consistently lower transport emissions through to 2050. Emissions are higher for non-transport energy for much of this projection, however they converge to approximately the same level by 2050. This is due to multiple factors.

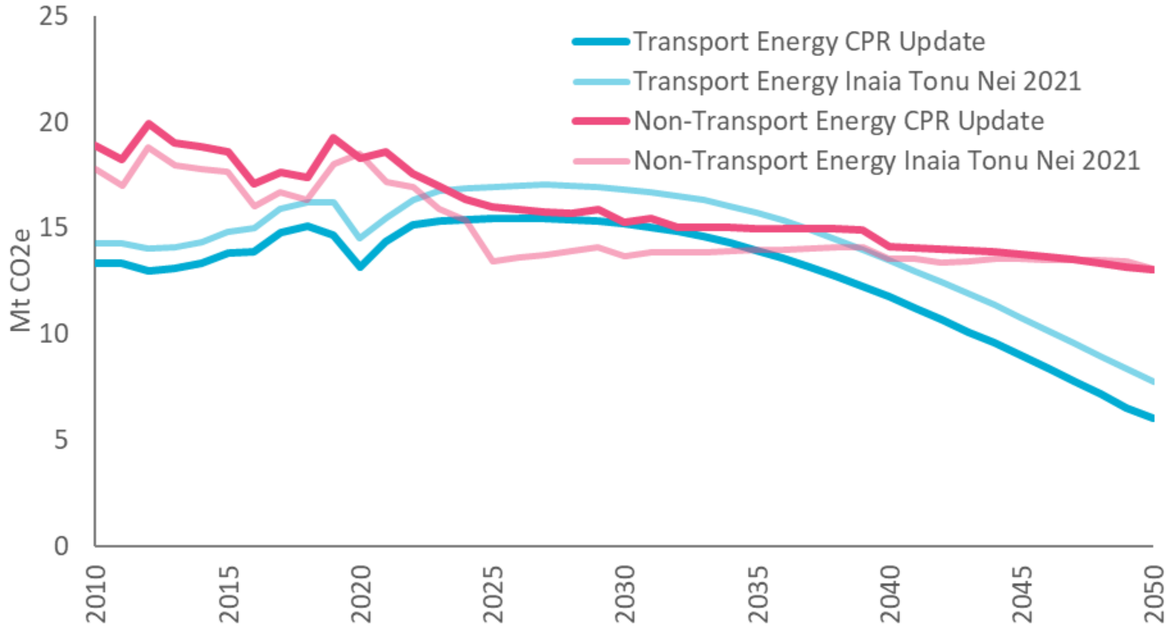

Figure 11: Transport and non-transport energy emissions in the updated CPR compared with Ināia Tonu Nei

3.5 Comparison to the government's latest greenhouse gas emissions projections

The government published the latest official emissions projections in March 2022.[22] These projections precede the latest national greenhouse gas inventory data and do not factor in the conversion of the Marsden Point refinery to an import-only terminal. The projections also assume that the Tiwai Point aluminium smelter ceases operation in 2024, while we assume it keeps operating in the updated CPR. Altogether, this makes a direct comparison difficult for the energy, transport and IPPU sectors.

The ERP provides information on the government's assessment of the emissions impact of the refinery conversion and the continued operation of the smelter. Figure 12 shows the emissions in each budget period when we make these adjustments to the published projections to align with our updated CPR assumptions. The overall differences are relatively small. Note that the higher levels of forestry removals in the CPR compared with the government projections are due to our use of the provisional estimated exotic afforestation area in 2021 and 2022.

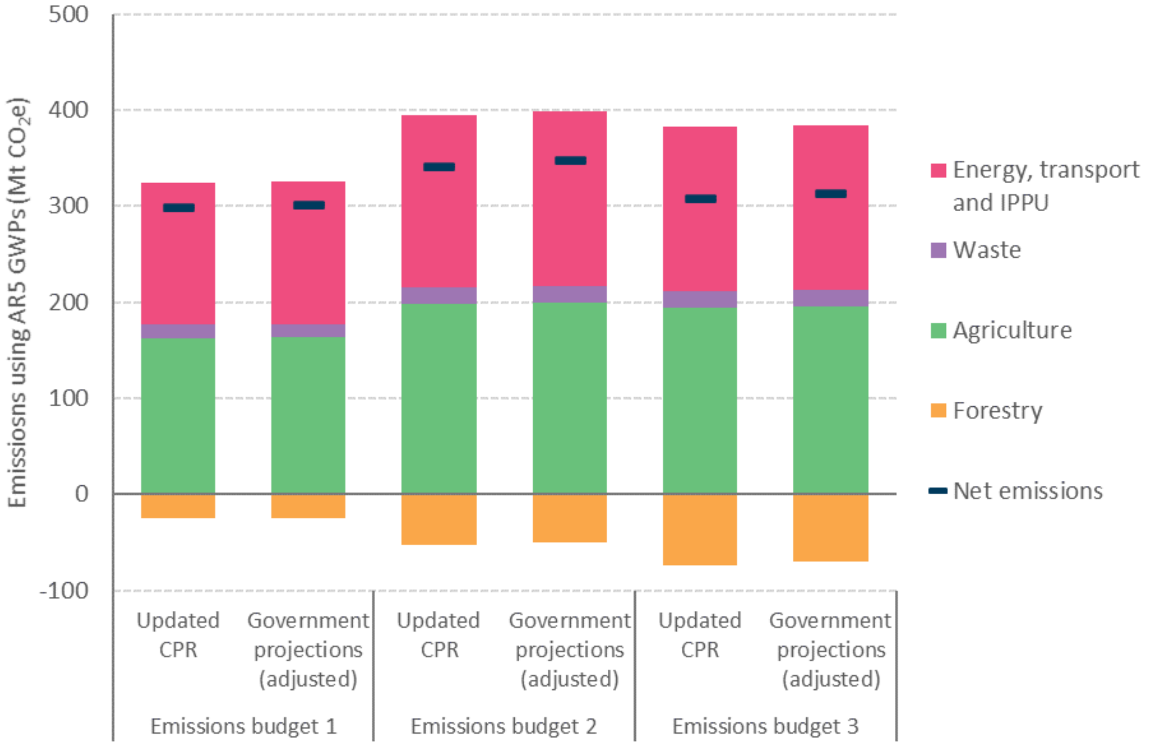

Figure 12: March 2022 government emissions projections when adjusted for the Marsden Point refinery closure and the continued operation of the Tiwai Point aluminium smelter, compared with the updated CPR (using AR5 GWPs)

22(Ministry for the Environment, 2022).

Note that in Figure 12 and Table 3 we present CO_2e emissions using the 100-year Global Warming Potentials (GWP_{100}) from the IPCC's Fifth Assessment Report (AR5) for consistency with the ERP.

Table 3: March 2022 government emissions projections when adjusted for the Marsden Point refinery closure and the continued operation of the Tiwai Point aluminium smelter, compared with the updated CPR (using AR5 GWPs)

	Emissions (Mt CO2e) using AR5 GWP100 values		
Gross emissions	**Emissions budget 1 (2022-2025)**	**Emissions budget 2 (2026-2030)**	**Emissions budget 3 (2031-2035)**
Updated CPR	324	394	383
March 2022 government projections (adjusted)	326	398	384
Difference	-2	-4	-2
Net emissions			
Updated CPR	299	342	309
March 2022 government projections (adjusted)	301	349	314
Difference	-2	-7	-5

3.6 Updated demonstration path

The demonstration path was the core scenario the Commission used in developing its recommended emissions budgets in *Ināia Tonu Nei*. We have updated this for use in the NZ ETS settings advice. All updates to data and baseline assumptions made to the CPR scenario have also been applied to the demonstration path. We have made two additional updates as summarised in the boxes below.

Updates to assumptions

Emissions value price path	The emissions values in ENZ represent a shadow emissions price which drives the uptake of low emission technologies in the energy and transport sectors. The values for 2021 and 2022 are aligned with actual NZU prices, deflated to 2019 dollars. For 2022 we used a year-to-date average up to 31 March. We slightly increased the future emissions values so that the updated demonstration path accords with emissions budgets 1, 2, and 3. To do this, we increased the 2050 value from \$250/t CO_2e to \$260 (in 2019 dollars), while maintaining the same discount rate (3%) and approach using a straight-line trajectory to 2030. The updated values are shown in Figure 13.
Committed electricity generation	We have reviewed the assumed build schedule of committed generation. The Mt Cass windfarm has been removed from the short-term build schedule as development has not progressed at the rate previously assumed.

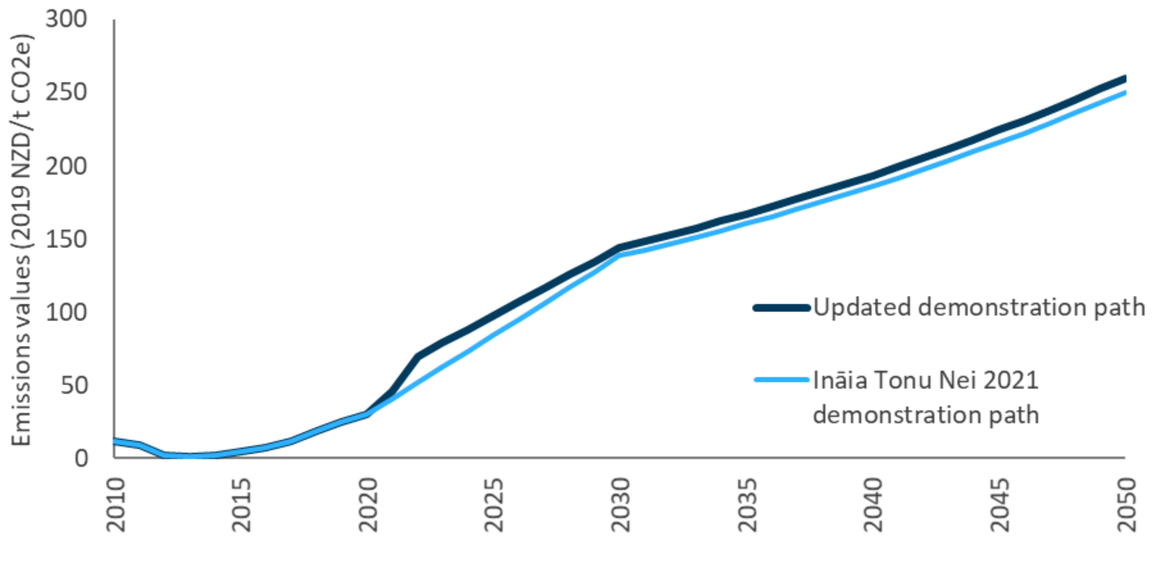

Figure 13: Emissions values in the updated demonstration path compared with Ināia Tonu Nei

3.7 Comparison to Ināia Tonu Nei 2021 demonstration path

Total gross emissions are slightly higher in the updated demonstration path whilst net emissions are lower (Figure 15). While this increase is due to several factors, changes to levels of industrial activity (aluminium smelting, refining and methanol production) has the most significant impact on non-transport energy and IPPU emissions. As in the CPR, the lower net emissions of the updated demonstration path are due to higher projected removals from forestry, which was considered in the government's emissions budgets. In the transport and non-transport energy sectors (Figure 15), the differences introduced by the methodological changes in the national greenhouse gas inventory gradually reduce as fossil fuels are phased out.

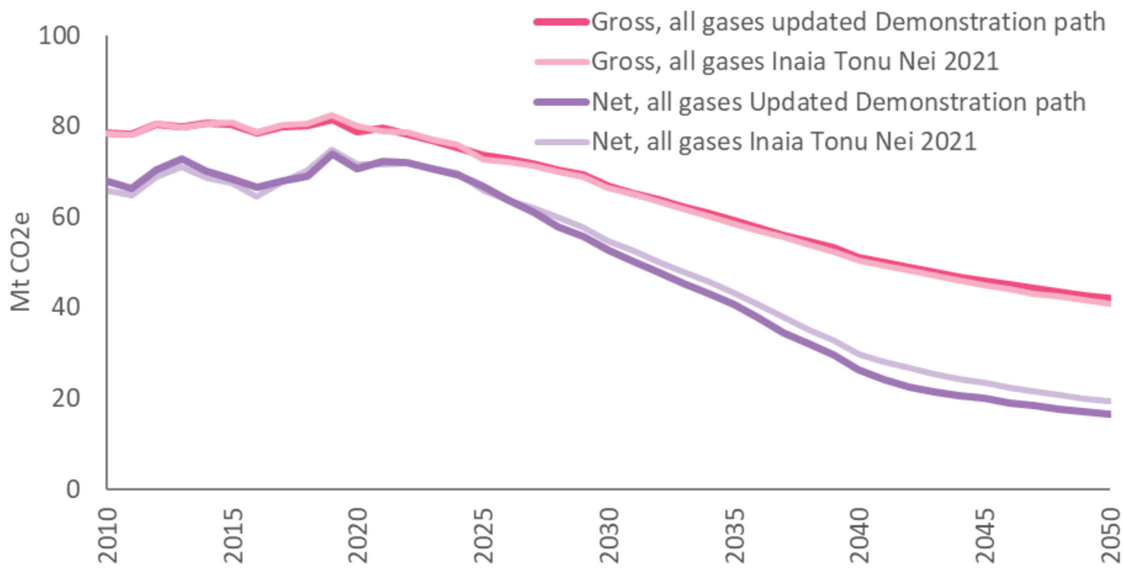

Figure 14: Total gross and net emissions in the updated demonstration path and Ināia Tonu Nei

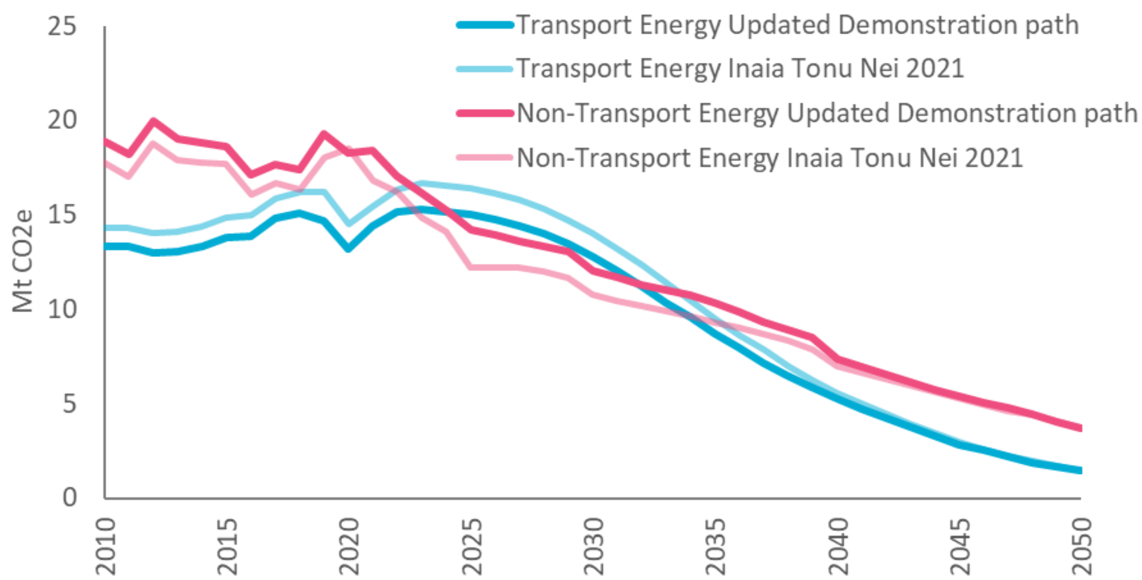

Figure 15: Transport and non-transport energy emissions in the updated demonstration path and Ināia Tonu Nei

3.8 Results using AR5 Global Warming Potentials (GWPs)

Below we present the summary emissions results for the updated CPR and demonstration path converted to use the GWP_{100} values presented in the IPCC's AR5. This is the basis on which the emissions budgets were set and emissions will be reported in the national greenhouse gas inventory from 2023.

Table 4: Updated CPR and demonstration path emissions by sector and emissions budgets using AR5 GWPs

	Updated CPR (Mt CO2e)			Updated demonstration path (Mt CO2e)		
By sector	**EB1 (2022-2025)**	**EB2 (2026-2030)**	**EB3 (2031-2035)**	**EB1 (2022-2025)**	**EB2 (2026-2030)**	**EB3 (2031-2035)**
Transport Energy	61	77	73	61	69	52
Non-Transport Energy	67	79	76	63	66	55
IPPU	19	23	22	18	22	21
Agriculture	162	198	195	160	191	183
Waste	14	17	17	14	15	13
Forestry	-24	-53	-74	-25	-60	-84
Gross total	324	394	383	316	364	324
Net total	**299**	**342**	**309**	**290**	**305**	**240**
Emissions budgets						
Mt CO2-e	290	305	240	290	305	240
Abatement gap	**9**	**37**	**69**	**0**	**0**	**0**

Using AR5 data, Figure 16 shows emissions by sector in the updated demonstration path with the emissions budgets overlaid.

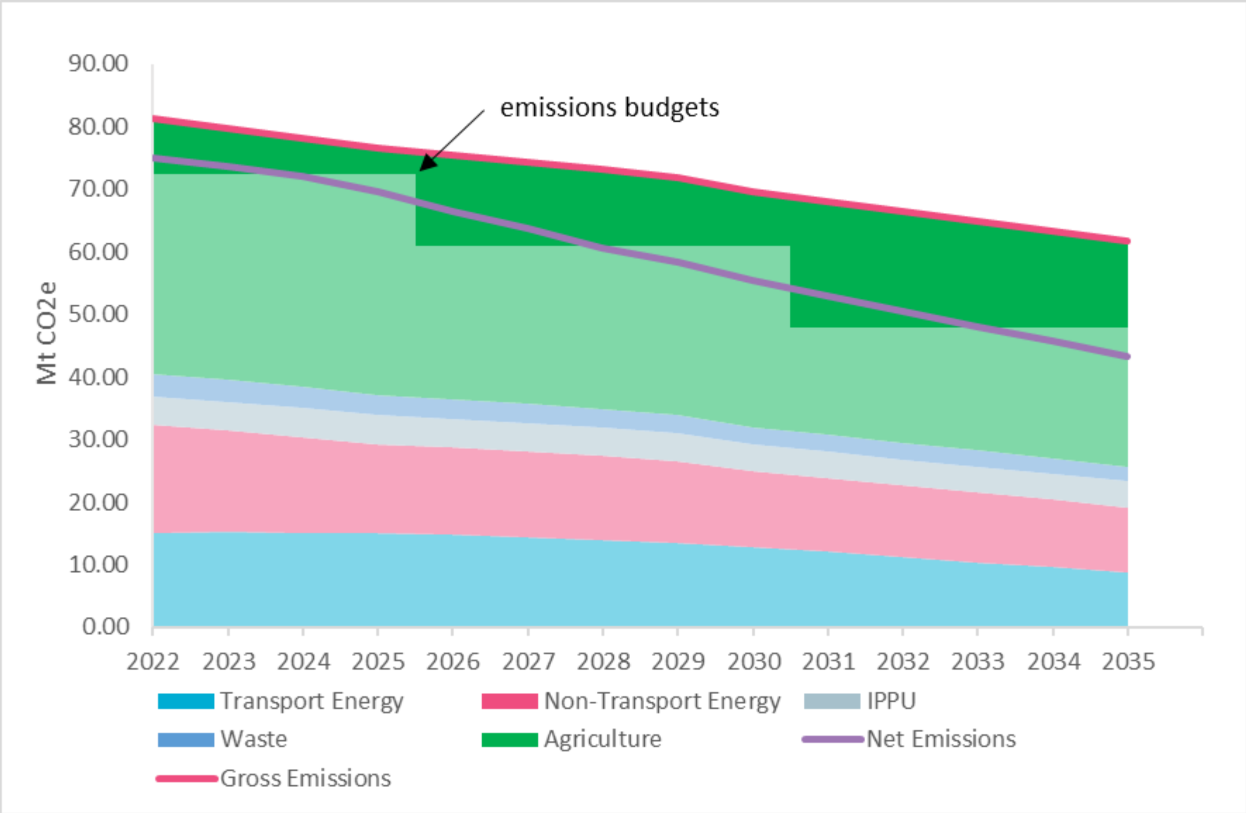

Figure 16: Updated demonstration path emissions by sector (overlayed with emissions budgets in transparent white).

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