Te Arotake Mahere Hokohoko Tukunga

Review of the New Zealand Emissions Trading Scheme

Summary of modelling

Ministry for the Environment
Manatū Mō Te Taiao

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New Zealand Government

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Introduction

Two modelling exercises were carried out:

1. NZ ETS market modelling
2. NZ ETS household impacts modelling

The first model simulates supply and demand for New Zealand Units (NZUs) in the NZ ETS under different prices. It has been used in the review to assess the potential market dynamics of the NZ ETS under its current design and settings in the future.

The second model estimates the impacts of NZ ETS prices on households and on consumer inflation.

The Ministry for Primary Industries (MPI) provided data for the forestry projections used in the model and this report. The modelling was then developed by the Ministry for the Environment and reviewed by MPI, the Ministry for Business, Innovation and Employment, and the Treasury.

This modelling is subject to limitations and uncertainty. It provides simplified accounts of NZ ETS market dynamics and household cost impacts. The model results are not intended to predict future prices. Rather they are intended to capture the core dynamics of the ETS and draw insights on the potential implications of these dynamics under different assumptions.

The NZ ETS market model is being further developed to estimate the impacts of options for ETS reform. Feedback on the key assumptions and methodologies is very welcome.

NZ ETS market model

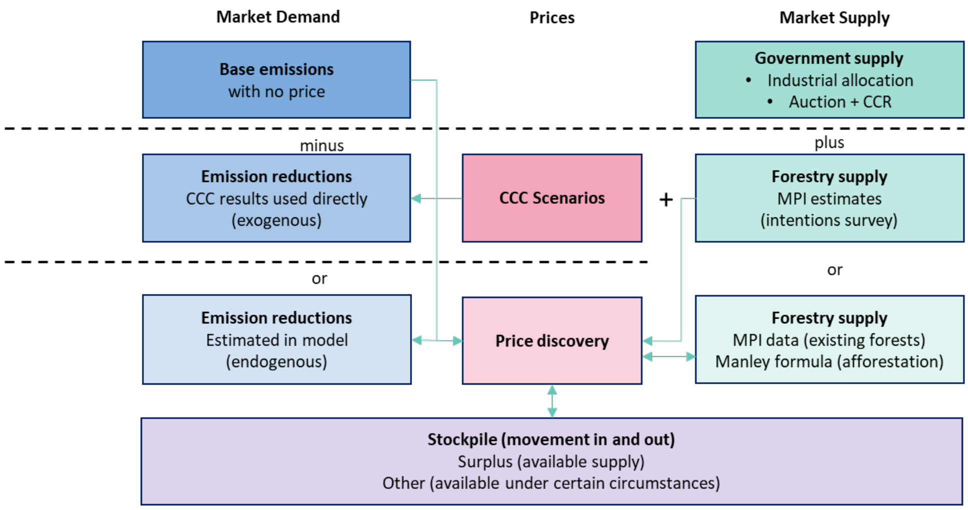
Model components

Overview

This model has been developed to simulate supply and demand for NZUs in the NZ ETS in its current form, under different emissions prices. It has been used to date to understand the nature of the current problem rather than to model the impacts of options for ETS reform. The components of the model are summarised in Figure 1 and described in the rest of this document.

The model operates in two broad ways. One involves external or exogenous assumptions for price, emission reductions and forestry removals. This uses emission and price paths from the Climate Change Commission (CCC) and projections from MPI. The other way estimates emission reductions and removals, and the flow of units in and out of the stockpile, internally (endogenously) in the model using equations that relate these changes to different prices. It sets an objective for the market (minimising the stockpile by 2050 while meeting demand every year) and uses price to optimise relative to that objective. A variant is also used in which MPI projections are used, combined with endogenous estimates of emission reductions.

Figure 1: Components of NZ ETS market model



The modelling results presented in this report are also included in the accompanying spreadsheet (*NZ ETS Market Model Results*).

Market demand

Market demand for NZUs is defined in the model by:

- the gross emissions of mandatory and opted-in participants in the NZ ETS, ie, those with surrender obligations
- the harvest and deforestation obligations of forestry participants

- investors in NZUs.

These sources of demand interact with the market in different ways.

- Forestry demand is from deforestation and the harvesting of post-1989 forests that are using stock change accounting.[1] This demand is expected to be mostly met using NZUs that have been added to (or 'banked' in) a stockpile of units in earlier years.

- Participants in other emitting sectors are assumed to be obtaining NZUs to meet surrender obligations over a shorter time frame.

- Investors add or remove NZUs from the stockpile in response to differences between current and expected future prices.

Annual demand for NZUs from gross emitters was modelled as though operating in a short-term market relying largely on the current year's supply, while the demand from foresters (at harvest or deforestation) was assumed to be met via a long-term market using the stockpile (which is assumed to include removal units set aside by foresters to meet future obligations). Separately, investor behaviour was modelled to simulate the interaction between the stockpile and the short-term market.

Because the model is used to analyse prices that may be quite different from current expectations, including prices that might fall over time, a gross emissions baseline is defined that:

- includes the impacts of investments (eg, in low emission vehicles or industrial production) that will produce (unavoidable) future emission reductions and technology trends (eg, towards more use of electric vehicles regardless of emissions price); and

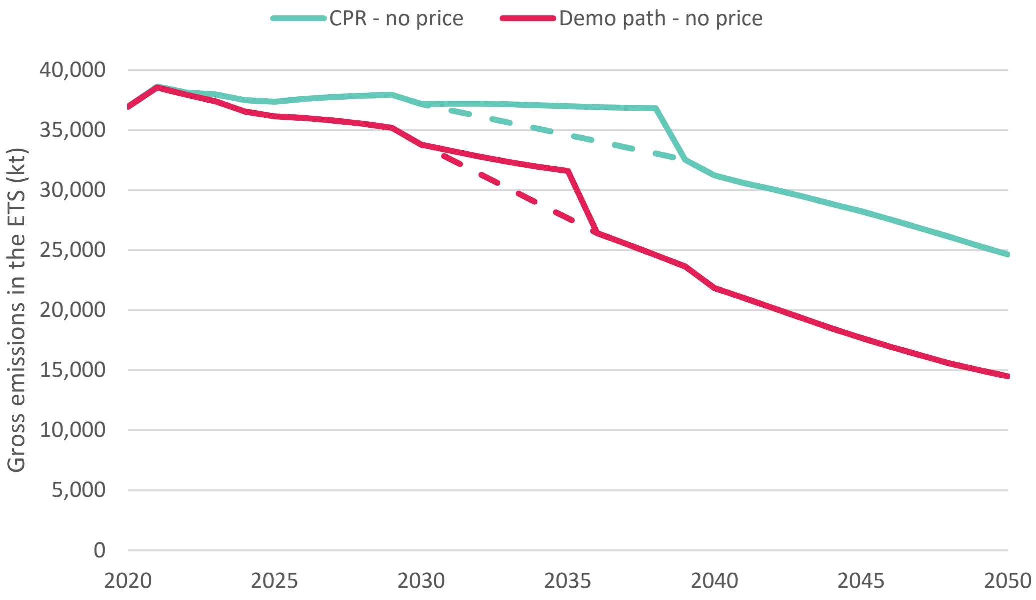
- **assumes a zero price from now on**. This is so that the model can simulate the effects of different price responses with different balances of reductions and removals.

The Climate Change Commission (the Commission) has produced emission estimates for two modelled price paths that assume a zero price from 2023 (Figure 2). These are variants of the current policy reference (CPR) which includes policies as of 2021, and of the demonstration path (Demo-path) that assumes additional policies to those in the CPR.[2] In both zero price scenarios, emissions are forecast to fall because the Commission assumes reductions in energy emissions, particularly from the uptake of electric vehicles and the greater use of renewables in electricity supply. These reductions are not sufficient to meet emission budgets or the 2050 target.

[1] Since 2019, participants have been able to use averaging accounting, and it is compulsory from 2023. Under averaging, forests are a source of supply but not of demand, unless the forests are deforested.

[2] The assumptions are included in Chapter 6 of Ināia tonu nei (Climate Change Commission 2021); the price path numbers (with zero prices) are in the Price controls analysis data sheet in Climate Change Commission (2022d).

Figure 2: Emission estimates for sources in the NZ ETS under Climate Change Commission price paths



Source: Data from Climate Change Commission (2022d)

Both zero-price scenarios have a sudden drop in emissions in the 2030s. This is because of an assumed large fall in non-transport energy emissions in 2039 (CPR) and 2036 (demo path).[3] For this analysis, a smoothed zero-price path is shown by the dashed lines in Figure 2.

Demand response to an emissions price

When an emissions price is included, demand is estimated in the model in one of two ways:

1. Exogenously using scenario results (prices and associated emissions) from the Commission's Energy and Emissions in New Zealand (ENZ) model. The main scenario modelled is the demonstration path;[4] and
2. Endogenously by estimating emission reductions relative to a baseline in response to price within the model. The modelling approach is described in detail below.

Emissions reductions

Emissions reductions are estimated in the model either exogenously, using the Commission's scenarios, or endogenously using a formula to relate emissions to price changes.

[3] These result from a threshold in the Commission's modelling, where the long run marginal cost of new renewable generation drops below the short-run marginal costs of baseload gas generation and there is a significant shift to renewable electricity supply.

[4] Climate Change Commission (2022d)

Exogenous assumptions: Climate Change Commission emission scenarios

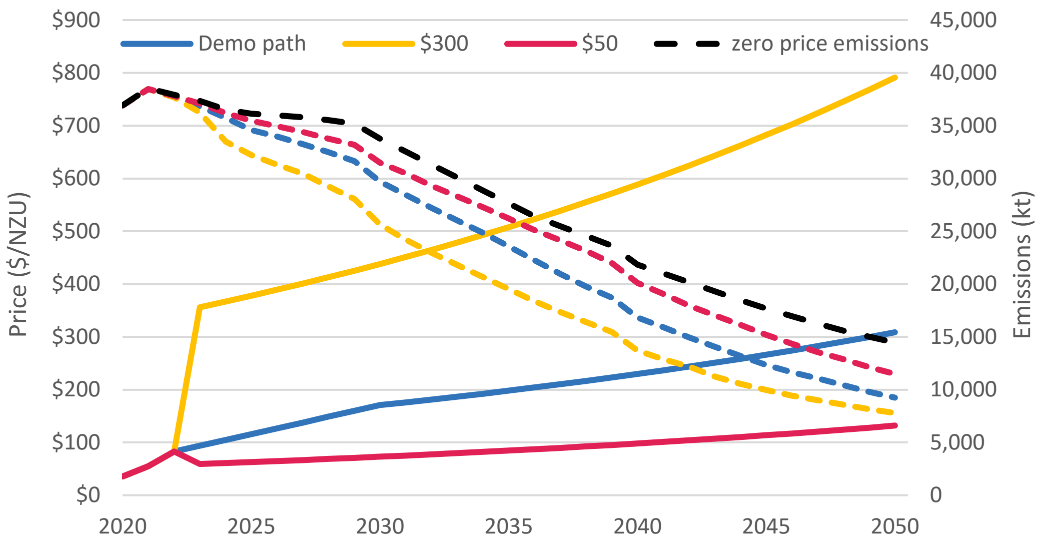
Emission scenarios are taken from the Commission's ENZ model results published alongside its advice on NZ ETS settings for 2023-2027.[5] These estimates are based on a range of emissions price paths that include its demonstration path, which is the central scenario underpinning its emission budget recommendations.[6]

ENZ is a bottom-up model, which means it includes detailed assumptions about technologies, energy use and emissions for individual industries.[7] It includes a mix of endogenous responses to price and exogenous assumptions about expected future technology, fuel mix and policy trends. Although ENZ includes routines to project forestry and land use change, exogenous assumptions have been used by the Commission based on MPI projections.

Figure 3 shows three of the Commission's price paths and the associated emissions estimated for sources in the NZ ETS. This includes (all in 2019$):

- the demonstration path, which increases from $70 in 2022 to $144 in 2030 and to $260 in 2050. Emissions fall from 37.7 million tonnes (Mt) in 2022 to 29.7 Mt in 2030 and to 9.2 Mt in 2050 (a 76 per cent reduction)
- a demonstration path variant that jumps to $300 in 2023 and climbs at 3 per cent annually to $666 in 2050. Emissions fall by 79 per cent to 7.8 MT in 2050; and
- another demonstration path variant that falls to $50 in 2023 and then rises at 3 per cent annually to $111 in 2050. Emissions fall by 70 per cent to 11.7 Mt in 2050.

Figure 3: Emission price paths (solid lines) and associated emissions (dashed lines) in the NZ ETS



Source: Using results from Climate Change Commission (2022d)

[5] Climate Change Commission (2022d)

[6] For the 2022 advice on NZ ETS settings, modelling of the demonstration path and other scenarios was updated to reflect new data and information. This included the latest greenhouse gas inventory, updated government projections for the agriculture and forestry sectors, announcements or decisions regarding large industrial closures, and other updates to data sources.

[7] See more at: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/modelling

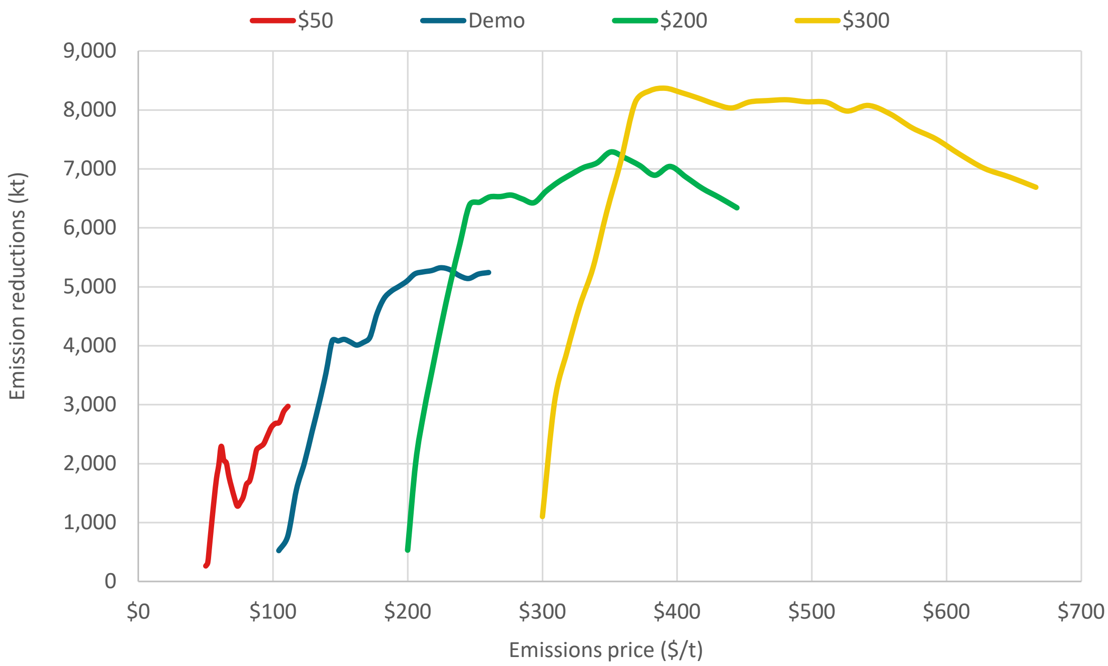
Endogenous estimates

The Commission's analysis provides the emission impacts of several price paths, but this analysis examines the price impacts of changing assumptions, including NZU supply and demand settings. This requires a model that estimates emissions prices dynamically, reflecting the interaction of supply and demand in the market.

The relationship between price and emissions in the Commission's results was calculated and used to derive an equation that estimates the emission reduction response to price under different assumptions.

Figure 4 shows the emission reductions under the demonstration price path (Demo) and variants with different 2023 starting prices (ranging from $50 to $300, compared to $70 in the main demonstration path, which is the blue line in Figure 3). The lines in Figure 4 are the marginal additional emission reductions to those in the zero-price demonstration path. Price paths with starting prices of $100, $150, and $250 follow the same pattern but are not included in the figure. The Commission's modelling is not simulating the response to an emissions price. Rather it is estimating the marginal cost of emission reductions that might be achieved via a price instrument or some other policy. However, in the absence of other data, we use these marginal cost estimates as proxies for emissions prices.

Figure 4: Demonstration price path emission response (reductions below base case) to price



The lines in Figure 4 suggest that the starting price affects the future level of emission reduction at any given price. For example, the $200 price path (the green line that starts with a price of $200/t in 2023) suggests emission reductions of approximately 500 kt at this $200/t price, whereas in the demo path, prices build over time and there are estimated emission reductions of approximately 5,000 kt when price reaches $200/t. The reason for the higher level of emission reduction is that the response to price in ENZ builds over time. A particular price level achieves certain emission reductions from investments in low emissions technologies. Investments take time before they are fully implemented and/or spread to all of an industry so there is a greater level of emission reduction from a price that builds over several years to a high price than from an instantaneous high price.

Under the demonstration path, the price does not reach \$200/t until 2042, 19 years after it is reached in the scenario starting with \$200/t in 2023.

All the emission reduction curves show an initial highly elastic price response before reaching a point where there is little price response. This pattern can be observed in Figure 3. The initial departure of the demonstration path (dashed blue line) from the zero-price baseline (black dashed line), is followed by a period when the lines shift downward but broadly in parallel.

Because of the dependency of the price response on what has occurred to date, the model relates emission reductions to price and the level of emission reduction achieved in the previous year. Because the price response in ENZ is to the estimated future price over the lifetime of the investment, assuming the investor has perfect information about future prices, a forward estimate of prices is used in the analysis: an annualised cost using the current year and ten future years discounted at 3 per cent real. This means if prices are increasing at 3 per cent per annum, the discounted future price is equal to the current price.

This initial equation tested takes the following form:

$$\Delta E = a.ER + b.P + c \qquad [1]$$

Where: ΔE = change in emission levels compared to the zero-price baseline (kt in year)

ER = emissions reduced to start of year (in kt)

P = forward price (\$/t) in 2019 dollar values

a, b = coefficients on emission reductions and price

c = a constant

We also tested a log version:

$$log_e(\Delta E) = a \cdot log_e(ER) + b \cdot log_e(P) + c \qquad [2]$$

The estimated parameter values using least squares regression are shown in Table 1. All have the right sign, and all are highly statistically significant (p <0.01).

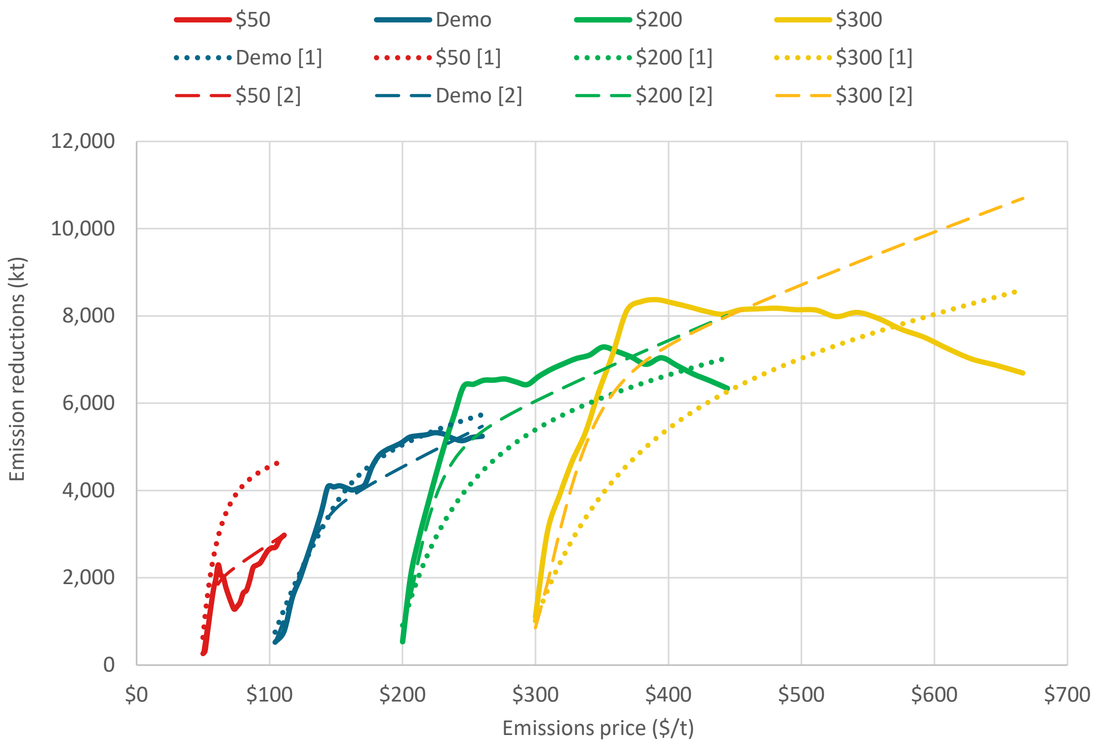
Table 1: Parameter values for Equations [1] and [2]

Parameter	Equation [1] Values	Equation [2] Values
a	0.8775*** (0.016)	0.6091*** (0.0119)
b	1.0533*** (0.2679)	0.2783*** (0.0171)
c	491.2747*** (48.0877)	1.8298*** (0.0751)
Adjusted R^2	0.98	0.98
N	196	196

Note: standard errors in brackets; Significance (p-value) * <0.1; ** <0.05; *** < 0.01

A time variable has not been included in the models because time is also picked up in the price variable which increases each year in all ENZ scenarios. The results using the two models are shown in Figure 5 compared with the results from the ENZ model.

Figure 5: Marginal emission reductions – ENZ model results (solid lines taken from Figure 4) compared with results estimated using equations [1] and [2]



Both equations produce high adjusted R^2 values[8] suggesting the variables are explaining a very high percentage of the differences in emission reductions in the ENZ model results. Figure 5 suggests the models provide a closer match to the demo path than to the variants that include a sudden jump in price in 2023.

In equation [1], parameter '*a*' is multiplied by the already achieved level of emission reduction, ie, the difference in the previous year between the emissions in the base case (demonstration path with a zero price) and the result estimated using equation [1]. The parameter value is 0.88 (Table 1), which means across all years, 88 per cent of the already achieved emission reductions persist into the next year, regardless of the price or the level of emission reductions to date. This might be explained by emission reductions resulting from investments in new lower emission assets or from fuel switching with multi-year supply contracts.

In equation [2], although a constant parameter value is used, the relationship is non-linear because the log of the number has a declining marginal impact as a number increases.[9] This means, the effect of the level of emission reduction achieved last year on emission reductions this year reduces in percentage terms as emission reductions increase.

In equation [1] the parameter 'b' coefficient suggests a $1 increase in emission price results in emissions reducing by 1,053 tonnes (Table 1). In equation [2] the effect is non-linear; there is a diminishing impact of an additional dollar as the price increases.

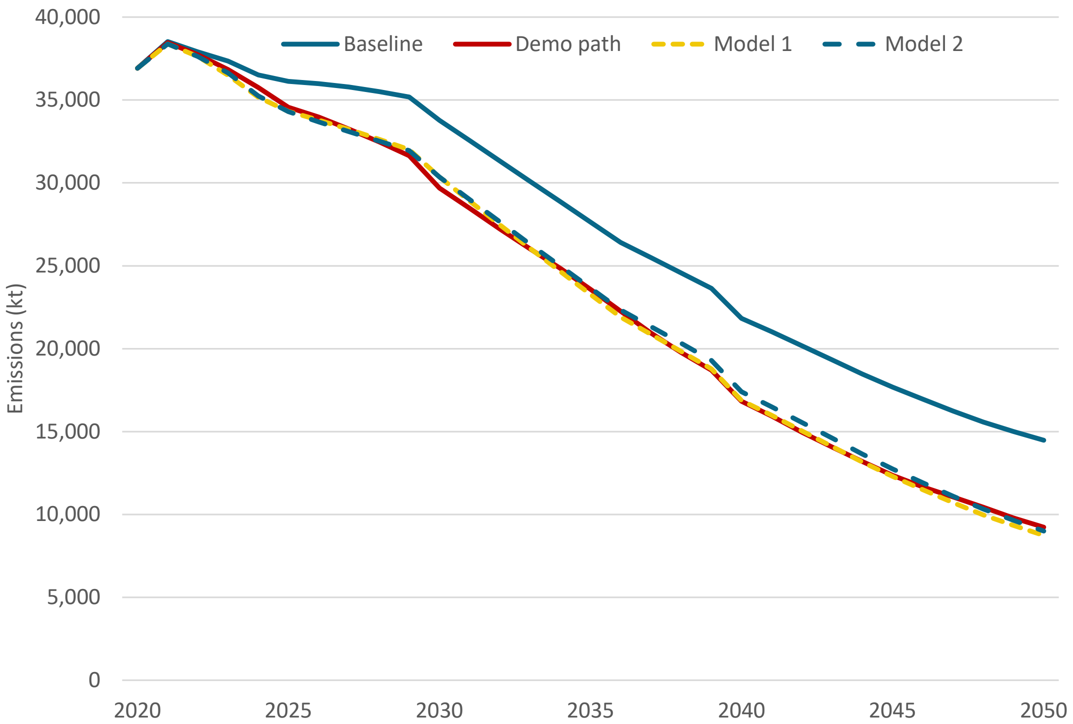
Figure 7 shows the comparison of the emissions in the demonstration path and the estimates using either equation [1] or [2] and the parameter values in Table 1. Figure 6 shows that the two equations broadly reproduce the pattern of results from the ENZ model, although it does

[8] Adjusted R^2 is used because the equations have more than one parameter; adjusted R^2 adjusts the value to take account of the number of parameters.

[9] For example, loge(101) – loge(100) > loge(201) – loge(200)

not reproduce the post-2030 drop-off in impact in the higher price options. It suggests a diminishing price responsiveness with increasing price. The log model (equation [2]) is preferred based on the closer fit across all options in Figure 5 and has been used in the analysis.

Figure 6: Commission's Demonstration path and modelled version



Market supply

Market supply of NZUs includes:

- government supply – these are units given or sold to market participants and include
  - industrial allocation
  - auctioned volumes
  - units released from the cost containment reserve (CCR)
- forestry supply, estimated using:
  - estimates from MPI based on projections from the University of Canterbury extrapolated from data for the next two years in the 2021 Afforestation and Deforestation Intentions Survey, as exogenous inputs to the model;[10] or
  - estimates derived partly from MPI estimates (for existing forests) as exogenous inputs and endogenously in response to price in the model, using a formula and parameter values building on work undertaken for MPI.[11]

[10] See Manley (2022a)

[11] The formula and parameter values are derived from Manley (2022b)

Government supplies

There are three potential sources of government supplies to the market, separate from those resulting from forestry activity:

- allocations to NZ ETS participants in emissions-intensive, trade-exposed (EITE) industries
- auctions of units; and
- release of volumes in the cost containment reserve (CCR) if the trigger price is reached at auction.

Some announcements have been made over the quantities available, although new decisions on volumes are pending. These are shown in Table 2, with prices adjusted to current (2023) dollar values.

Table 2: Potential Government Supply ('000 NZUs) plus auction price control settings

Calendar year	Industrial allocation forecasts	Auction	Action reserve price (2023$)	CCR trigger price (2023$)	CCR volumes available	Total potential supply
2022	5,833*	19,300	$30.00	$70.00	7,000	34,869
2023	6,412	17,900	$33.06	$80.64	8,000	32,312
2024	6,325	17,100	$34.71	$88.70	7,700	31,125
2025	6,259	15,300	$36.45	$97.57	7,200	28,759
2026	6,172	13,500	$38.27	$107.33	6,500	26,172
2027	6,106	11,700	$40.18	$118.07	5,900	23,706

Source: * = actuals for 2022 from EPA ETS Unit Movement Report (https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/ets-reports/unit-movement/); IA projections from Climate Change Commission (2022b). Auction reserve and CCR trigger prices actuals for 2023 then increased at 5 per cent and 10 per cent per annum respectively in 2023 dollars.

Actual volumes for industrial allocation are used for 2022, with future projections from the Commission (2022b). Auction volumes have been announced through to 2027 (Table 2).[12] It is assumed these fall thereafter by 1,500 kt per year, reaching zero in 2035. The current auction floor price) has been included, with no units sold below this price. The CCR was triggered in 2021 and 2022, with 7,000 kt released in both years.[13] The current trigger prices (in 2023$) and volumes as shown in Table 2 are included.

Forestry supply

There are two options for the inclusion of forestry unit supply estimates in the model. One is the estimates made by MPI using data extrapolated from the 2021 afforestation and deforestation intentions survey.[14] The other is to combine MPI data for existing forests with projections of new afforestation using a modelled response to price.

[12] These are based on announcements in December 2022

[13] No auction volumes, including the CCR, have been released in 2023 to date. However, the model does not make any alternative assumptions for total supply in 2023.

[14] Manley B (2022a)

Exogenous inputs only: MPI estimates

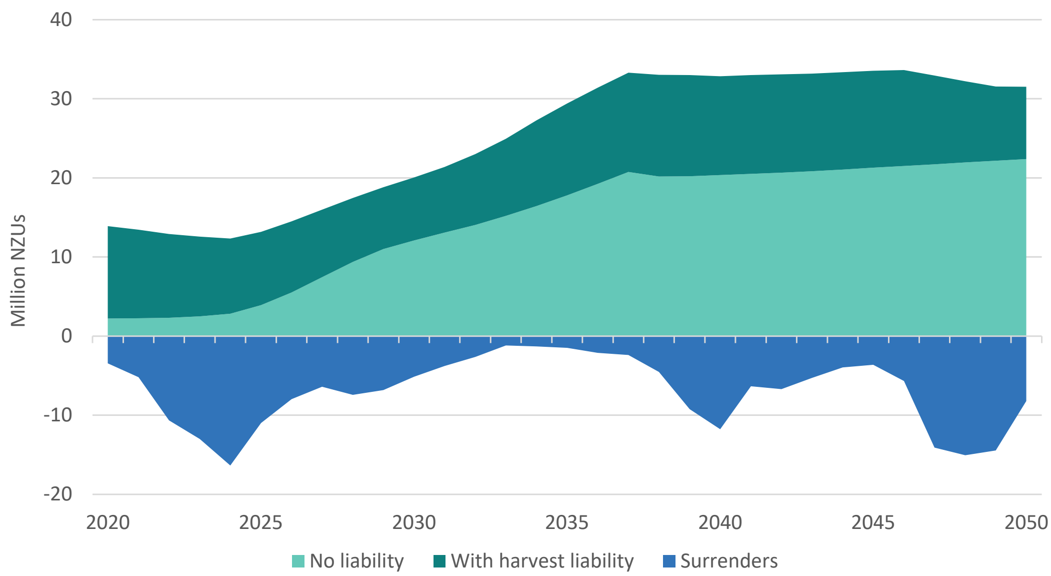
MPI has projected forestry unit supplies to 2050, including units allocated to foresters for emissions removals and surrenders of units at harvest. The allocations have been split into:

- "No liability" – units very likely to be made available to the market, including units from permanent forests and those expected to be produced from forests under 'averaging' rather than 'stock change' accounting from 2019 (and compulsorily since 2023); and
- "With harvest liabilities" – those unlikely to be made available to the market as they are being held to meet future harvest liabilities.

These estimates are based on historical data and the 2021 planting intention surveys[15] and reflect market expectations of NZU prices.

Figure 7 shows the time profile of these supplies. The light green shaded area is the "no liability" supplies, whereas the dark green area is the units expected to be held to meet harvest liabilities. Some of these are potentially available to the market if owners decide to switch from rotation to permanent forest, which might occur if NZU market prices rise to high levels and/or if expected log prices fall.

Figure 7: Estimated annual supply and surrenders of NZUs from forestry (MPI Central scenario)



Source: MPI data

Figure 7 also includes the expected surrenders of units (blue shaded area) to meet this requirement, NZUs would be expected to be taken from the non-surplus component of the stockpile (see the following section describing the stockpile). The surrenders total 209 million tonnes from 2022 to 2050 inclusive, which is more than the current stockpile, so more units will need to be added to cover these surrenders. The stockpile additions would include the dark green area which totals over 300 million units.

As with the Commission's pathways for gross emissions, the MPI projections are based on a limited number of assumptions and reflect the responses obtained in a survey.

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[15] Manley (2022a)

The MPI projections are included in the accompanying spreadsheet (*ETS forestry unit flows MPI 22092022 and Allocation from 2023 – 2050 afforestation*).

Endogenous estimates

Manley (2021) has developed a simple model for MPI to predict future afforestation levels. This can be used to estimate an expected response to price, although it has its limitations. Specifically, the model's parameter values are based on the marginal afforestation response to historical changes in emission prices (and changes in prices of land and of logs); the historical emission price data do not include prices as high as recent or expected future market prices. The model takes the following form and with all prices in 2021$ values:

$$\text{Afforestation rate} = f / (1 + \exp(-h \times (\text{Profit} - g))) \quad [3]$$

Where: Profit $= LEV_{logs} + (k \times LEV_{carbon}) - (d \times LMV)$

f = maximum new afforestation per annum ('000 ha)

d,g,h,k = coefficients

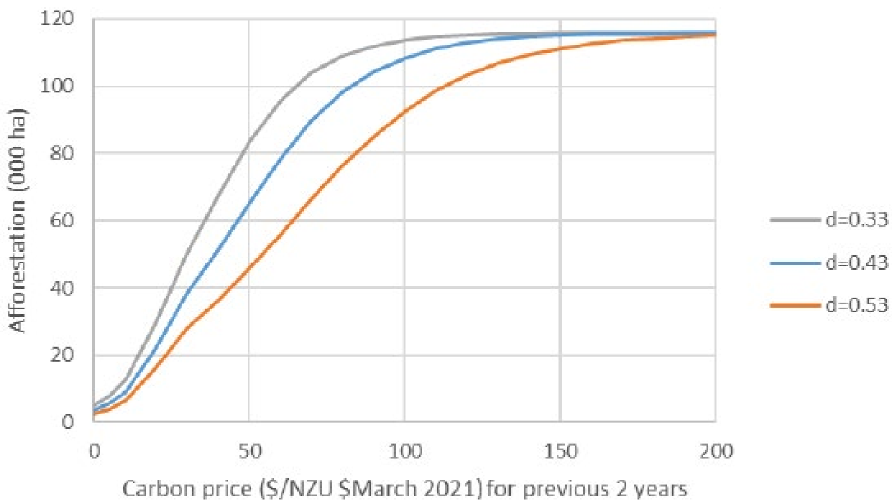
LEV_{logs} = land expectation value for logs. It is the net present value (NPV) per ha at an 8 per cent discount rate of future forestry costs and revenues in perpetuity.

LEVcarbon = the NPV (at 8 per cent) of future carbon costs and revenues per ha in perpetuity.

LMV = Land Market Value = the weighted average per ha value of North Island Hard Hill land (weight of 2) and South Island Hill land (weight of 1)

Using this formula, Manley estimates new afforestation at different emission prices as shown in Figure 8.[16] This includes curves based on different values for coefficient '*d'* which is multiplied by the LMV variable to simulate more (d = 0.33) or less (d = 0.53) afforestation. We have included assumptions to broadly mimic the middle curve.

Figure 8: Forecast of exotic afforestation at different NZU prices (for the previous two years)



[16] The forestry response is dominated by estimated NZU and log income streams. This does not capture the change in incentives in a future in which there are alternative income streams, such as from biofuels.

Source: Figure 3 in Manley (2021)

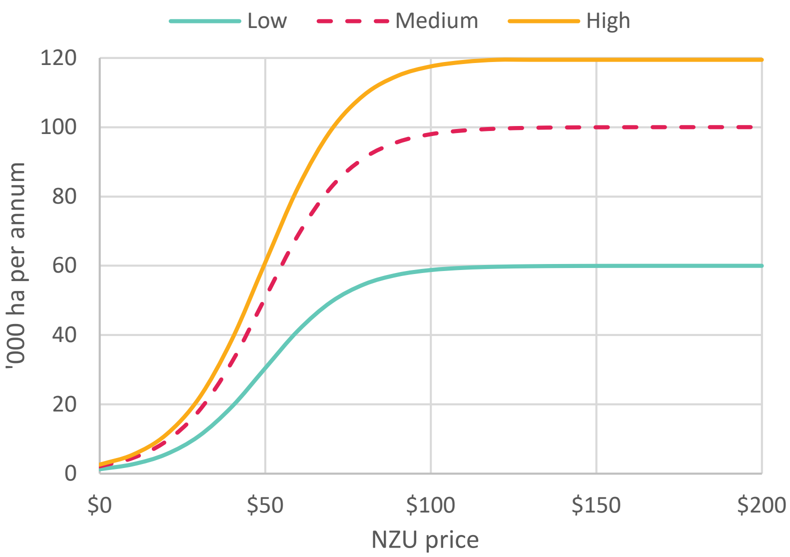
Manley's modelled relationship (equation [3]) is used, with assumptions consistent with different maximum annual afforestation rates. Parameter values are chosen to broadly mimic the shape of the afforestation supply curves in Figure 8. Manley builds these up using different data by region, but more generalised assumptions are used here so that no assumption is made about where the afforestation is taking place. Figure 9 shows the price response when limiting maximum annual afforestation to 60, 100 or 120 thousand ha per annum (parameter f in Table 3). The model also allows this parameter to change by year, eg, assuming land for forestry is a diminishing resource that becomes more difficult to obtain with time.

Table 3: Parameters values used in model

Coefficient	Value	Variable	Value ($/ha)
d	0.4329	LEV_{logs}	$1,965[a]
f	60 (Low) 100 (Medium) 120 (High)	LEV_{carbon}	$175.776 per $1/t[b]
g	4844	LMV	$10,000 (Low/Medium) $7,500 (High)
h	0.0005292		
k	0.8262		

[a] Weighted average of values in Table 10 in Manley (2021); [b] Based on 4,588 @ $26.10/NZU
Source: adapted from Manley (2021)

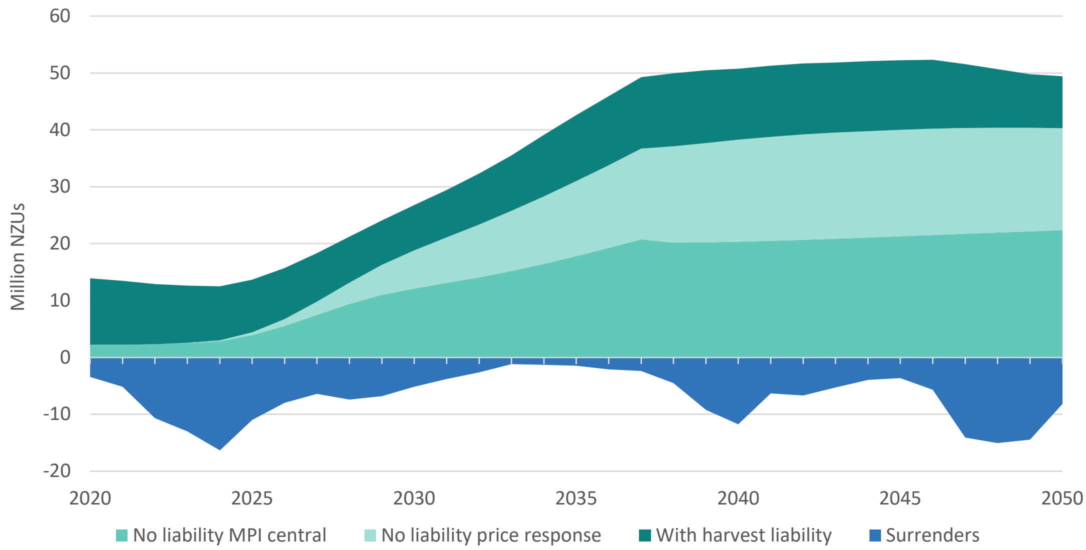
Figure 9: Planting rate at different NZU values



This formula affects estimates of new afforestation for which emission removals will be estimated using an averaging formula. It does not affect estimates of removals and surrenders from forests that have been planted in historical years and which continue to generate removals for many years to come.

Figure 10 shows the results based on an assumed 100,000 ha per annum maximum planting (the medium curve in Figure 9) and assuming a constant price of $70/t in current dollar values.[17] It suggests a significant additional volume of NZUs produced above those in the MPI central forecasts (those labelled as 'no liability price response' in Figure 7). In contrast to the MPI projections where potential supplies to the market increase to approximately 22 million NZUs in 2050, here the potential 2050 NZU supply is over 40 million NZUs. The 'with harvest liability' volumes might be supplied to the short run market under some circumstances also.

Figure 10: Estimated annual supply and surrenders of NZUs from forestry (modelled result under medium afforestation scenario and constant $70 NZU price)



The stockpile

The stockpile is the quantity of NZUs held in private accounts by NZ ETS participants. At any point in time, it includes NZUs supplied by the government and from emissions removals, in addition to units supplied in previous years that have been retained. NZUs do not expire and can be kept for future use. The stockpile is currently much larger than annual demand for units. This is because NZUs were available to the market historically at prices less than the estimated investment value of units,[18] many were purchased or obtained and retained for their future value. Others are retained to meet future surrender liabilities.

The Commission analysed the components of the stockpile as part of its 2022 advice on NZ ETS price control settings.[19] It estimated those potentially available to the market from the total number of units held in private accounts and not held for one of three specific purpose:

- Units held for post-1989 forest harvest liabilities. These are held by participants with forests that are intended to be harvested in the future. The central estimate is 52 million NZUs, but this may change if NZU prices are high and it is more profitable to sell units (and retain a permanent forest) than to harvest the timber.

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[17] This is the same assumptions as used for Figure 4 in the Discussion Document (Ministry for the Environment, Ministry for Primary Industries and Ministry of Business, Innovation & Employment, 2023).

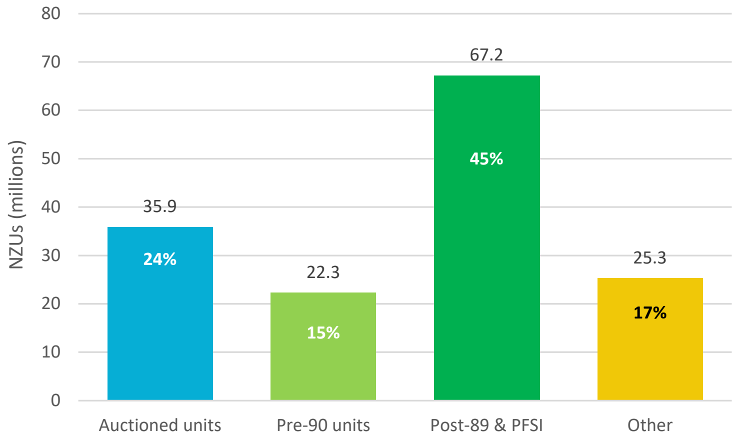
[18] This included international units when the market was open to Kyoto units and when the fixed price option (first at $25/t and then $35) could be used as a substitute for NZU surrender. It also includes units from forestry re-registration arbitrage in 2013-14 when landowners could register post-1989 forests in the NZ ETS, claim NZUs then de-register, paying their obligations using low-cost international units while retaining the NZUs. Landowners could do this multiple times for the same land.

[19] Climate Change Commission (2022a)

- Units held for hedging are those held either by emitters or by banks that have sold NZU forward contracts. The Commission estimates the non-forest hedging at 30 million units.
- Pre-1990 forest allocations held long term were originally allocated as partial compensation for the harvest liability created by the introduction of the NZ ETS. Some are expected to be held for the long term. The Commission estimates this at around 14 million units.

At the end of June 2022, there were 151 million NZUs in the stockpile,[20] equivalent to several multiples of the current supply gap (Figure 11).

Figure 11: Stockpile at 30 June 2022



The Commission has estimated that 49 million units are not held against future liabilities and are therefore potentially "surplus" and could be supplied to the market (Table 4).

Table 4: Stockpile surplus

Purpose	NZUs (millions)
Privately held units (1 June 2022)	144.1
Units held for post-1989 forest harvest liabilities	-52.2
Units held for hedging by emitters	-30.2
Pre-1990 forest allocations held long term	-13.8
Surplus before CCR release	47.8
CCR release June 2022	1.3
Surplus	49.1

Surplus NZUs would be expected to be a potentially liquid supply in the market and be removed from the stockpile to meet a shortfall between supply and anticipated demand.

[20] https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/market-information/privately-held-units/

However, the extent to which this occurs is also determined by price, such that the stockpile functions as a price control measure.

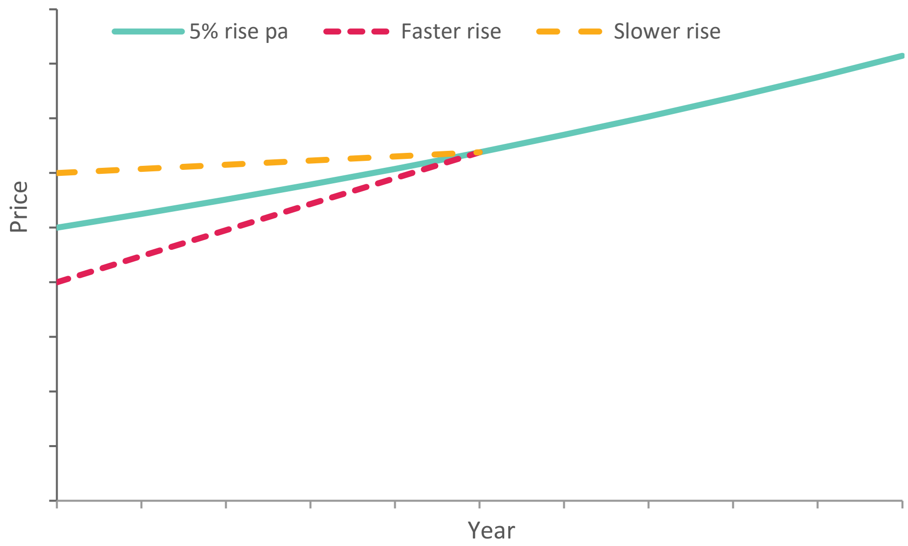
Modelling stockpile behaviour

Theory

Surplus or liquid stockpile units are equivalent to an investment in NZUs. As with all investments, participants will continue to hold (or increase) these investments if the returns are expected to be as great as can be achieved elsewhere, ie, if prices are rising at a rate at least as high as the discount rate.[21] Thus it is expected that (as illustrated in Figure 12):

1. If NZU price is not rising at a rate equal to or above the discount rate (yellow dashed line), it is assumed participants will sell more units to obtain better returns elsewhere. As a result of the increased supply, current prices will fall. This is assumed to occur such that the rate of price increase to expected future prices is equal to the discount rate
2. Conversely, if the price is expected to rise faster than the discount rate (red dashed line), more of the resource will be retained in the stockpile and withheld from the market this year because of those high expected returns. The reduced supply will cause current prices to rise. This is assumed to occur such that the expected price change to next year (or expected future prices) is again equal to the discount rate.

Figure 12: Price change assumptions



Assumptions

The stockpile behaviour used in the modelling assumes the following:

- If the NZU price is not rising at the discount rate (5 per cent real) or higher, units in the surplus stockpile (49 million in 2022) are made available immediately as an additional source of supply.

[21] This is broadly consistent with the Hotelling rule that applies to the efficient pricing of depletable stock resources (Hotelling 1931), although there are significant differences in the NZU market, including falling demand (under business as usual) and additional sources of supply (auction volumes, removals etc).

- Surplus (liquid) stockpile units are added to supply when there is otherwise a gap. This is done after the other responses have occurred (emission reductions and removals) and effectively so the stockpile is optimised across time.
- If the stockpile units are added when price is rising faster than the discount rate, we assume stockpile holders have market power, so price rises in the years the units are used. They will rise such that price will then increase at the discount rate.

Non-surplus stockpile units are also made available when there is a supply shortfall, but it is assumed these are "paid back" some years later to meet future obligations.

Price and price discovery

In the model, changes in emission prices result in changes to the level of supply and demand for units.

- Levels of supply change because:
  - There is a forestry response to price and therefore a change to the supply of removals units.
  - Prices affect the quantities auctioned based on the price control settings.
- Demand changes as there is a price elasticity of demand for emission units (more emission reductions occur at higher prices)

The NZ ETS market model runs with different price paths to 2050. However, the shape of the price path is limited. Rather than allowing price to be set independently each year, the price path options are restricted to constant annual percentage changes in price, eg, a 3 per cent annual rise, although this can be positive or negative.

Total demand and supply are estimated for each year. The model optimises prices by using the following rules:

1. Supply is sufficient to meet demand in every year, including supplies from the stockpile surplus
2. Excess supply over demand aggregated over the period 2023 to 2050 (which might be otherwise added to the stockpile) is minimised. The reason for minimising this surplus is that it is assumed there will be significantly less demand for NZUs in 2050 because of falling emissions, even under the base case with no price. It is not credible for rising prices to be maintained by a growing stockpile when demand is falling.

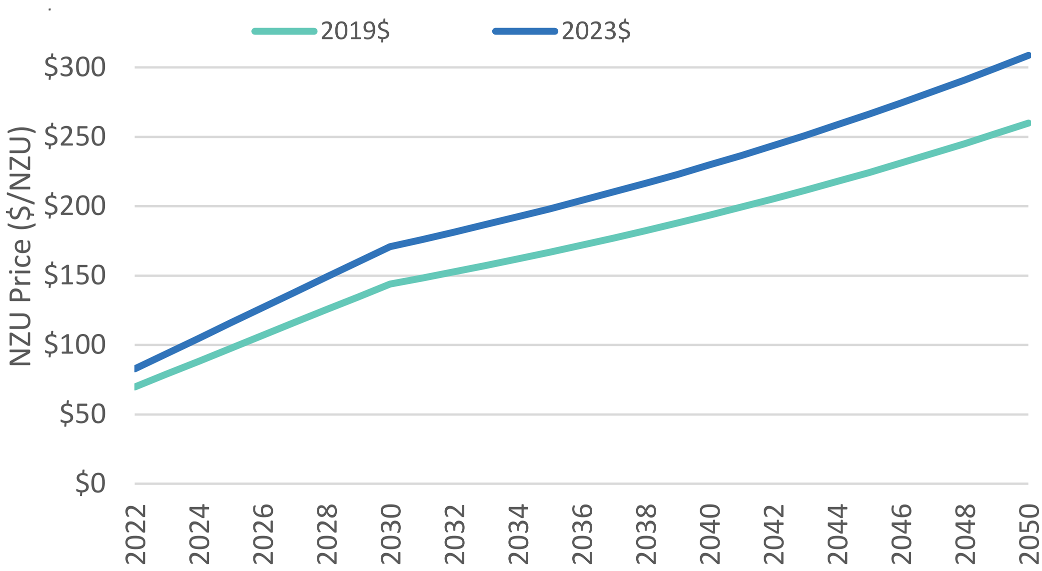
The model result is the price path that best meets these two criteria.

Results

Demonstration path

To illustrate the analysis, the model assesses the expected market outcomes if prices changed according to the Commission's demonstration price path (Figure 13). It increases from $70/t in 2022 to $144 in 2030 and then at 3 per cent per annum to $260 in 2050 (all in 2019$).[22]

Figure 13: Demonstration price path

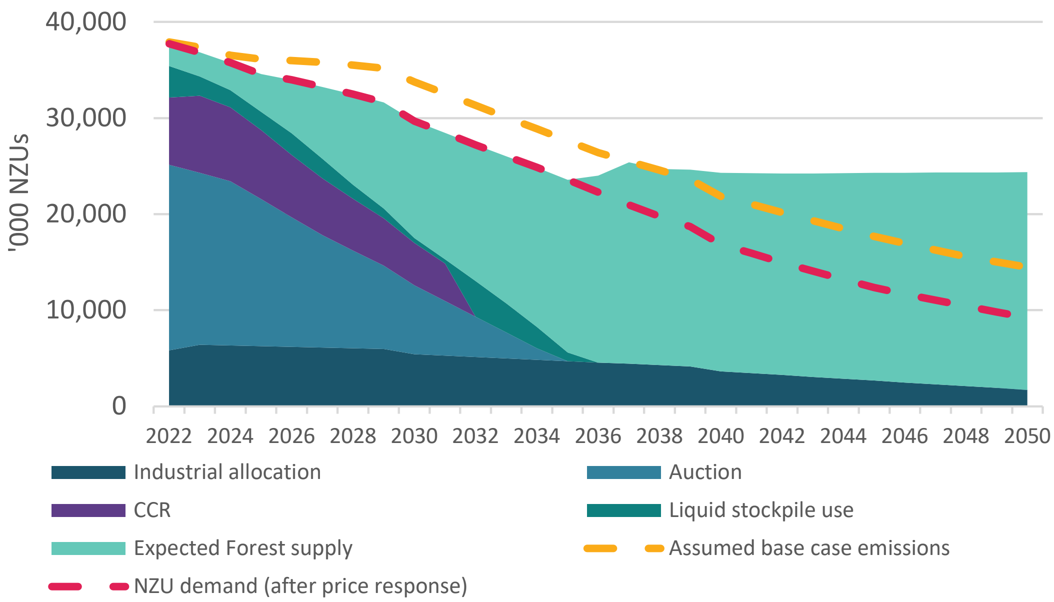


The impacts of these prices on supply and demand are shown in Figure 14 using the current industrial allocation, auction volumes and price control settings, alongside forestry volumes as projected by MPI. The yellow dashed line is the initial assumed level of demand for units, based on the Commission's demonstration path model run, but assuming a zero price from 2023.[23]

[22] We have updated these to 2023$ values using CPI. NZStats CPI All Groups for New Zealand (Qrtly-Mar/Jun/Sep/Dec) Table Ref: CPI009AA.

[23] This includes all the non-price policies assumed in the demonstration path that would enable achievement of the 2050 net-zero target for long-lived gases. The demonstration path assumptions are described in more detail in Climate Change Commission (2021).

Figure 14: Estimated NZU supply and demand under demonstration path (for gross emissions) combined with the MPI central projection for afforestation)

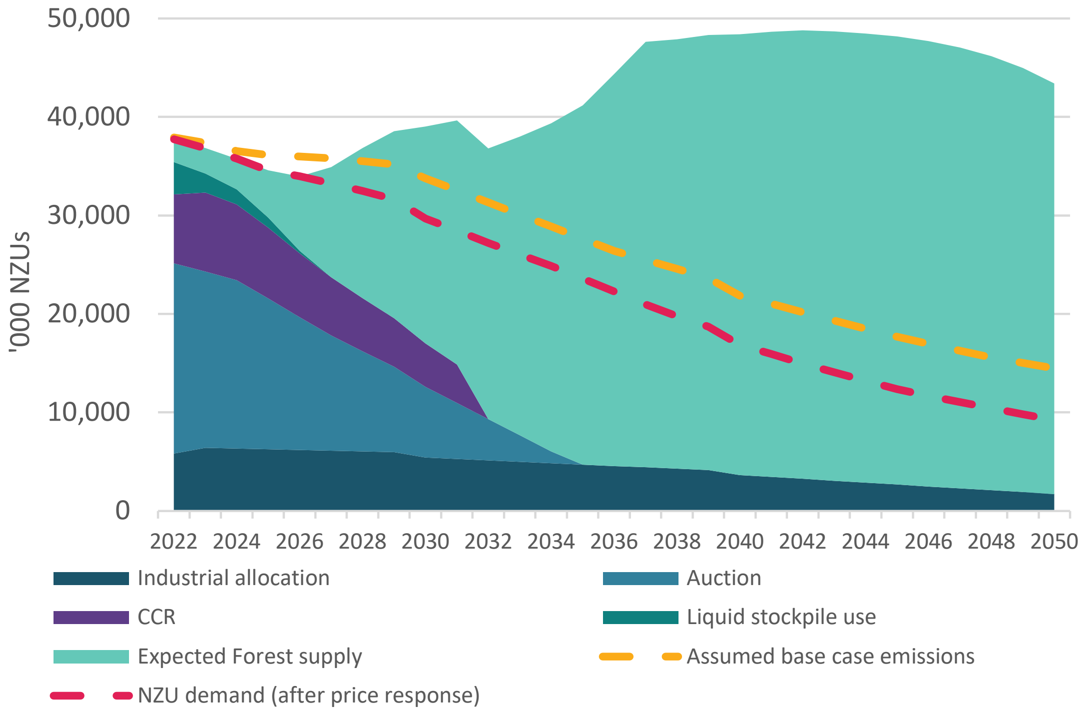


The red dashed line shows the demand for units following emission reductions (below the yellow dashed line) that occur in response to price.

Figure 15 shows the analysis using the same assumptions but a formula under which new afforestation is responsive to price (equation [2] discussed above), but prices specified exogenously. The removals volumes are far more significant, with a surplus of units occurring before 2030. In contrast to the MPI central projection used in Figure 14, in which the long-run planting rate is approximately 38,000 ha per annum, under this price-responsive formula, planting rates peak at approximately 100,000 ha per annum initially but fall to zero before 2050 as new afforested areas approach an assumed maximum planted area of 2.78 million ha.[24]

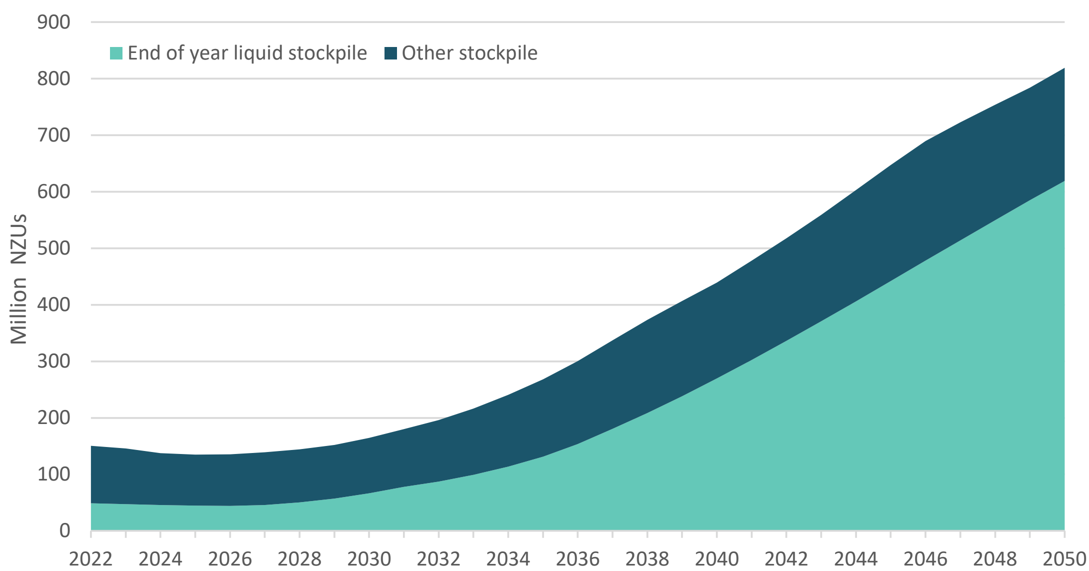
[24] This is based on the land area suitable for forestry estimated by the NZ Forest Service (2022)

Figure 15: NZU supply and demand if assuming demonstration path (for gross emissions) and price-responsive forestry projections



The large surplus of units suggested by Figure 15 would be added to the stockpile, which would rise to very high levels (Figure 16). This would be necessary for prices to be maintained at the demonstration path levels. However, it is extremely *unlikely* that the rising price assumptions could be maintained if they rely on stockpile volumes rising to this level, noting that demand for NZUs is expected to fall to approximately 10 Mt by 2050. Rather the price is more likely to fall.

Figure 16: Stockpile volumes under demonstration path assumptions



Price expectation with no policy change

The demonstration path analysis above was used to suggest that the rising price expectations are highly unlikely to occur in practice because they would lead to a large market over-supply from the large volume of removals units. The model has been used to estimate what prices may result if market supply was sufficient to just meet demand over the long run. It uses the price-response formulae both for emission reductions and for forestry, and then estimates the price path that would ensure supply would meet demand in every year but that the surplus to be added to the stockpile is minimised (using the stockpile behaviour assumptions described earlier in the summary).

The estimated results under these status quo settings are shown in Figure 17, based on a price path shown in Figure 18. This is the price path estimated by the model when run with the objective of NZU supply meeting demand in every year while minimising the surplus of NZUs accumulated to 2050. It suggests, under the medium assumptions, that forestry removals unit supplies will be sufficient to meet demand at prices that fall over time. It suggests that, under current ETS settings, rising prices will lead to a growing number of units stored in the stockpile and that this is not sustainable. Rather the expectation, under the assumptions used in the model, is for prices to fall.

Below we test the robustness of these conclusions to different input assumptions.

Figure 17: Estimated NZU supply and demand under status quo settings (price-responsive forestry)

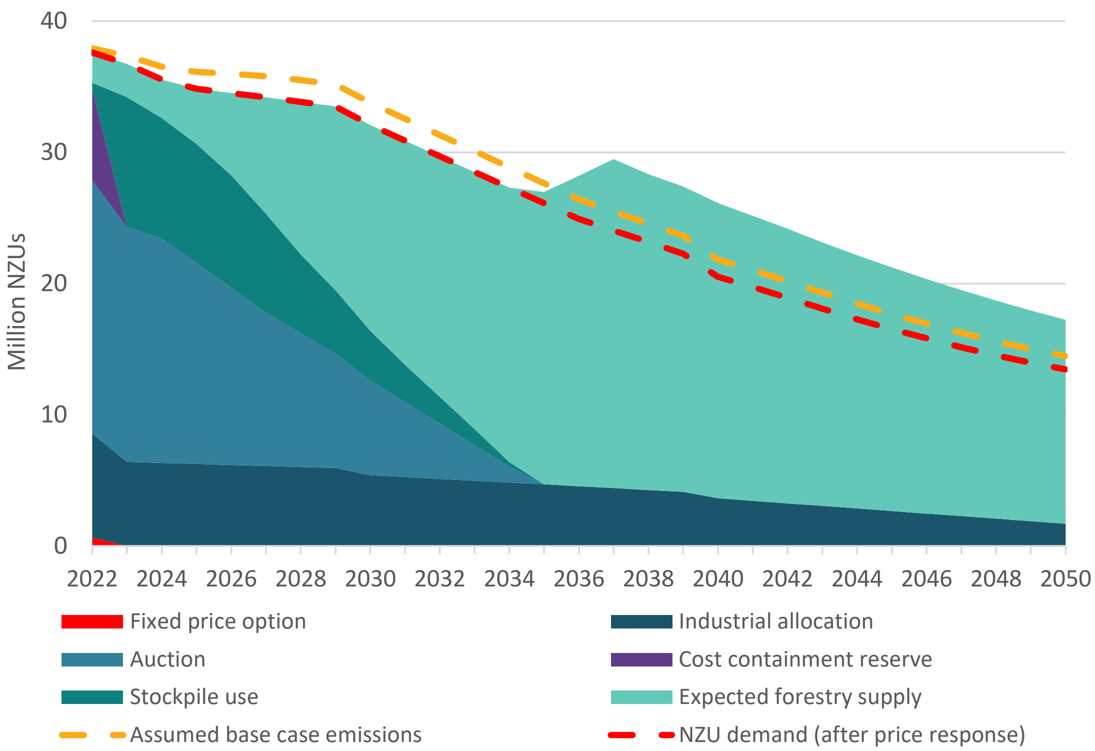
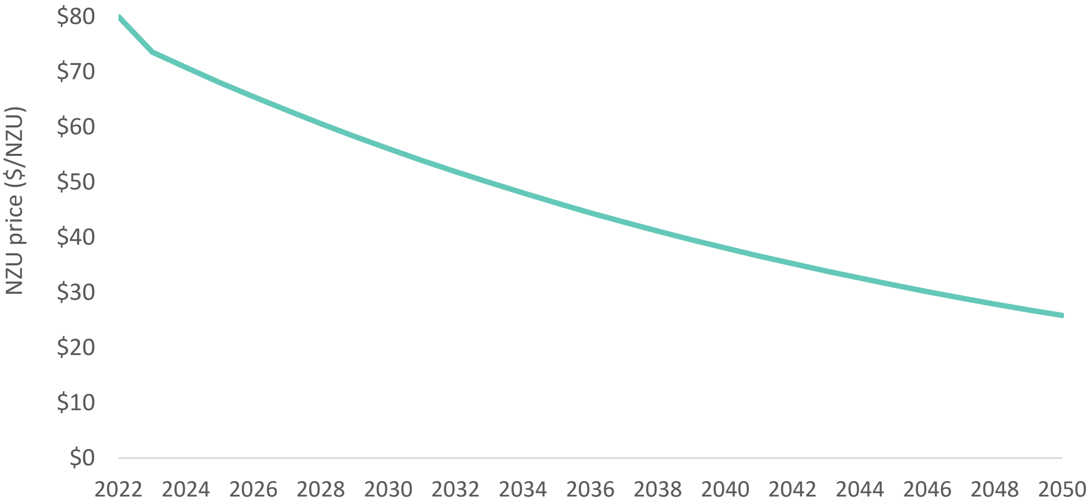


Figure 18: Estimated NZ ETS price path under status quo settings



Sensitivity Analysis

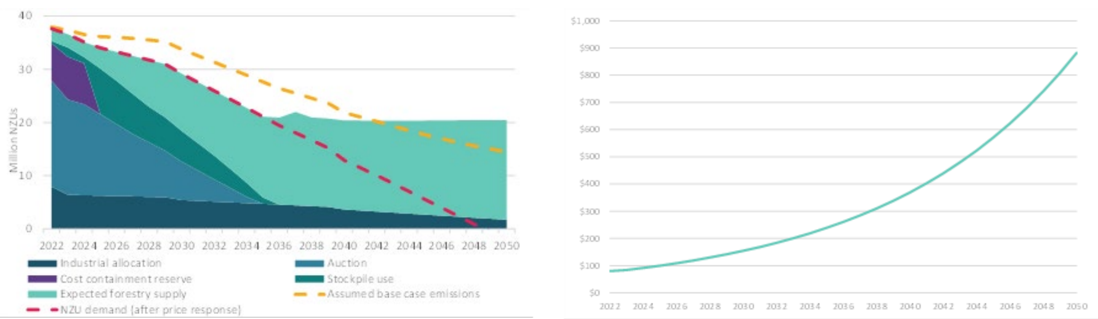
Alternative assumptions are tested to understand the implications for supply, demand, and price.

MPI Forestry Projections

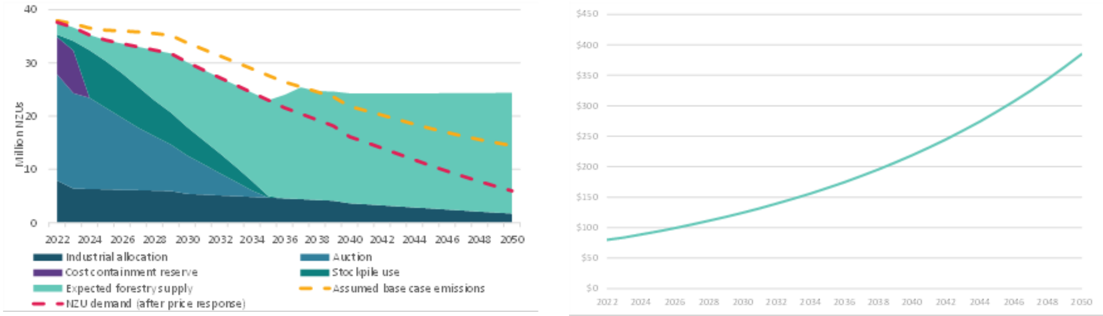
Figure 17 and Figure 18 above are derived by running the model to estimate removals unit supply, emission reductions and price using endogenous assumptions. The model was also run with exogenous forestry supply assumptions (using MPI's projections of forestry extrapolated from the 2021 intentions survey) while estimating emission reductions and market prices endogenously. The problem with this approach is that the resulting estimated price is likely to be different from that assumed by landowners when responding to the survey on planting and deforestation intentions. Given this, the results should be used with caution. The results are shown in Figure 19 under the low (c.30,000 ha per annum of afforestation), central (c.38,000 ha pa) and high (c.46,000 ha pa) assumptions.

Figure 19: Impacts on NZU Supply, Demand and Price with MPI survey-based forestry projections and limited stockpile liquidity

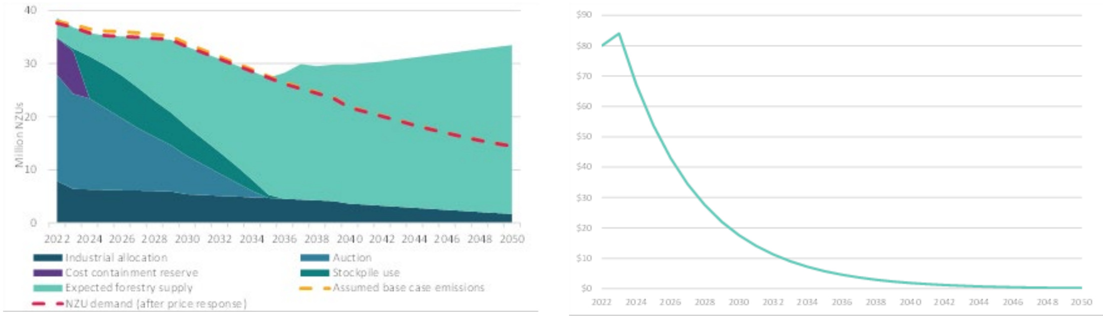
(a) MPI Low afforestation



(b) MPI Central afforestation



(c) MPI High afforestation



The model shows rising prices under the low and central projections, although this is largely driven by the modelling assumptions that include:

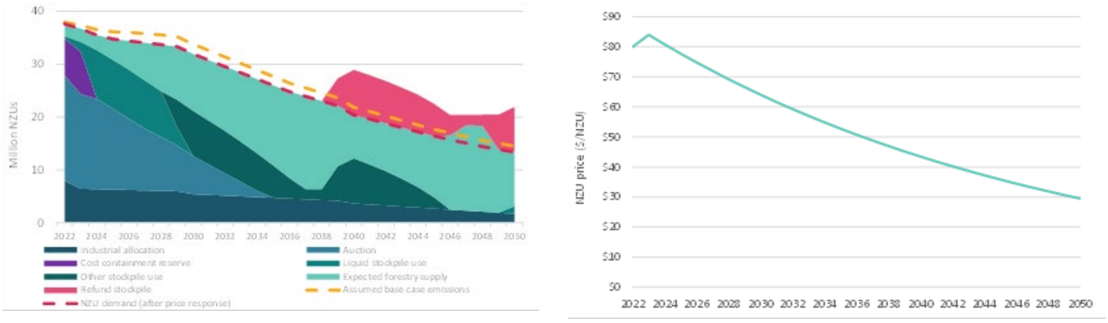
- the potential incompatibility of the price estimates and those used by landowners expressing their afforestation and deforestation intentions.
- price paths are limited to constant annual percentage changes; and
- there are limits to movements in and out of the non-surplus stockpile.

The central afforestation projection results in a rising price but this is largely to ensure sufficient supply in the earlier years. After 2035 there is a projected net surplus which results in a large stockpile by 2050, including a surplus or liquid stockpile of approximately 150 million NZUs. This would be unlikely and suggests, in reality and/or with different model assumptions, prices and market supply would be lower than projected here. To address this, the model is re-run while relaxing the limits to movement in and out of the non-surplus stockpile, which is the NZUs retained to meet future liabilities. The revised assumption is that, if market prices are not rising as fast as the discount rate, or even falling, then more of the stockpile will become a liquid source of supply, able to meet supply shortfalls. In the original analysis this was restricted to a maximum of 5 per cent of the stockpile; here we double that to 10 per cent. The stockpile is assumed to be reimbursed later (10 years is assumed) with units that are surplus to demand. This assumption is used while still requiring demand to be met in all years.

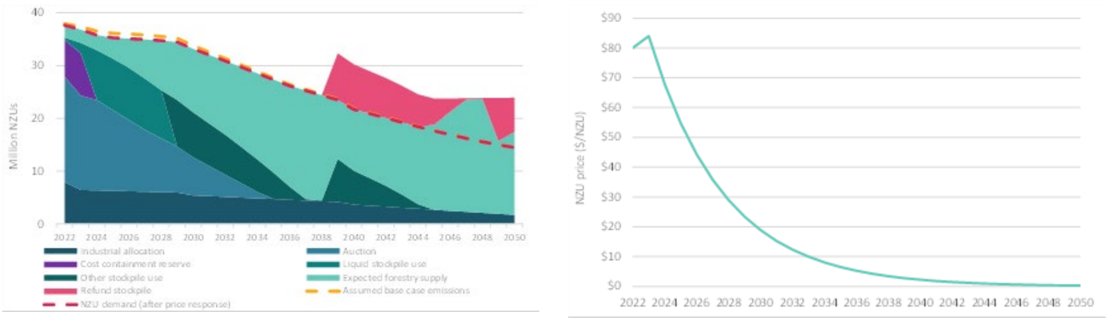
The alternative results using this new set of assumptions are provided in Figure 20. It provides more detail than in Figure 19, including the use of NZUs in the liquid (surplus) and “other” stockpile, plus the later ‘refunding’ of the stockpile so that there are sufficient units to meet the surrender liabilities. The pink shaded area represents surplus removals units that are used to refund the stockpile and are not available to the market that year.

Figure 20: Impacts on NZU Supply, Demand and Price with MPI survey-based forestry projections and greater stockpile liquidity

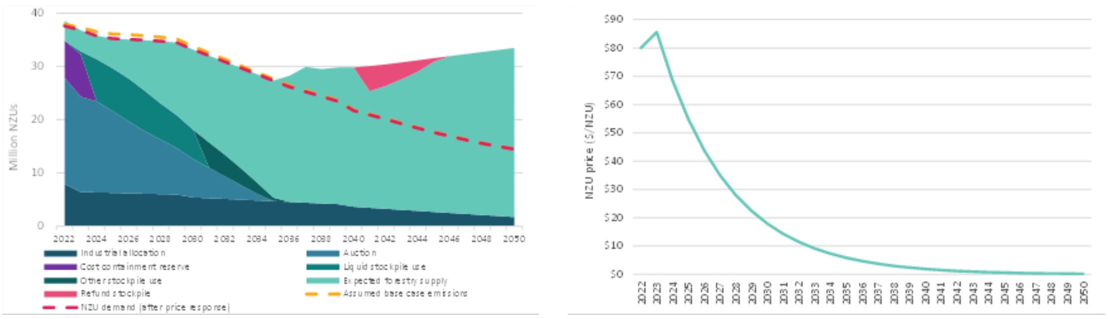
(a) MPI Low afforestation



(b) MPI Central afforestation



(c) MPI High afforestation



These results suggest that, by relaxing the assumptions on stockpile use, there is sufficient unit supply to the market in the early years such that demand can be met with lower and falling prices. The behaviour simulated is that of participants holding units in the stockpile to meet future liabilities releasing these in anticipation of purchasing at lower cost later.

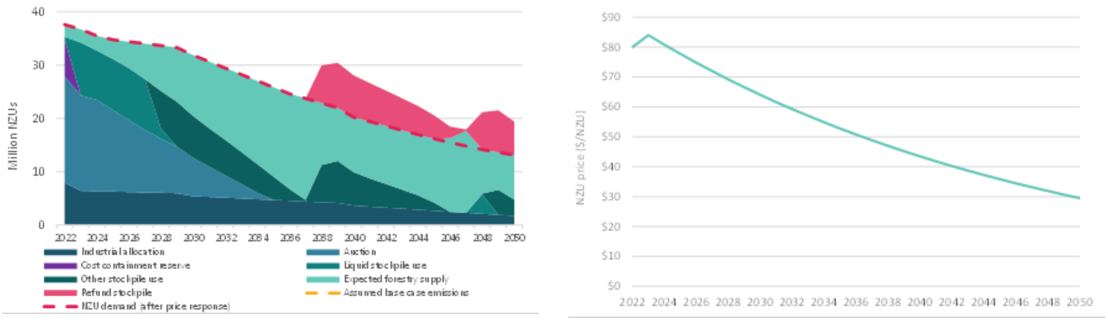
As noted above, these results need to be interpreted with caution as the forestry supply assumptions will reflect different prices from those derived from the model. However, the results demonstrate that the levels of supply in the MPI projections are sufficient to meet demand under low, medium, and high afforestation assumptions, with very little requirement for gross emission reductions.

Endogenous Supply

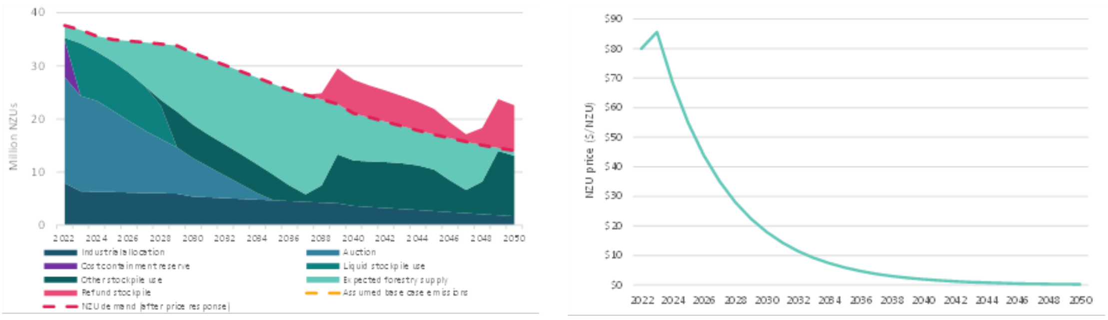
The assumptions used in the analysis above using Manley's equation to simulate afforestation (Figure 17 and Figure 18) use the medium assumptions for annual afforestation (Figure 9). The implications of the low, medium, and high assumptions, including the greater stockpile liquidity assumptions as used above, are shown in Figure 21. A falling price is estimated in all options.

Figure 21: Impacts on NZU Supply, Demand and Price with endogenous forestry supply and price and with greater stockpile liquidity

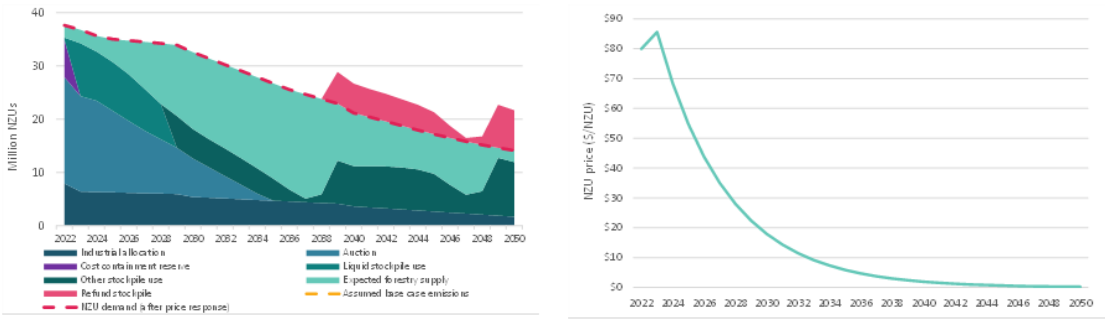
(a) Low afforestation response



(b) Medium afforestation response



(c) High afforestation response



Conclusions

The analysis using a wide range of input assumptions, including exogenous and endogenous estimates of forestry removals, suggests there will be sufficient supply of NZUs under current settings to meet demand at low or declining prices and/or with the need for very little gross emission reduction.

New Zealand Emissions Trading Scheme household impacts model

Model components

Overview

This model has been developed to estimate the impacts of NZ ETS prices on households and on consumer inflation. The core of the model estimating inflation impacts was originally developed by the Treasury to support the Commission.[25,26] It has since been updated with more recent data by the Ministry for the Environment, including rebasing the model to 2019 to align with the latest Input-Output tables, and extended to capture impacts on different household types using Household Expenditure Survey (HES) data.

Fuel and energy use attributable to households

The first component of the model estimates the total fuel and energy use that can be attributed to New Zealand households. Household use categories are based on Consumers Price Index (CPI) group, subgroup, and class categories. The source data is Stats NZ Input-Output tables for the year ended March 2020, specifically the “Use” and “Ultimate Disposition” tables.[27,28]

The first step of the calculation was to estimate the total fuel and energy used for each CPI subgroup or class. The different fuel and energy types that are directly used are coal, gas, petrol, diesel, “other fuel” and electricity. These are all derived from the “Use” table. In addition, the fuel costs associated with different transport types (road freight, sea freight, rail freight, and air freight) are also included. These were derived from the respective freight values in the “Use” table multiplied by the fuel cost as a percentage of output. The result of this first step estimated the total fuel cost for each subgroup or class valued in millions of dollars. This is also aggregated to the group level.

The second step was to estimate the fuel and energy use attributable to households. This is a simple calculation based on multiplying the fuel use estimate by the household consumption share of each subgroup or class. The household consumption share is based on the final household consumption share in the “Ultimate Disposition” table.

[25] https://www.climatecommission.govt.nz/public/ETS-advice-July-22/Technical-annexes-and-supplementary-documents/Cover-page-Treasury-TAWA-modelling.pdf

[26] https://www.climatecommission.govt.nz/public/ETS-advice-July-22/Technical-annexes-and-supplementary-documents/TSY_household-expenditure-impacts-of-emissions-prices.zip

[27] https://www.stats.govt.nz/information-releases/national-accounts-input-output-tables-year-ended-march-2020/

[28] The “Use” table sets out how products are used by different industries in the economy. The “Ultimate Disposition” table sets out where the output of industries finally ends up – as consumption (by households, government, or non-profits), investment, or exports.

Emissions from household consumption

The second component of the model follows a similar approach to attribute emissions to households. Emissions data is sourced from the Greenhouse Gas Inventory.[29] For consistency with the Input-Output table data, 2019 emissions data is used.

Three different approaches are used to attribute emissions to household consumption:

1. Some emissions are directly attributed to households in the inventory – solid fuels and gas used for household energy.
2. Private road transport emissions are attributed based on the household consumption share (derived from "Ultimate Disposition" table) multiplied by total fuel emissions for road transport – petrol and road transport – diesel. Similarly, electricity emissions are based on the consumption share multiplied by emissions from public electricity generation.
3. For all other subgroups and classes, that subgroup or class's share of total fuel use by fuel type is multiplied by the relevant emissions category to estimate total emissions against a subgroup or class. This creates a weighted sum. That figure is then multiplied by the household consumption share of that subgroup or class.

Estimating the impact of NZ ETS prices on the CPI

The first two components of the model describe the basic allocation of fuel costs and emissions to households by CPI subcategory or class. One key feature is that these costs already include some emissions costs, which are assumed to reflect the average NZ ETS price of $25 in 2019.[30] The third component of the model estimates the impact on the Consumer Price Index (CPI) of changes to the NZ ETS price from this $25 base.

The impact on the CPI is estimated using the following equation:

$$\Delta CPI = \sum_{c} W_c \times FS_c \times \Delta FP_c \times P_c$$

Where:

c = CPI group

W = the CPI expenditure weighting

FS = the fuel cost as a share of output

ΔFP = the implied fuel price change from emissions prices

P = the pass-through rate to households

[29] Table 1A "Fuel combustion activities – sectoral approach" https://environment.govt.nz/assets/publications/climate-change/Common-Reporting-Format-output-tables-Compressed-Zip-file.zip

[30] Based on the average of the daily NZU spot price in the secondary market for 2019. Spot price data is sourced from Jarden Commtrade.

All the variables are expressed as percentages. 2017 CPI weightings are used for the expenditure weights. The fuel cost as a share of output is derived from the "Use" tables. The pass-through rate is simply an assumption of the extent to which firms pass through costs to households. By default, it is set at 100 per cent (see assumptions section for further discussion).

The implied fuel price change is calculated by multiplying the change in the NZ ETS price (the deviation from the $25 base) by the emissions for that subgroup or class. This gives an estimated total additional emissions cost. The implied fuel price change is the additional emissions cost as a percentage of total fuel use attributable to households. This is calculated at the subgroup or class level and then aggregated to the group level for the CPI calculation.

Estimating CPI impacts for different household types

The estimates of the impact on the CPI can be estimated for different household types using the Stats NZ household living costs index. This changes the CPI expenditure weighting above for different household types but otherwise the methodology set out above remains unchanged.

Estimating annual household emissions expenditure

The final component of the model estimates annual household expenditure on emissions for different household types. The main additional data source for this part of the model is the Stats NZ Household Expenditure Survey (HES), particularly the household expenditure for group and subgroup by household income group.[31] For consistency with the other data sources, HES data for 2019 is used.

HES provides average weekly household expenditure by group and subgroup for households by income decile and for households of different compositions (eg, couple only, couple with child, single parent with children etc). The CPI impact equation is modified as follows to estimate implied expenditure on emissions.

$$EXP_h = \sum_c HES_{c,h} \times FS_c \times \Delta FP_c \times P_c$$

Where:

- c = CPI group
- h = household type (either by income decile or household composition)
- EXP = household expenditure on emissions (expressed in dollars)
- HES = average weekly household expenditure by CPI group and by household, multiplied by 52 (expressed in dollars)
- FS = the fuel cost as a share of output (expressed as a percentage)
- ΔFP = the implied fuel price change from emissions prices (expressed as a percentage)
- P = the pass-through rate to households (expressed as a percentage)

[31] Household expenditure for group and subgroup by household income group (stats.govt.nz)

Key assumptions

A broadly consistent time period has been used in the various datasets used for this analysis. The latest input/output tables apply to the year ending March 2020. Emissions data is for calendar year 2019 to get the best match with the input/output tables. 2017 CPI weightings are used because more recent CPI weightings reflect the impact of COVID-19 on expenditure patterns. Notably, all these data and the corresponding economic structures they represent pre-date COVID-19. An average NZU price of $25 for 2019 is used as the base.

The main simplifying assumptions are:

- That the economy has not changed significantly since the time of the baseline data (2019) including that household expenditure patterns have not changed materially. Given COVID impacts, household expenditure patterns are likely to have changed, although to what extent is somewhat uncertain.[32]
- That NZU costs are passed through directly and fully from businesses to consumers simultaneously and instantaneously.[33]
- That business and consumer demand does not change in response to higher prices – there is no change in the level of consumption or in the uptake of low-emissions technologies and practices.

Because of these limitations, the results are likely to overstate the direct impacts of higher emissions prices on households. They are also likely to be a better representation of impacts of relatively small changes in emissions prices. This is considered further in the limitations and uncertainty section of the summary.

Results

Annual household emissions costs

New Zealand households are exposed to emissions prices, largely through their impact on fuel and energy costs. Emissions prices are a direct component of fuel prices. For example, MBIE estimates that emissions prices make up about $0.10-0.12/litre of petrol at present.[34] The impact of emissions prices on other goods and services is usually more indirect, often reflecting fuel as an input into production of that good or service, or as part of freight costs.

Overall, at a NZU price of approximately $75/t, emissions costs are estimated to be equivalent to about 0.5 per cent of total household income for the average household. Data limitations mean this estimate is based on gross income as a share of disposable incomes the estimate will be somewhat higher. In dollar terms this is just under $500 per annum per household, with the emissions component of transport fuel costs comprising a little under three quarters of this.

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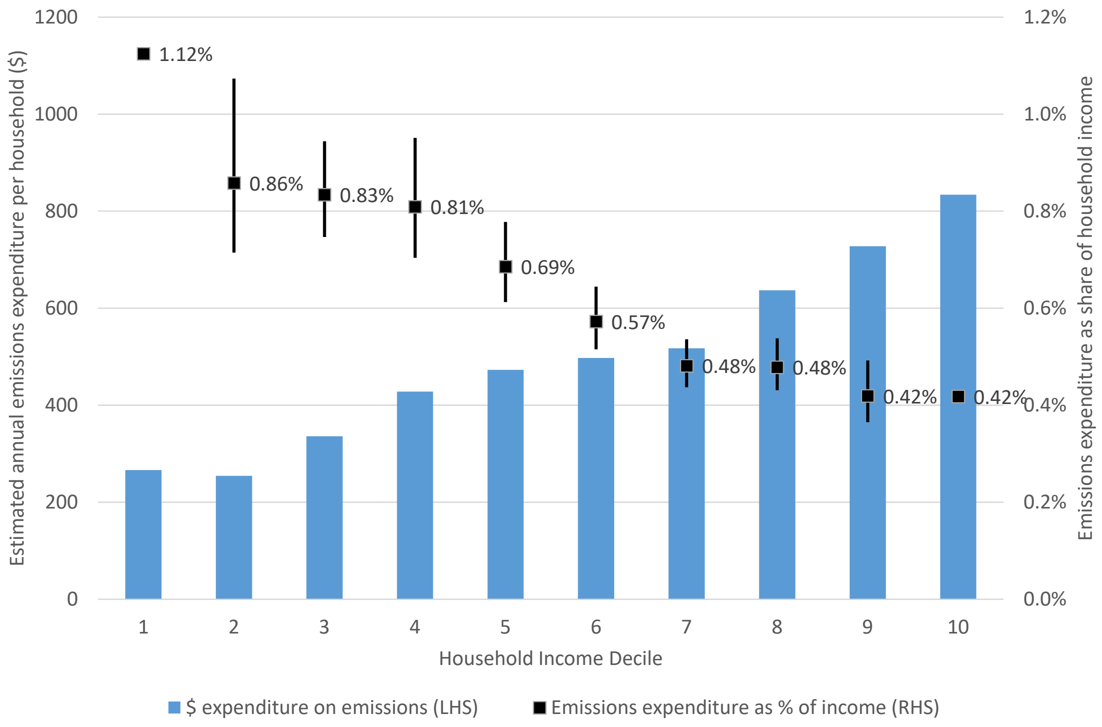
[32] Changes in consumption patterns may become more apparent when HES data for 2022 is published (in early 2024).

[33] The model has been set up such that the pass-through rate can be varied where there was evidence or a rationale (eg, sensitivity testing) for doing so.

[34] MBIE Weekly Fuel Price Monitoring https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/weekly-fuel-price-monitoring/

Emissions pricing is commonly found to be regressive in the economics literature. Household costs attributable to emissions tend to rise with income (Figure 19). The lowest income households spend about $250–270 per annum on emissions, on average, while the highest income households spend over $700 per annum. However, as a share of income, the impact of emissions prices is felt much more heavily by lowest income households.

Figure 22: Estimated household emissions costs



Note: Calculated on basis of NZU price of $75/t.

Source: Stats NZ, MfE, MfE calculations

Vertical bars on the chart denote the change in expenditure as a percentage of the lower and upper brackets of each income decile, while the square denotes the change as a percentage of the mid-point of each income decile. For deciles 1 and 10 there are no lower and upper brackets respectively, so only the change relative to the upper and lower bound are shown.

Impact of NZ ETS prices on inflation

Changes in emissions prices, at least at current levels, are a modest contributor to household inflation. A $10 increase in emissions prices leads to an approximate 0.11 per cent increase in the CPI.

Prices for NZUs increased sharply over 2021 and 2022 but are unlikely to have made a sizeable contribution to inflation impacts. Over 2021, NZU prices rose approximately $31, which is estimated to lead to a 0.33 per cent increase in the CPI. Similarly, NZU prices increased by $12 in 2022, leading to an estimated 0.13 per cent increase in the CPI. For comparison, annual inflation as measured by the change in the CPI was 5.9 per cent in 2021 and 7.2 per cent in 2022.

Table 2: Estimated impact on CPI of changes in emissions prices

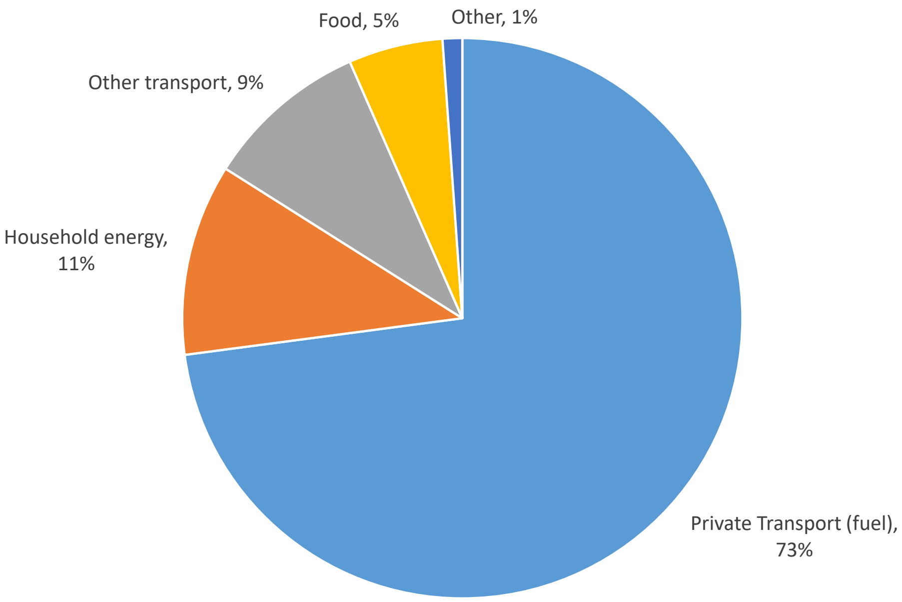
	Change in emissions price	Estimated impact on CPI
"Rule of thumb"	+/- $10	+/- 0.11%
Increase over 2021	$31	0.33%
Increase over 2022	$12	0.13%

Source: Stats NZ, MfE, MfE calculations

Sources of impacts on households

Vehicle fuel is by far the most important component of household expenditure directly impacted by emissions prices. About three quarters of the emissions price impact on the CPI is from the private transport category (Figure 20), with about 78 per cent of this coming from petrol and a further 17 per cent from diesel. The next largest contributor is the housing and household utilities group, accounting for about 10 per cent of the impact. Unsurprisingly, this is mostly driven by household energy costs, primarily electricity.

Figure 23: Household emissions costs by category



Source: Stats NZ, MfE, MfE calculations

Impact on inflation by household type

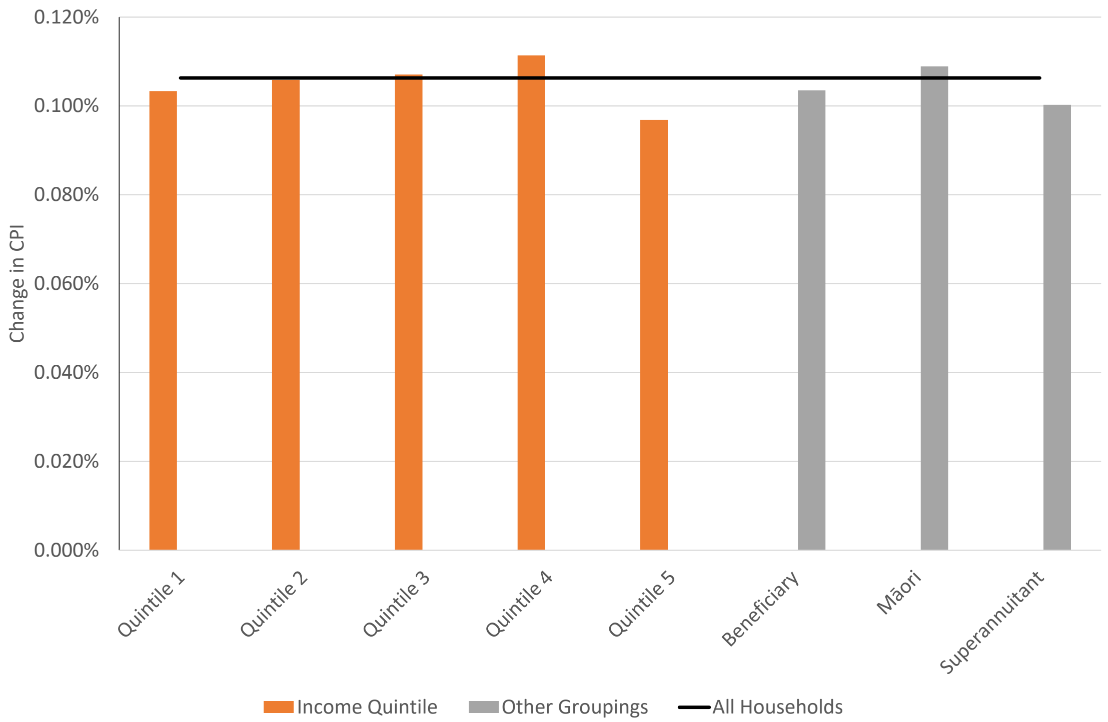
Emissions costs have relatively even impacts on expenditure by different household types

Stats NZ produces different CPI weightings for different household types, allowing for a basic comparison of distributional outcomes. Applying the same methodology but using these different weightings can test the relative exposure of different household types (Figure 21).

From an expenditure perspective, there is not a great deal of variability in the inflation impacts by household type. This is because the overall composition of household expenditure doesn't vary greatly (at least in these aggregated measures).

Middle quintile households and Māori households are estimated to experience a slightly larger than average impact. The lowest income households, beneficiary households (which will have a large overlap with lower quintile households) and super annuitant households are estimated to experience slightly lower impacts, largely due to lower household expenditure devoted to private transport. The highest income households have the largest deviation from the average impact. This reflects these households having a lower share of expenditure spent on private transport and larger shares of expenditure devoted to activities such as international air travel, which at present do not face an emissions price.

Figure 24: Impact of $10/t increase in emissions price on expenditure by household type



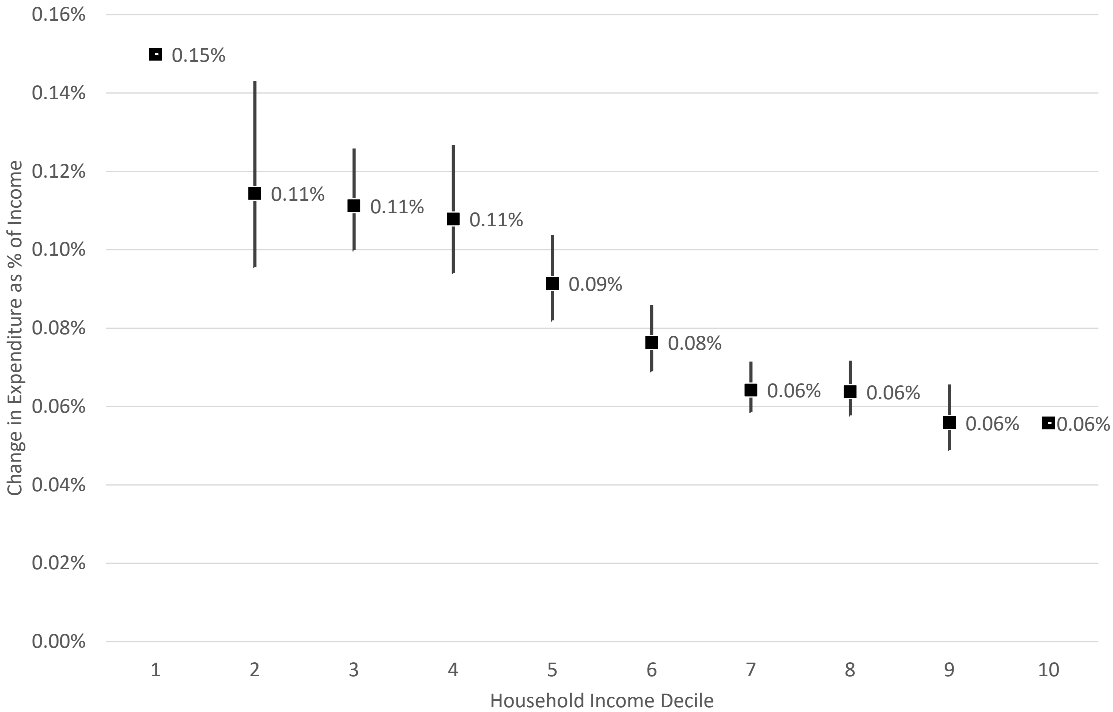
Note: Quintile 1 refers to the 20 per cent of households with the lowest incomes, quintile 2 the households with the next lowest incomes, and so on. Stats NZ also provides estimates for household expenditure baskets for Beneficiary, Māori, and super annuitant households.

Source: Stats NZ, MfE, MfE calculations

However, higher emissions prices are regressive once household incomes are considered

While an increase in the emissions price leads to similar impacts on expenditure for different households, those impacts make up a much larger share of income for lower income households than for higher income households (Figure 22). Two clusters of households emerge in the analysis. The lowest four income deciles face similar sized impacts on their income, while the four highest income deciles also face similar impacts. However, the impact on the four lowest income decile households is close to double that of the highest income households.

Figure 25: Impact on households of $10/t increase in emissions prices as a share of income



Note: Decile 1 refers to the 10 per cent of households with the lowest incomes, decile 2 the households with the next lowest incomes, and so on. Vertical bars on the chart denote the change in expenditure as a percentage of the lower and upper brackets of each income decile, while the square denotes the change as a percentage of the mid-point of each income decile. For deciles 1 and 10 there are no lower and upper brackets respectively, so only the change relative to the upper and lower bound are shown.

Source: Stats NZ, MfE, MfE calculations

Sense checks

The Treasury was commissioned by the Climate Change Commission to analyse the distributional impacts of emissions pricing (Treasury 2022).[35] The modelling used Treasury's Tax and Welfare Analysis microsimulation model at a range of emissions price points. The original CPI model used for the household cost modelling used in the review was an input to the analysis, and the extended methodology used by this note looks to replicate many features of the Treasury analysis.

The Treasury modelling estimated that a $20.27 increase in emissions prices increased the share of income spent on fuel and food expenditure by 0.15 per cent for the median household (with a range of 0.08 per cent to 0.25 per cent across different income quintiles). For the same increase, Ministry for the Environment modelling estimates a 0.16 per cent increase in the share of income for the median household with a range of 0.11 per cent to 0.30 per cent across different income deciles (which should result in a slightly wider range than by quintile). That is, the results are very similar, albeit the measures differ slightly from one another.

The results presented here are also broadly consistent with more recent Treasury analysis (Davis, Hart and Stubbing, 2023 (forthcoming)).

[35] The Treasury (2022) TAR 318: Household expenditure impacts of ETS carbon prices and cover note

Modelling limitations and uncertainty

The modelling used for the review of the NZ ETS is subject to modelling limitations and uncertainty. The Ministry's models provide simplified accounts of NZ ETS market dynamics and household cost impacts and are limited in their ability to predict the future. The market model is not intended to predict future prices. Rather the results are intended to capture the core dynamics of the ETS and draw insights on the potential implications of these dynamics under different assumptions.

NZ ETS market model

The NZ ETS market model is a simple model. It balances supply and demand in the NZU market using assumptions about future supplies, levels of demand in the absence of price, and the response to price of those with surrender obligations, forestry, and investors. There are several limitations and sources of uncertainty:

- The baseline emissions used to forecast demand in the NZ ETS are based on modelled estimates made by the Commission using assumptions on structural shifts in New Zealand's economy and the rate of market penetration of low-emission technologies.
- The emission reduction response to price is similarly estimated using the outputs from a model used by the Commission. It has a limited number of potential response options and may be conservative in its price response estimates.
- The forestry response to NZU prices uses a formula and parameter values developed by the University of Canterbury during historical periods in which prices were lower than they have been recently. It is not clear if the price response relationship will be the same at significantly higher prices.
- There are significant uncertainties with the Commission's analysis of the NZU stockpile. It estimated the range of the surplus volume to be between 33 million and 66 million units.
- The behaviour of unit holders assumes they are well informed about future prices so that rational decisions can be made about whether to add or withdraw NZUs from the stockpile. There are indications that NZ ETS market participant do not have accurate information about future NZU prices and that price expectations are overly influenced by signals from government decisions on the NZ ETS and other climate policies.
- The model itself has used simplifying assumptions including:
  - The price path options modelled are limited to those specified as constant annual percentage changes in price; and
  - The objective function of the model includes minimisation of the surplus stockpile by 2050.

These are simplifying assumptions using best available information. In reality, the NZ ETS is a complex policy, and the government has a limited visibility of how the market operates and the behaviour of participants. There are therefore inherent limitations to the extent to which a model can replicate this operation and behaviour.

The estimated NZ ETS price path under is not a prediction of future NZU prices

The modelled price pathway indicates how an NZ ETS market that operated as the NZ ETS market model does could respond to forecast unit supply and demand dynamics. This response would be quite different if the proposals set out in this discussion document were implemented. In reality, how the actual NZ ETS functions will differ from the NZ ETS market model for a number of reasons, including if the proposals set out in the discussion document or other changes were made to the NZ ETS through parallel government work programmes, such as the redesign of permanent forestry category.

NZ ETS household impacts model

Key sources of uncertainty

The household impacts model is a highly simplified model of the first order impacts of NZ ETS prices. The key assumptions highlight key sources of uncertainty in the model:

- Full and instantaneous pass through of NZ ETS costs to households is unlikely to be realistic. The actual pass-through rate is a source of uncertainty for most goods and services. Emitting firms can and do hedge against their NZU surrender obligations, which can smooth the impacts of changes over time. Furthermore, firms face a myriad of factors when settings prices for consumers, of which emissions costs are only one. This is likely to further dampen the pass through of emissions costs to households.
- Firms and household responsiveness to prices will vary over the time horizon in question and depending on the magnitude of the price change in question. Over shorter time periods firms and households may have limited options and are likely to be less responsive to changes in prices. Households and firms are more likely to change their behaviour or invest in abatement for larger changes in prices. These two factors mean the model is a better representation for short-term, marginal price movements. Over longer time horizons and for larger movements in emissions prices, households and firms' responsiveness to emissions prices is more uncertain.
- Household expenditure patterns are a further source of uncertainty, particularly when disaggregating by household income decile or other household groupings. This includes known limitations of the HES data.[36] Household expenditure patterns evolve constantly and are likely to have been especially impacted in recent years by the impact of COVID. Some of these impacts will become clearer when 2022 HES data is published in early 2024. How expenditure patterns evolve in future, include towards higher or lower emissions goods and services is a further source of uncertainty.

Model limitations

A key limitation of the household model is the estimation of NZ ETS impacts on electricity prices. Most of New Zealand's electricity is generated from renewable sources that do not generate emissions. Using the methodology set out above means that the NZ ETS prices has a relatively modest impact on household electricity expenditure. This is because aggregate electricity consumption has relatively low emissions per dollar of energy.

[36] See Davis, Hart and Stubbing, 2023 (forthcoming) for a good summary of HES limitations.

However, the price of electricity is set by the marginal generator supplying New Zealand's wholesale electricity market (the last source of supply needed to meet a given level of demand) and the marginal supply is often a fossil fuel source that faces NZ ETS prices.[37] This means that NZ ETS has a larger influence on electricity prices than the share of emissions in electricity generation would suggest. The overall impact is that the current approach likely somewhat underestimates the impact of the NZ ETS on household electricity expenditure.

Next steps

The NZ ETS market model is being developed for future stages of the review to simulate the impacts of different options to amend the scheme to prioritise gross emissions reductions, while continuing to incentivise emissions removals. This would include options that result in separate markets or different market prices for emissions reductions and removals.

The treatment of electricity prices in the household impacts model is also being updated. The key modification will be to re-weight the size of the emissions price impact so that it reflects NZ ETS price impacts on marginal pricing of all electricity, moderated somewhat by an assumption on the share of the time that fossil fuel sources (and therefore carbon prices) set the marginal price. Provisional analysis suggests this increases the inflation impact of a $10 increase in NZ ETS prices from 0.11 per cent to 0.13 per cent. This updated methodology will be used for future analysis on household impacts, including post-consultation advice to Ministers.

[37] Furthermore, hydroelectricity is often also priced at or near the cost of the fossil fuel supply that would replace it.

Appendix: Modelling webinar

Questions and Answers

On Thursday 27th July 2023 a webinar discussing the ETS Review Modelling was held. The presentation and recording of the webinar including questions asked and answered is available here: NZ ETS review: Consultation now open | Ministry for the Environment

Some questions from the webinar could not be answered or answered fully during the event.

Please see below for responses to these questions:

Q The 2021 survey by the University of Canterbury School of Forestry of forest owners about their afforestation and deforestation intentions, is obviously a key document in the forecasts. As the Elvidge paper concedes at paragraph 6.1, the uncertainty analysis in that survey excludes changes to the NZ ETS settings over 2023 - 2027 recommended by the Commission (and now accepted by the Government). Also excluded is the scrapping of most new forest plantings in 2023 and perhaps longer. At what point does all this uncertainty mean that the forecasts risk becoming meaningless?

A The published paper *New Zealand's Emissions Trading Scheme Forestry Allocation and Surrender Forecasts For March 2023 Baseline Budget* notes the uncertainty in the forecasts. The forecasts are compiled based on the latest data and evidence available and are subject to NZ ETS policy settings at the time of compilation.

Q The forecasts presumably underlie figures 3, 4 and 5 in the NZ ETS review consultation document. Fig. 3 in that document shows NZUs held by existing forestry participants to meet future harvest obligations, and notes that it is generally not expected these NZUs would be supplied to the market.

A The projected scenarios in figures 3, 4 and 5 in the NZ ETS review consultation document are described in the technical summary of the modelling used in the review, which can be viewed on our **consultation webpage.**

Q Changes to the Overseas Investment Act 2005 (OIA) (national benefit test for forestry investments) are not reflected in past intentions

A The 2021 Afforestation and Deforestation Intentions Survey notes the potential impact of OIA decisions. Page 13 notes that some of the difference in comparing 2020 and 2021 afforestation intentions could be due to some afforestation projects being deferred as awaiting OIA approval and client confirmation.

Further frequently asked questions

Q What are the Afforestation and Deforestation intentions Survey results based on?

A The results are based on phone interviews with large-scale forest owners, and forestry consultants and managers in December of each year. As the figures are based on intentions, they remain estimates.

Q Can you provide afforestation and deforestation intentions beyond 2023?

A Yes. Exotic and native afforestation and planted forest deforestation intentions are provided in the report out to 2030, although some of the people interviewed in December 2021 were focused on the logistics of afforestation for 2022 and 2023 and were still developing plans for subsequent years.

Q When is the next Afforestation and Deforestation intentions survey?

A This survey is conducted annually. The latest survey (2022) is published here Afforestation and Deforestation Intentions Survey 2022 (mpi.govt.nz). The next afforestation and deforestation intentions report will be published in early 2024.

Q Are the levels of afforestation indicated in the survey in-line with Government policy objectives?

A Forests provide an important contribution to achieving New Zealand's climate change emissions budgets and targets by reducing net emissions. However, the current NZ ETS settings may not be leading to best outcomes for all New Zealanders. That is why the Government is reviewing the NZ ETS to assess if changes are needed to provide a stronger incentive for businesses to transition away from fossil fuels while also supporting removals from forestry. The Government has also decided to progress further work to redesign the permanent forest category to better support the Government's forestry and climate change objectives, as well as Māori aspirations for their land.

Q What classes of land is most afforestation occurring on?

A The 2021 Afforestation and Deforestation intentions survey indicates that around 90 percent of afforestation is occurring on Land Use Capability classes 6, 7 and 8.

Q How have recent Government policy changes impacted reduced planted forest deforestation?

A Carbon prices are now having a significant impact on reducing levels pre-1990 planted forest deforestation. For example, the 2022 Afforestation and Deforestation Intentions Survey provides deforestation intentions over 2022– 2030, and these have decreased by around 15,800 hectares, compared with the 2017 survey when the carbon price was around $20 per NZU.

Reductions in deforestation will help New Zealand reach emissions reduction targets, including the 2030 target taken under the Paris Agreement.

Q What factors contribute to uncertainty around intentions beyond 2023?

A Uncertainty about afforestation arises from tree stock availability, land availability and affordability, labour availability, client confirmation, requirement for Overseas Investment Act approval and central and local government regulations. Uncertainty in future carbon prices, and the afforestation or deforestation response to these prices also increases uncertainty.

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