JULY 2026

TIMES-NZ 3.0

Results and insights

ENERGY EFFICIENCY & CONSERVATION AUTHORITY
TE TARI TIAKI PŪNGAO

Foreword

The release of TIMES-NZ 3.0 is the third iteration for the project, and the second time that the BusinessNZ Energy Council (BEC) and EECA (the Energy Efficiency and Conservation Authority) have worked in partnership to develop the model. Working across the spheres of business and government allows the project to utilise the strengths of each, and develop a product which is useful to all.

Energy sector stakeholders have helped to shape the model, especially the two new scenarios: Steady and Shift. These are built around the uncertainties which are most front of mind: energy demand from large users, the pace of technology change, climate policy, and the future role of gas. Each of these is reflected as a divergent path from today, and the combinations which make up the two scenarios are those which were thought to be most plausible. Of course, other combinations are possible, and maybe only a little less likely.

Comparing our new scenarios with those from the previous release in 2021, it is clear that much has changed. Most significant of all is perhaps the role of gas. In 2021, the prevailing view was that significant indigenous reserves remained, and this was not a large driver of scenario variation. In 2026 we are in a different place, and declining reserves are driving a transition. This may change again, and if so we will update the model.

The ability to capture the interplay between different energy sources, and different demands, is a key strength of the TIMES-NZ model, and leads to some of our key insights. These include the importance of electricity demand flexibility to the system, the flow-on effect to the cost of electrification for uses such as heavy transport, and the way in which the system finds replacements for natural gas. An underlying theme here is finding the lowest cost solution at a system level, balancing firming requirements with low-cost wind and solar generation; a problem which we believe New Zealand is at the forefront of due to our isolated location.

EECA and BEC want this release of TIMES-NZ to be the start of the conversation on what can be done with the model. Clearly there are many energy sector models, each with strengths and weaknesses, which are used to inform decision making. Mostly, different models also come with different assumptions, complicating comparisons. We would like to see TIMES-NZ adopted as a ‘benchmark’ model, and have worked hard to document all assumptions, and provide the model as an open-source package that others can take up, changing assumptions as they see fit, and producing fresh insights. We welcome collaborators for this, and look forward to what we can do together.

EECA ENERGY EFFICIENCY & CONSERVATION AUTHORITY TE TARI TIAKI PŪNGAO

WORLD ENERGY COUNCIL BusinessNZ Energy Council

Executive summary

The TIMES-NZ energy scenarios explore how the country's energy system could evolve over the coming decades. The scenarios were built using TIMES-NZ 3.0, a comprehensive model of the whole New Zealand energy system developed by EECA and the BusinessNZ Energy Council (BEC) based on the International Energy Agency's TIMES framework.

Using a richly detailed database of energy system demands, technology costs, and energy supply options, TIMES-NZ considers how supply and demand interact in our complex and interwoven energy system - and how changes in one area can have effects throughout the rest of the system.

We've created two scenarios – or possible energy futures – after discussions with a wide group of around 40 stakeholders, including representatives from other government agencies, energy companies, energy users, universities and non-profit organisations.

These stakeholders gave us feedback on which major uncertainties were front of mind when making decisions, resulting in the choice of four areas to explore: future energy demand from large users, the pace of technology change, climate policy and societal trends, and the future role of gas.

Combining these uncertainties in the way stakeholders thought most plausible gives us the two scenarios Steady and Shift. These represent two diverging paths from today, neither of which will exactly represent the future. Importantly they are also not upper and lower bounds for any individual energy variables, nor do they represent a specific set of potential government policies.

They are also not forecasts. In reality, there are countless possible futures, reflecting the complexity and interdependence of New Zealand's energy system.

Our two scenarios delineate the uncertainties as:

Economic structure and energy demand: Steady has relatively more primary production, while Shift has relatively more growth in technologies that support adoption of renewables, advanced manufacturing and data centres.

Technology costs: Steady has moderate cost reductions for clean technologies, while Shift has more rapid cost reductions. Clean technologies encompass solar, wind and batteries, and EV costs.

Climate policy and societal trends: Steady has lower carbon prices and higher discount rates, while Shift has the opposite. Shift also has lower private passenger vehicle use.

The role of gas: Steady has LNG, while Shift has greater availability of biomass and biogas.

The value of the scenarios comes from exploring how multiple factors come together, rather than from considering any aspect in isolation. They can also show us that the combined impact can be much greater than the sum of the parts.

The scenarios can be used as a benchmark for industry to test their own modelling against, while modellers are encouraged to use our open-source model to create their own insights and build other scenarios from among the many possible combinations.

Key insights from scenario outputs:

Energy demand: Total energy demand falls in both scenarios, as electrification and greater energy efficiency leads to lower overall requirements even as service demand grows. In Steady, total energy demand falls 10% by 2050, and in Shift it falls 22%. In Shift, a greater share of demand (53%) can electrify, leading to higher electricity use and lower fossil fuel demand.

Emissions: Road transport electrification is the single largest driver of emissions reductions across the energy system in both scenarios. However, the scale and rate of emissions decline is strongly affected by how quickly New Zealand adopts clean technology, particularly electric cars and trucks. Declining domestic gas supply and an increase in renewable energy generation also drive emissions reductions in both scenarios. The combined impact is that by 2050, the Shift scenario's emissions are less than half that of Steady. These differences are driven by a range of factors, including lower technology costs and higher carbon prices in Shift.

Costs: The total cost of meeting energy demand from 2023-2050 is roughly $1.3 trillion, or approximately $45 billion annually. For context, this is roughly 11% of annual GDP, which was $393 billion in 2023.[1] However, costs in the Shift scenario are roughly $42.7 billion lower than in Steady across the whole model period (2023-2050), or $1.6 billion lower annually. This is because of lower clean technology costs, more available technology, and greater energy efficiency.

Renewable electricity: In both scenarios, the renewable share of electricity generation increases over time, and contributes to lowering optimised energy system costs. This is to be expected, as thermal gas and coal plants retire and new plants are dominated by lower-cost solar and wind generation, alongside geothermal and hydro. However, it remains challenging to move to a 100% renewable electricity system: In Steady, the renewable share of electricity generation reaches 93% by 2050, while in Shift it reaches 98%. Thus, while dispatchable hydro, baseload geothermal, flexible electricity use, and batteries all contribute to balancing supply and demand (and more so in the Shift scenario), the model finds that fossil-fuel generation is still often the most effective marginal solution for peak support and grid firming, even with higher carbon prices.

Replacements for natural gas: Although domestic natural gas supply is falling in both scenarios, the model finds that many existing industrial heat applications, such as meat or dairy processing, can be cost-effectively electrified or converted to biomass or biogas. In the Shift scenario the model finds that up to 50 PJ of biomass can be cost-effectively used for energy annually, and nearly 40 PJ of biogas. This is assumed to result in greater diversion of organic waste from landfill, hence increasing the available feedstock for biogas.

1 Values expressed in 2023 NZD, which is the same price base as used in TIMES-NZ 3.0. Annual GDP figures (March year) extracted from Stats NZ - https://infoshare.stats.govt.nz/ViewTable.aspx?pxID=e4025147-ff97-48be-bfd5-420fa7f85a61

Use of LNG: While the model is not designed to undertake a full cost-benefit analysis of constructing an LNG import terminal, the results indicate that imported LNG is the most cost-effective way of providing winter energy firming under certain settings. In the Steady scenario (where an LNG terminal is built) LNG at a marginal cost of $25/GJ is a cost-effective source of energy after 2032, and is used for electricity generation, and in the industrial, residential and commercial sectors. This date coincides with indigenous supply falling below 50 PJ/annum and the assumed retirement of the Huntly Rankine units.

Value of flexible electricity and batteries: A rapid expansion of demand flexibility and battery capacity is important for a secure and affordable energy system. Batteries and other technologies that enable flexible electricity use (including shifting demand on the electricity grid away from peak periods, such as winter evenings) play a key role in the evolving energy sector, and become even more important in the Shift scenario, which has higher rates of renewable electricity generation. At a whole system level, these technologies can save energy users between $5.4 and $20.8 billion in total through to 2050. This is achieved by facilitating greater electrification, and highlights the importance of cost-effective renewable electricity to the wider economy.

Acknowledgements

TIMES-NZ 3.0 would not be possible without a large team of contributors.

The EECA project team are: Sarah Barnett, Will Catton, Sarah Cooper, Tim Crownshaw, Eloise Gibson, Andrew Greed, Gareth Gretton, Megan Hurnard, Erin Leuschke, Andrew Neal, Bill Nelson, Thomas Pappafloratos, Bethany Plant, Felicity Rookes, Luke Searle, Vincent Smart and Achini Weerasinghe.

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A wide group of stakeholders contributed to scenario development and model assumptions. The EECA and BEC teams wish to thank them for their engagement, and note that their inclusion here does not imply their endorsement of the model: Alpine Energy, Ara Ake, Arup, Bioenergy Association of NZ, BP, Climate Change Commission, Climate Navigator, Contact, Electricity Authority, Earth Sciences NZ, Elemental Group, Fonterra, GasNZ, Genesis, Gas Industry Co, Helios, Intelligent Transport Systems NZ, Massey University, Ministry of Business, Innovation, and Employment, Ministry for Cities, Environment, Regions, and Transport, Mercury, Meridian, Mitsui NZ, NZ Geothermal Association, Nova Energy, NZ Steel, Orion, Rewiring Aotearoa, Scion, Thundergrid, Transpower, Unison, University of Auckland, University of Otago, Victoria University of Wellington, Whirika, Z Energy.

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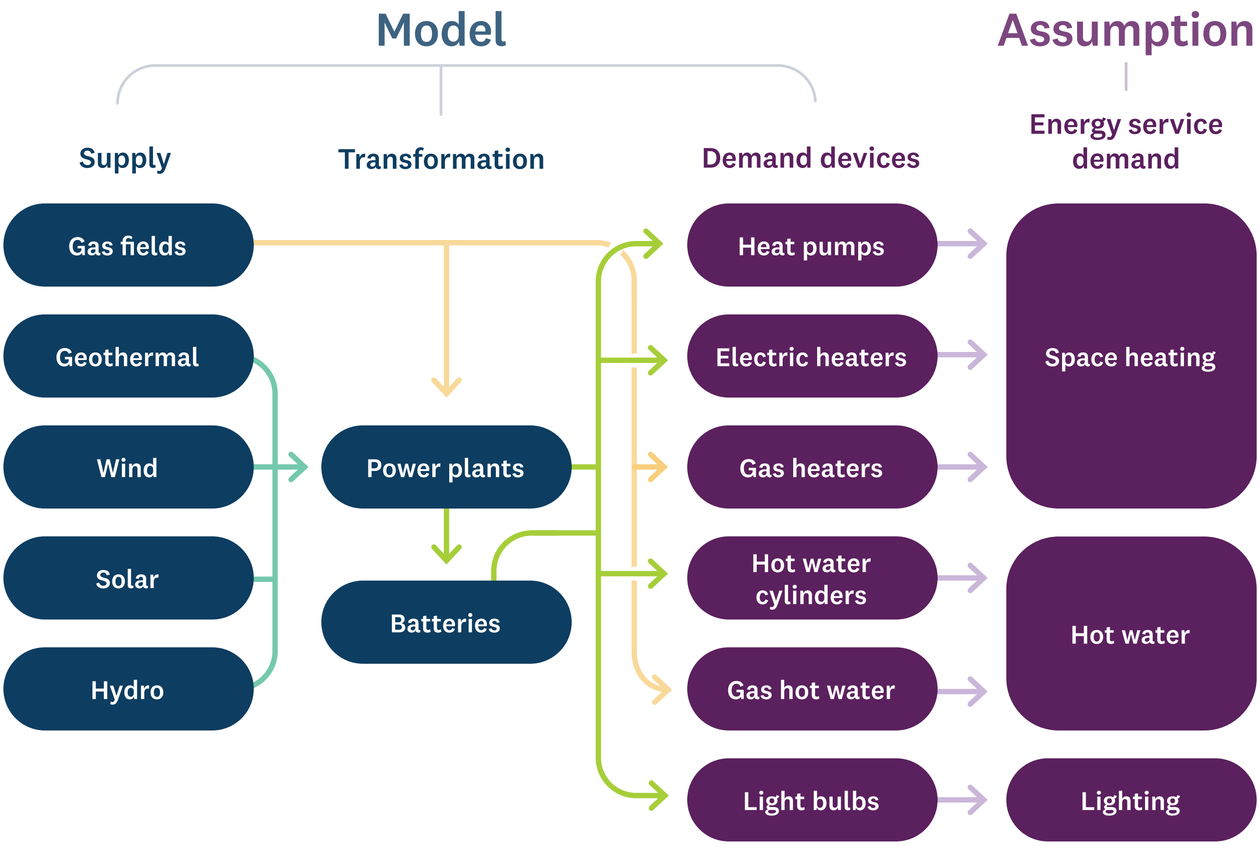
Table of contents

1 What is TIMES-NZ?

TIMES-NZ captures production, transformation, distribution, storage, and interisland flows of energy on a bottom-up, detailed database. Then, based on assumptions about future demand trajectories, such as manufacturing growth or increased vehicle travel, the model identifies the least-cost configuration of energy sources, generation plants, and other technologies to meet demand. This includes any potential fuel switching, technology upgrades, or other investments required. Figure 1 illustrates a simplified process of how energy flows in the model, with residential space heating, water heating, and lighting as the end use demands.

Figure 1: Example TIMES-NZ process flow



To use the model, we first define and quantify energy service demand, which is the useful form of energy: such as heated water, vehicle kilometres travelled, industrial process heat, and so on. The model draws from our technology database to identify the range of technology options to meet this demand: such as different process heat boilers, residential heating options, vehicle types, including both existing technology stocks and future build.

It also considers the upstream components: fuel import costs, gas supply, electricity generation at different times of day and in different seasons, the transmission and distribution network, and the constraints associated with peak demand. Finally, it chooses a system configuration that minimizes total system costs across all of these factors simultaneously.[2] This approach considers each component and also how they all interact with each other. **The result is the lowest cost solution to meet demand for energy in any given future.**

It's important to note that the lowest-cost result across the system may not mean the lowest cost for any individual energy user. The focus on system costs also means that real-world outcomes will sometimes differ from the model results – for example, grid-scale solar might have lower costs across the system than rooftop solar, however individual incentives at the household level might favour rooftop solar over grid-scale solar in the real world. The result is that more rooftop solar may installed in reality than the model predicts.[3]

Some of the key data and assumptions are outlined in Appendices 1 and 2, with full documentation and an open-source model online.

2 This uses the Linear Programming optimisation technique, or potentially Mixed Integer Programming depending on the model structure. See documentation for the TIMES Model for further details. https://github.com/etsap-TIMES/TIMES_Documentation/blob/master/Documentation_for_the_TIMES_Model-Part-I.pdf

3 For rooftop solar specifically, we have added exogenous growth projections to increase the reality of the scenarios. See the TIMES-NZ documentation on rooftop solar for further details. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/electricity/future_techs.html#distributed-rooftop-solar

2 Scenarios

2.1 Steady and Shift

The future shape of New Zealand's energy system is uncertain; however, businesses, households and policymakers need to make choices today. TIMES-NZ's energy scenarios have been designed to help inform these decisions.

Our scenarios represent two contrasting and plausible futures. They show how the energy system might adjust if 'critical uncertainties' go one way, or the other. These critical uncertainties were informed by stakeholders, and describe factors influencing the energy sector which are both highly impactful and deeply uncertain. Infrastructure planning therefore needs to consider both possible futures.

We've called these scenarios Steady and Shift.

The Steady scenario isn't static, but the economy and the energy sector change less in this possible future. In the Shift scenario, the drivers of change across a range of inputs are stronger, resulting in greater and more rapid change in the energy sector.

2.2 Four critical uncertainties

The four critical uncertainties underpinning the Steady and Shift scenarios are:

Economic structure and energy demand

Whether strong and growing demand continues for New Zealand's dairy and meat exports and traditional manufacturing (Steady) OR whether the economy shifts towards a greater focus on clean tech and advanced manufacturing (Shift).

In both scenarios, the level of economic activity is broadly similar, but the mix of goods and services produced is different. In the model, this variable primarily affects demand for industrial heat and the trajectory of electricity demand.

Global technology prices

Whether clean technologies (solar panels, EVs etc) fall moderately in price (perhaps due to lower levels of free trade between New Zealand and the rest of the world) (Steady) OR prices for these technologies fall faster (perhaps due to more free trade) (Shift).

In both scenarios, prices for clean tech fall in the next twenty years; what differs is the pace. In the model, this variable affects the rate of electrification and uptake of renewable energy sources.

Climate policy and societal trends

Whether the carbon price remains low (Steady) OR rises (Shift), whether investment decisions are made with a relatively short-term view (higher discount rates in Steady) or a relatively long-term view (lower discount rates in Shift), and whether per-capita private passenger vehicle demand follows existing trends (Steady) OR decreases (Shift).

Collectively, these variables affect the ability and willingness of consumers and businesses to make upfront investments in renewable energy and clean technology that improve their long-term energy efficiency. Per-capita private passenger vehicle demand is also specifically represented, given the impact this has on overall energy demand in New Zealand. This could be a result of urbanisation, mode-shift, or other factors.

Role of gas

Whether LNG is available for import (Steady) OR not (Shift) and how much feedstock (such as organic waste) is available for producing alternative fuels such as biogas (less in Steady versus more in Shift).

Domestic gas reserves fall quickly in both scenarios, in line with current government projections, and there is an assumption that no new domestic gas reserves are developed in either scenario. In the model, this variable affects the use of fossil gas versus alternatives such as biogas and electricity.

Other combinations and other factors

The two mutually exclusive combinations of the four critical uncertainties were those judged by stakeholders to be the most plausible – reflecting which were most likely to occur together. Other combinations (e.g. Steady without LNG, or Shift with LNG) could eventuate, and these could be the subject of future work.

Many other factors will also influence the energy system, but these were judged by stakeholders to be less critical, less uncertain, or both. These factors remain the same between scenarios, and modelling choices assumed that current or anticipated trends continue unchanged. These factors included:

- Population growth, which is most likely to impact the rate of growth of the energy system, rather than the structure.
- The Tiwai Point aluminium smelter, which is assumed to stay open throughout the modelled period.
- The future of methanol production, which is assumed to stop in 2027 when the Maui gas field closes.

A table outlining the key assumptions for each scenario in each sector can be found at Appendix 2.

2.3 How to use the scenarios

These scenarios show how New Zealand's energy system could work under different conditions. They look at the whole system, including how different parts of the system affect each other.

The scenarios are not meant to show the highest or lowest possible result for a single quantity, such as electricity generation or energy emissions. This is because different inputs to a given scenario can push and pull on a given output, and because a change in one part of the system can be balanced out by changes somewhere else. For example, higher energy service demand coupled with a lower carbon price could lead to higher or lower electricity generation.

It is usually most useful to compare the scenarios than to focus on just one. Comparing them can show how different parts of the energy system interact and develop over time, what outcomes are common across scenarios, and which assumptions have the biggest effect.

The scenarios can help inform energy decisions, but they should be used alongside other evidence and analysis, such as models which focus on the electricity system in more detail.

3 Results

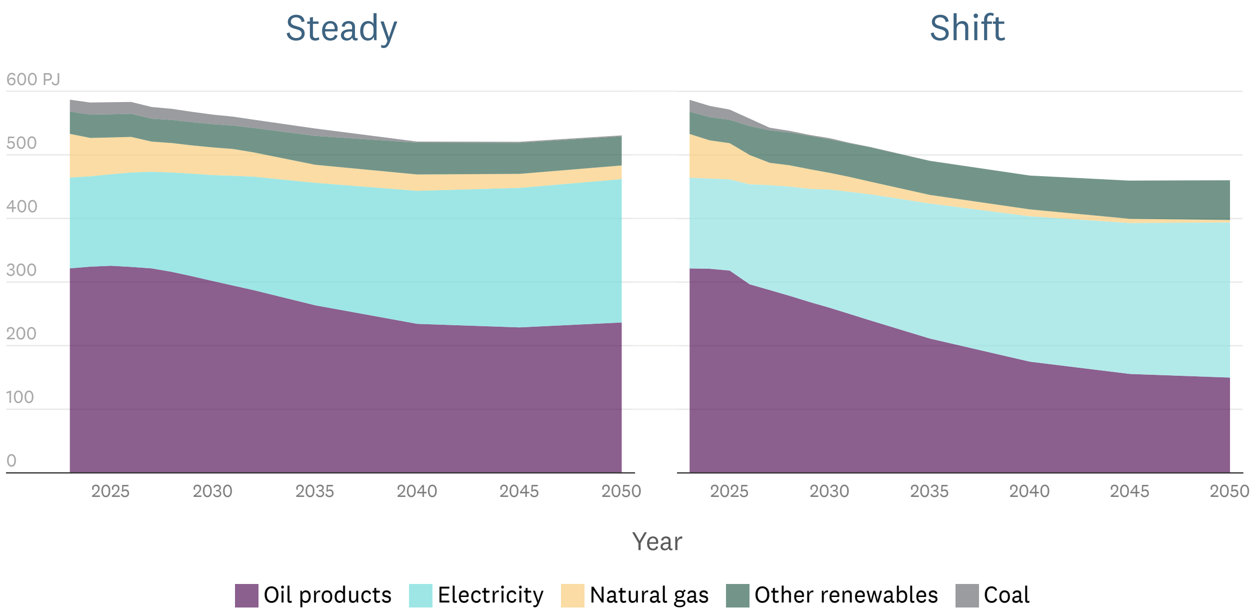
This section explores results for:

- Energy demand, emissions and costs, at a whole of system level
- Electricity, gas and biomass fuels
- Transport, industry, residential and commercial sectors

Note that data for 2024 and 2025 is modelled, so will differ from actual historical results.

3.1 Total energy demand

Figure 2: Total energy demand by fuel



Both of our scenarios see total energy demand falling, as electrification and greater energy efficiency leads to lower overall requirements even as service demand grows.

In Shift, a greater share of demand can cost-effectively electrify, leading to higher electricity use and lower fossil fuel demand. One significant component of this is greater uptake of electric transport, discussed in more detail below, which displaces demand for oil products. Gas and coal demand also fall faster in the Shift scenario. For gas specifically, this is driven by constrained availability (only Steady has access to LNG) but for both fuels it is driven by access to more competitive alternative technologies for process heating, noting that the regulatory settings for coal use are the same in both scenarios.

Despite these differences, there are also similarities: in both scenarios the two fuels with the largest shares in 2050 are electricity and oil products.

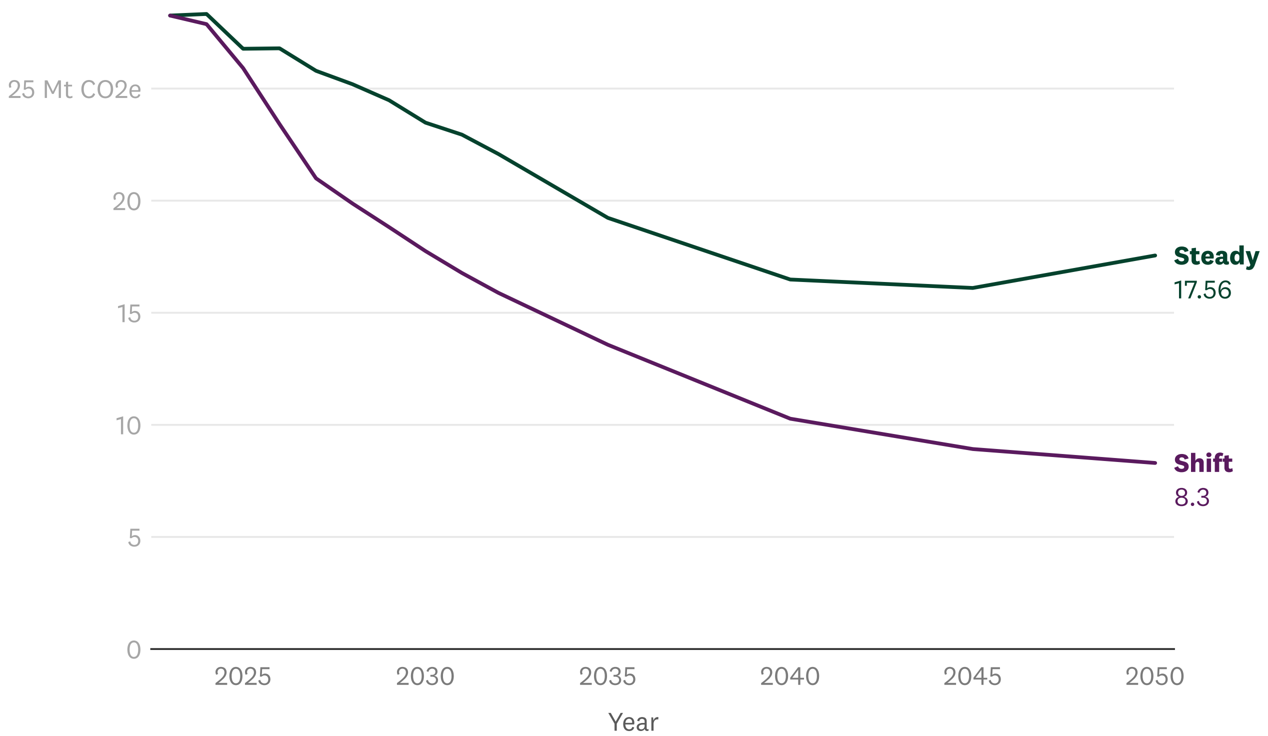
3.2 Emissions

The TIMES-NZ Steady and Shift scenarios were not designed as high/low emissions scenarios, but emissions outcomes are very different between the two. Both scenarios see energy emissions fall over time as gas supply falls, more renewable energy sources come online, and some new technologies are proven at scale, but the Shift scenario's emissions are less than half those of Steady by 2050, as shown in Figure 3. The renewable share of total final energy consumption (TFEC)[4], shown in Figure 4, moves in the opposite direction, rising from around 30% today, to approximately 50% in Steady and 75% in Shift.

This is in large part driven by differences in the uptake of low-emissions transport: cheaper electric vehicles in the Shift scenario drive strong uptake of EVs, reducing diesel and petrol use even for heavy freight demand. Shift also has high carbon prices, which further pushes up the cost of fossil fuel use, making electrification more competitive. Additional parameters like discount rates and private vehicle use also play a role, with Shift having lower discount rates and lower per-capital vehicle kilometres travelled.

While road transport electrification is the single largest driver of emissions decline, and differences in scenario outcomes, the model also finds that other sectors, particularly industrial demand and electricity generation, contribute to the emissions difference between the two scenarios, as shown in Figure 5. By 2050, annual energy emissions fall by 37.9% in the Steady scenario, and 70.6% in the Shift scenario.

Figure 3: Energy emissions



4 Total final energy consumption is defined as all end-use energy, excluding non-energy use such as natural gas for chemical feedstock, or oils used as lubricants. International transport is also excluded from TFEC, and the total and sectoral emissions presented in this section, but is included elsewhere in this document.

Figure 4: Renewable share of TFEC

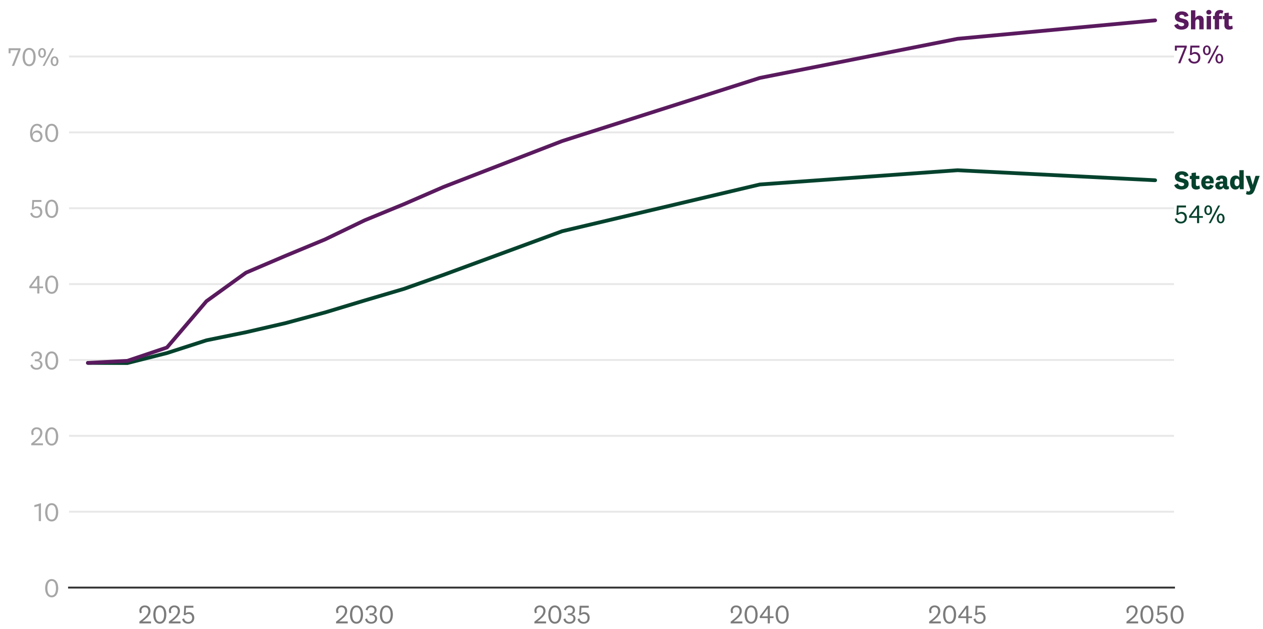
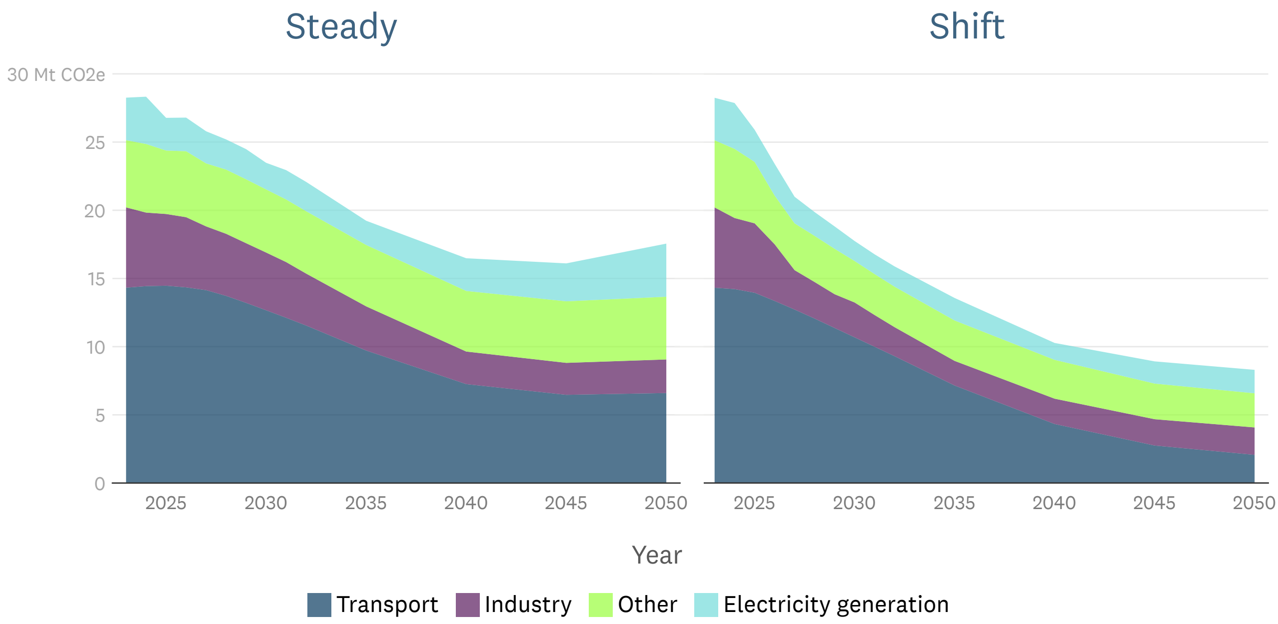


Figure 5: Emissions by sector



"Other" includes residential, commercial, and agriculture/forestry/fishing emissions.

3.3 System costs

The TIMES-NZ model identifies the composition of technology and energy flows that meets all assumed energy demand at the lowest net present system cost.

For both Steady and Shift, the total discounted cost of meeting energy demand from 2023-2050 is roughly $1.3 trillion, or approximately $45 billion annually, as listed in Table 1. For context, this is roughly 11% of annual GDP, which was $393 billion in 2023.[5] However, costs in the Shift scenario are roughly $42.7 billion lower than in Steady across the whole model period (2023-2050), or $1.6 billion annually. This is due to a range of factors including lower clean technology costs, more available technology, and greater energy efficiency.[6]

Table 1: Steady and Shift total system costs

	Total system cost	Annual average cost[7]
Steady	$1,325.8 billion	$47.35 billion
Shift	$1,283.1 billion	$45.83 billion

The system cost[8] includes the capital costs of investment in new technologies from electricity generation to end-use, the cost of producing or importing fuels, the operating costs of both new and existing technologies, and carbon costs. The only costs which are not fully represented are those which relate to processes for which there are no alternatives modelled; this ranges from large-scale industrial processes such as ammonia-urea production, to small-scale processes where the energy use is minor, such as consumer electronics. We have tested variations and components of system cost in our sensitivity analyses, detailed later in this report.

3.4 Electricity generation and demand

3.4.1 Renewable electricity generation

Both scenarios show the renewable share of electricity generation increasing over time (Figure 6). This is to be expected, as thermal gas and coal plants retire and new plants are dominated by lower-cost wind and solar, alongside geothermal and hydro. However, it remains challenging to move to a 100% renewable electricity system, because of the costs associated with firming intermittent wind and solar generation. While dispatchable hydro, baseload geothermal, flexibility electricity use, and batteries all contribute to resolving this problem, the model finds that fossil generation is still often the most effective marginal solution for peak support and grid firming, even with higher carbon prices.

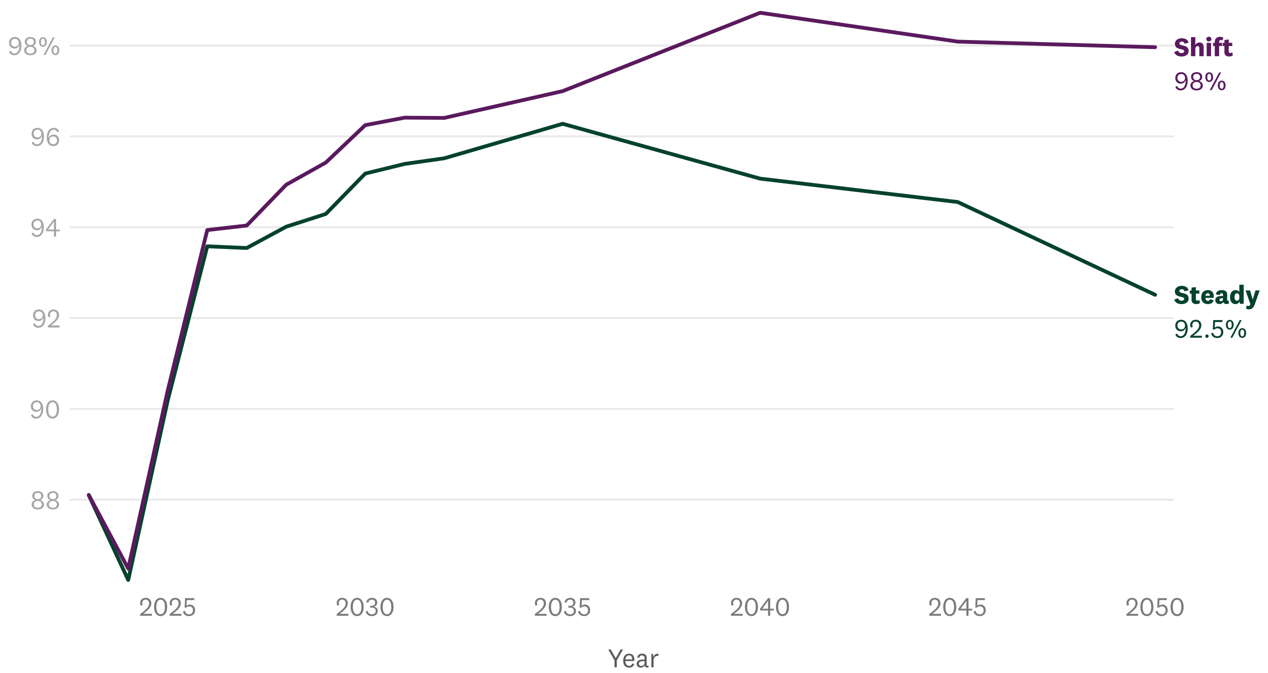
5 Values expressed in 2023 NZD, which is the same price base as used in TIMES-NZ 3.0. Annual GDP figures (March year) extracted from Stats NZ https://infoshare.stats.govt.nz/ViewTable.aspx?pxID=e4025147-ff97-48be-bfd5-420fa7f85a61

6 Note that Shift has lower discount rates, meaning that the difference in costs between scenarios would be larger if comparing undiscounted costs.

7 The annual average system cost is for illustrative purposes only, across the 27 years. Total system costs are not evenly distributed across each year of the model scenarios.

8 The total system cost is also referred to as the “objective function”, which is minimised by the TIMES Linear Programming solution.

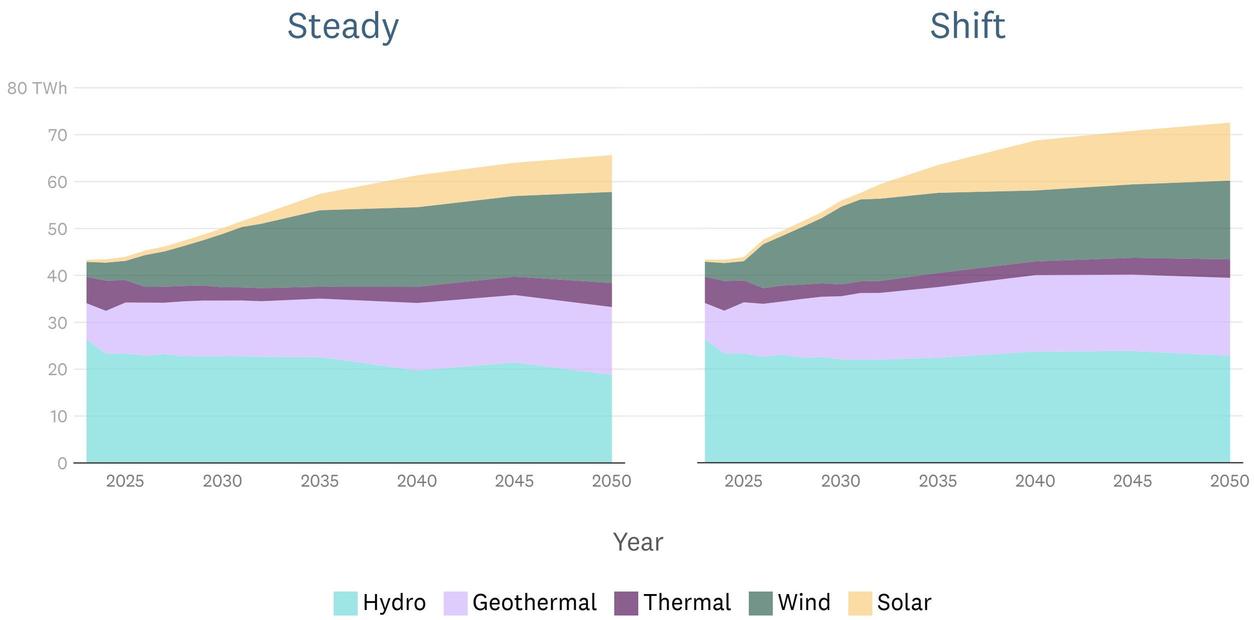
Figure 6: Renewable share of electricity generation



While the model finds a greater share of renewable electricity generation in both scenarios, the Steady scenario shows this share beginning to fall again in the lead-up to 2050 from a peak in the late 2030s. This is caused by an increase in fossil fuel firming required to meet growing peak demand. Some of this is supported by imported LNG, but the model also identifies new diesel peakers as a potentially effective option following the closure of Huntly's Rankine units (assumed 2033).

In the Shift scenario, renewable options such as wind and solar become cheaper over time, but this alone is not enough to encourage greater uptake. Supporting infrastructure and technology, such as greater options for flexible electricity use (such as batteries enabling lower peak-time electricity use) and more renewable energy sources available for peaking plants, enable greater shares of renewable energy in the system. The combination of greater renewable generation and technology enabling flexibility (largely batteries) is an important driver of lower costs in this scenario.

Figure 7: Electricity generation by technology

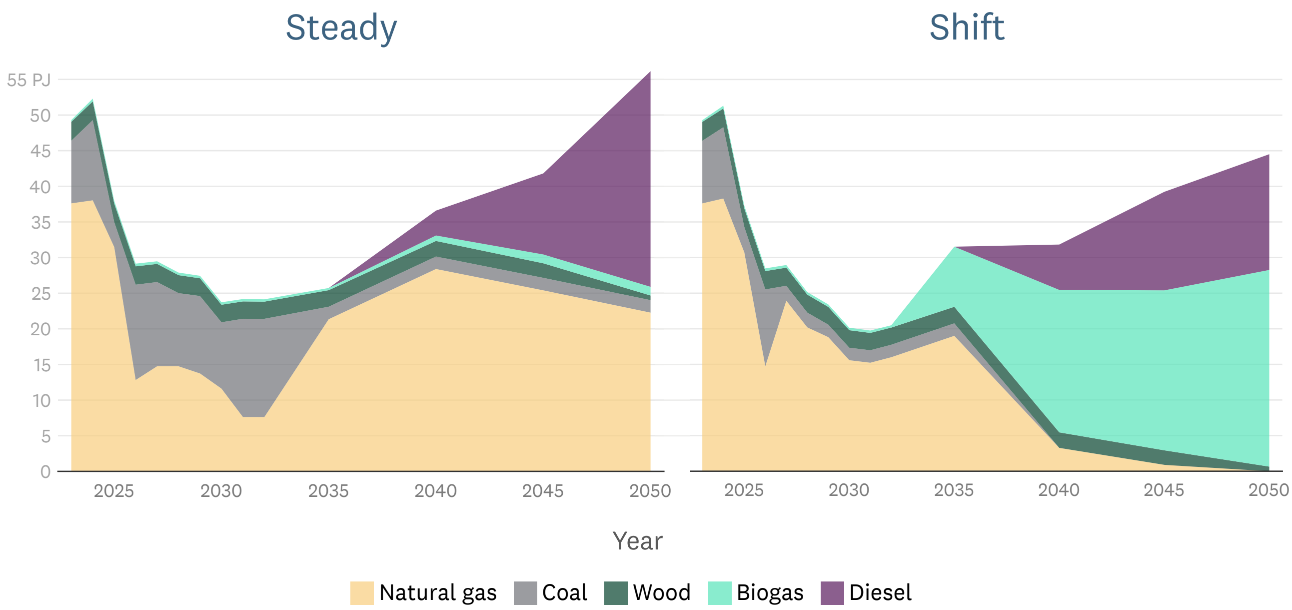


Dispatchable thermal generation, such as gas and diesel peakers, are key in both scenarios to firm generation during periods of low wind and solar output. In the Shift scenario, more biomass and biogas feedstocks are available, meaning that the dispatchable thermal generation becomes more renewable.

The Huntly Rankine units are assumed to retire in 2033 in both scenarios, and black pellets[9] are modelled as a potential input fuel for these. However, this modelling currently suggests that black pellets are too expensive to be considered an optimal system solution, even in the face of rising carbon prices. This is due to a combination of the cost of their production and the impact on available biomass energy feedstocks, as these may have more value in other areas of the energy system.

9 Black pellets are a type of biomass fuel made by heating wood or other plant material in a low-oxygen process called torrefaction before compressing it into pellets. This process makes them more energy-dense, water-resistant, and easier to store and transport than conventional wood pellets.

Figure 8: Fuel used by thermal electricity generation



In the Steady scenario, future thermal generation is supported by natural gas, imported into New Zealand as LNG. In the Shift scenario, there is no LNG but greater biogas feedstock availability, so this scenario utilises higher rates of biogas generation for firming. However, both scenarios also significantly expand diesel peaking technology, which can provide reliable grid firming despite high costs and emissions.

In both scenarios, short-term thermal generation use falls, owing to the construction of several new renewable plants, but then rises again as greater electrification demand increases demand overall and leads to more firming capacity being required.

3.4.2 Dry years

TIMES-NZ assumes average hydrological (rainfall) years, and so the variance in hydroelectricity supply that can be driven by unusually dry or wet years is not fully reflected in these results. Instead, the model represents dry year risk using an energy margin constraint. This constraint requires the electricity system to have enough spare capacity to meet demand even if hydro generation is lower than average, and means that it will invest in additional generation over and above requirements.[10]

When modelling 2024, which was historically a dry year with low hydroelectric generation, the model could not meet these margin constraints.[11] This implies that the electricity supply balance in that year was not robust to a potential dry year. This modelling result aligns with the reality of 2024, which provides some assurance that the model is calibrated well.

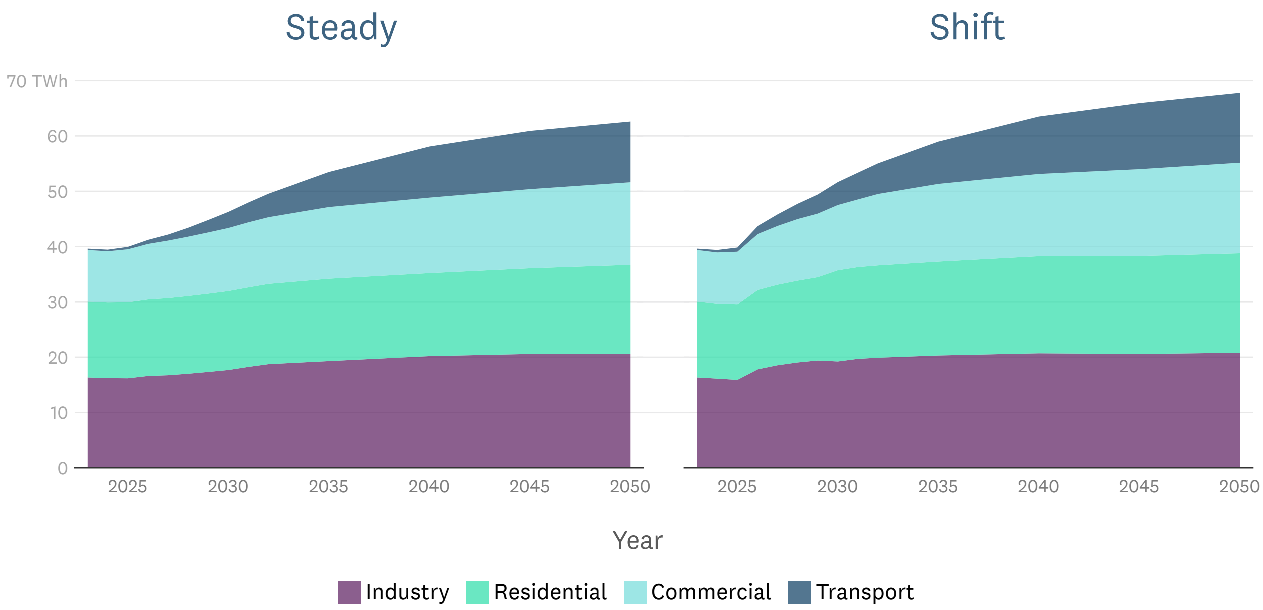
10 More information on TIMES-NZ energy and capacity margin methodology can be found in the TIMES-NZ documentation for time of use and meeting peak demand. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/electricity/time_of_use.html

11 During model development, once calibration was complete, the margin constraint was relaxed slightly to allow 2024 to solve correctly. Note 2024 is a modelled year because we utilise 2023 year data as the starting point. This choice of starting point was driven by data availability during the TIMES-NZ model development.

3.4.3 Electricity demand

Figure 9 shows total electricity demand by sector. Broad trends are similar in both scenarios, with consumption increasing in all sectors, and transport being the largest driver of growth in both absolute and relative terms. In Steady, this transport demand growth to 2050 is approximately 11 TWh, and accounts for 47% of overall electricity demand growth, while in Shift it is 12 TWh and 44%.

Figure 9: Electricity demand by sector



3.4.4 Battery uptake rates

In TIMES-NZ, batteries can support grid capacity to meet peak electricity demand, by shifting energy from one period of a day to another.

The model includes grid-scale and distributed batteries, which have different cost and technical parameters.[12] Grid-scale batteries are large installations connected to the transmission grid, like those at Ruakākā and Huntly. Distributed batteries represent smaller batteries installed at households or businesses; these are more expensive per unit of capacity, but have the benefit of sitting behind the meter (between the household or business and the grid), which means they can support peak demand without adding additional load to the transmission and distribution network. More details are available on the TIMES-NZ documentation pages.[13]

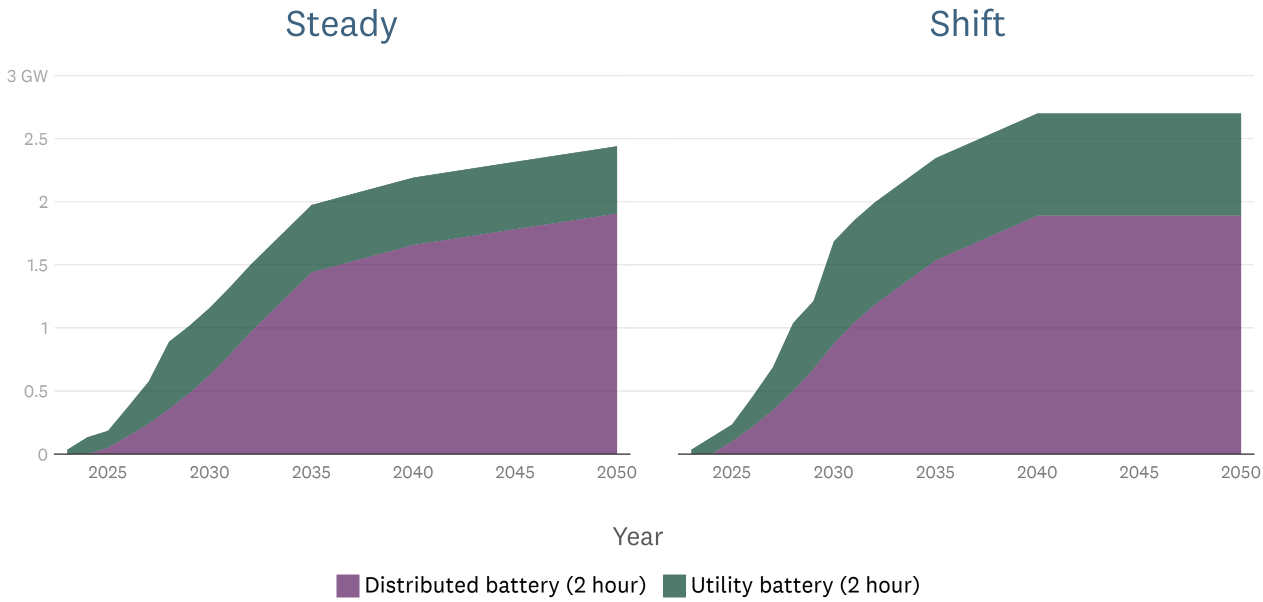
12 In TIMES-NZ, model batteries can shift stored electricity within a single day, but we assume they cannot shift energy between days or seasons. The model will choose when batteries charge or discharge if doing so is economic, including the relevant costs or efficiency losses. Battery capacity limits how much energy can be shifted.

13 Storage technologies — TIMES-NZ documentation. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/electricity/storage.html

By default, we assume that battery installations are 2-hour storage ratios, meaning they include 2 kWh of storage for every kW of output capacity. 8-hour batteries are also included as model options. However, the model finds that these larger 8-hour batteries are less useful than 2-hour variants under most settings. This is because the daily arbitrage opportunity is maximised during the one or two hours around the time of peak demand, so the additional storage capacity can go unused.[14]

Figure 10 shows the battery installation paths that the model finds most cost-effective to meet the system's needs. This includes a mixture of grid-scale and distributed batteries. TIMES-NZ's modelling of the transmission grid is a key driver of this relationship, as additional load on the transmission grid is required to meet growing peak demand. This additional grid investment requires both capital and increased operating expenditure in the modelling.[15] Distributed batteries can support growing peak demand without additional transmission grid load, so they allow peak demand to rise without incurring additional grid investment costs. The model finds that a certain level of investment in grid-scale batteries is cost-effective, but eventually this reaches an equilibrium and greater investment in distributed batteries is preferred.

Figure 10: Battery capacity



In the Shift scenario, battery costs decline much faster than in Steady. However, sensitivity tests show that the costs of battery installation and maintenance have very little impact on the optimal battery stack.[16] Instead, the higher build rate of batteries in the Shift scenario is driven by the greater arbitrage opportunities from higher electricity demand and a greater share of renewables. In both scenarios, the model finds a rapid expansion of battery capacity is the optimal path to a secure and affordable system.

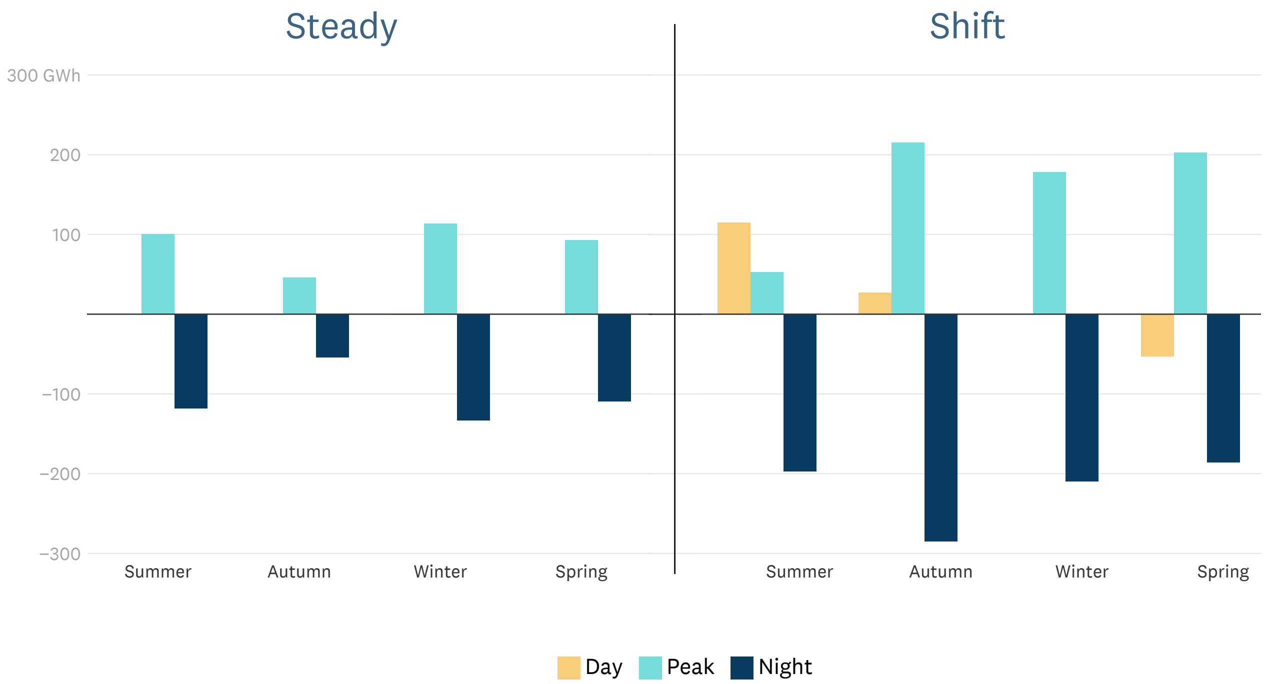
14 The system cost approach strongly favours distributed batteries, and this can lead TIMES-NZ to find very high distributed battery capital outlay favourable for the system. To produce more realistic expenditure scenarios, considering financial constraints faced by homeowners and businesses, we limit the annual capital rate for distributed batteries. These limits are assumption only, and further research could lead to more precise estimates. More detail on this method can be found in the TIMES-NZ documentation for Capital expenditure constraints. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/other_constraints/cap_constraints.html

15 More detail on the TIMES-NZ implementation of transmission and distribution network expansions and cost estimates can be found in the TIMES-NZ documentation for Transmission and distribution. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/electricity/transmission_distribution.html

16 Internal testing shows that even reducing capital costs to zero does not materially increase battery installations in the Shift scenario. Other factors, like the losses in battery roundtrip storage, effective arbitrage already underway, and current peak support put a ceiling on the level of batteries that are useful for the modelled energy system.

Figure 11 demonstrates how the model uses these batteries across time periods and across the North and South islands, for the year 2035. Note that the model only considers four seasons, two day types (weekdays versus weekends), and three time-of-day periods (day, peaks and night), for performance reasons. A higher time resolution model might find different results.

Figure 11: Battery charging and discharging by timeslice, 2035



For most seasons and over both day types, the model prefers night charging to day charging, using spare wind and other non-dispatchable generation during this low demand period. However, there are some cases where solar output is high enough to justify daytime charging instead, particularly during non-winter months later in the Shift scenario.

This is partially related to the model dynamic between dispatchable hydro and solar power. As solar generation rises, the model finds the most effective response is to reduce dispatchable hydro output, as hydro dams can then store flows for night or peak periods in which generation output is more valuable, essentially operating as large grid-scale batteries.

3.5 Natural gas supply

In both scenarios, New Zealand's domestic gas supply is projected to fall sharply in the short-term, which will create significant pressure on the system's ability to provide firm electricity and meet industrial process heat demand. While the installation of an LNG terminal may provide an avenue for supporting flexible gas demand, this comes with higher commodity prices, and so this will drive some sectors to transition to other fuels.

For TIMES-NZ, the key scenario difference is the treatment of LNG. In the Steady scenario, we assume that a terminal is installed and functional from 2027, while in the Shift scenario no LNG is imported at all. In the Steady scenario, the terminal is assumed to be paid for and installed. This means the costs of installation and maintenance are included in the total system costs for that scenario, but the model cannot adjust these.

This approach means that these scenarios are not appropriate for fully assessing the system value of an LNG terminal. By either forcing inclusion or exclusion of an LNG terminal, we do not allow the model to fully assess its total system costs and benefits. Other modelling exercises in New Zealand have explored this topic more fully. However, the scenarios can be used to explore the interplay between LNG (if it is available) with other sources of energy when it comes to meeting energy demand, as well as how the system might adapt without LNG.

3.5.1 A simplified gas model

This iteration of TIMES-NZ does not fully represent the complexity of New Zealand's gas market, and there are areas where we hope to add sophistication in future releases. We note three limitations below, which should be considered when interpreting results.

First, gas supply and demand is modelled only at an annual level, and so does not capture seasonal variation. This seasonal dynamic is becoming increasingly important in the sector as fields mature and become less flexible, while at the same time gas for electricity generation is becoming increasingly focused on winter and peaking generation. We also note the role Methanex has played as a source of flexible demand, which is now becoming more constrained.

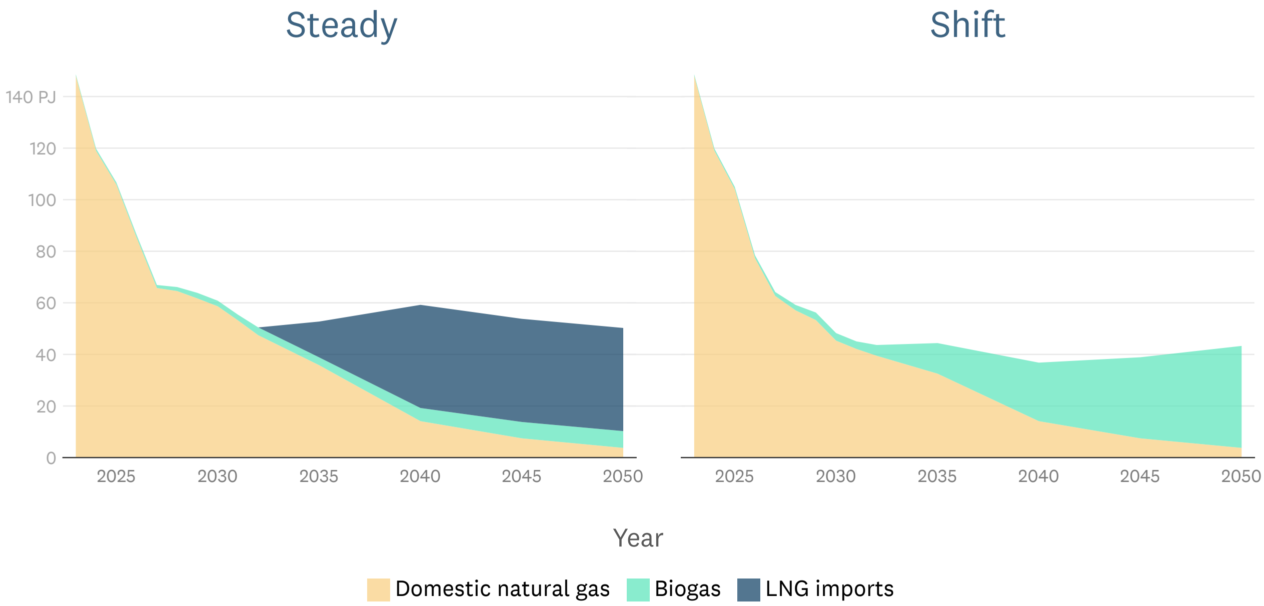
Second, an intrinsic feature of TIMES-NZ is that energy service demand is a model input, meaning that TIMES-NZ does not allow for business closures when energy prices rise too high.[17] Instead, it ensures that industrial activity matches our scenario assumptions. So, while the model ensures that there is enough energy to meet the scenario's demand, at any cost, it is possible that real-world activity rates might be different.

Third, the current gas transmission and distribution model is simplistic. It treats the gas network as a single asset with fixed maintenance costs, applied at a system level rather than being allocated to individual customers. This means that TIMES-NZ does not currently account for what would happen if the number of gas users declines, and where the network's fixed maintenance costs are shared among fewer users, increasing costs for each customer. Higher costs would then encourage even more customers to disconnect, creating a cycle of rising costs and declining demand. As a result, actual gas use could be lower than the model predicts, with more households and businesses switching to electricity than the model suggests.

17 We make an exception for Ballance Agri-Nutrients, as detailed in Section 3.8.2

3.5.2 LNG supporting post-Huntly firming

Figure 12: LNG, natural gas, and biogas supply



The Steady scenario imports LNG at $25/GJ, assuming a terminal is already paid for, but demand is limited until the mid 2030s, which is when we assume closure of the Rankine Units at Huntly.[18] LNG-based electricity generation, at existing and new gas peakers, then begins supporting winter energy firming in the Steady scenario.

In the Shift scenario, diesel and biogas perform this firming function instead. Increased biogas feedstock supply in the Shift scenario means that additional biogas production, some of which is converted to biomethane downstream, can be used to support demand.

18 The model is currently run in single year periods up to and including 2032, after which it is run in five year periods. Huntly is specified to retire in 2033, at the start of the 2033-2037 modelling period.

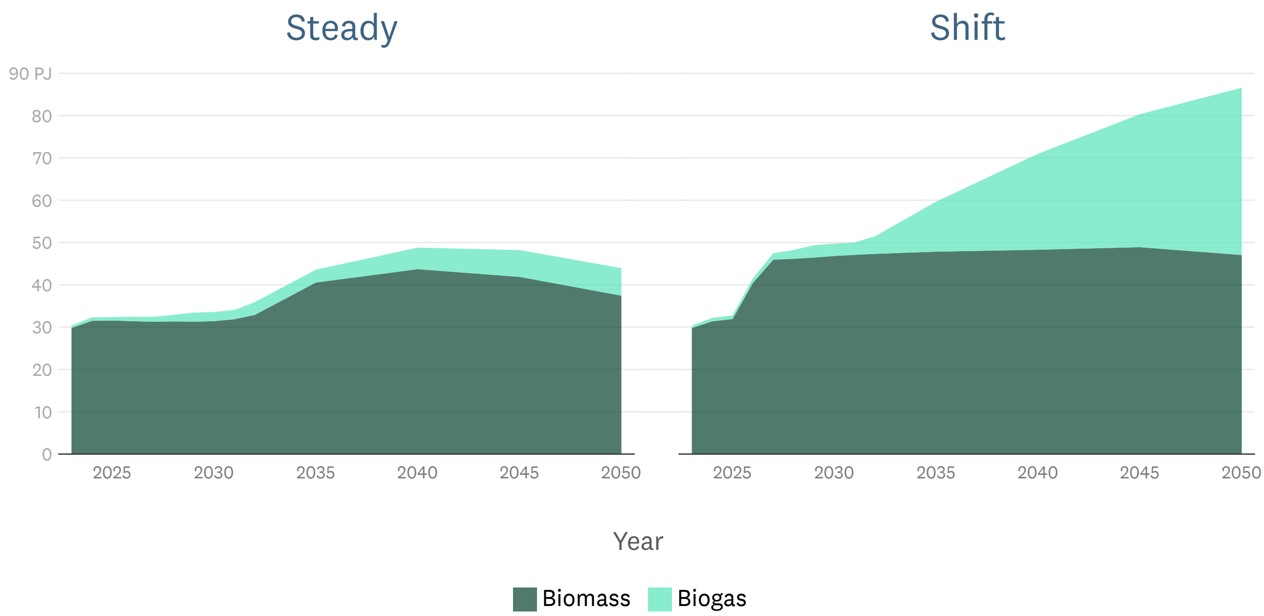
3.6 Biogas and biomass supply

Biomass and biogas feedstock availability assumptions in TIMES-NZ are based on Regional Energy Transition Accelerator (RETA) datasets, Scion's projections for the IEA Bioenergy Technology Collaboration Programme, and Beca–EECA biogas studies. In the Steady scenario, current regulatory and investment conditions are assumed to persist. In the Shift scenario, new and strengthened waste and residue management regulations – for example, those incentivising recovery of organic waste or forestry residues – improve feedstock access and reduce supply costs.

Feedback from biogas sector participants suggests that significant expansion in biogas feedstock supply is unlikely without significant government intervention to mandate the diversion of organics from landfill. In our Shift scenario, we assume such intervention takes place, but we currently have limited information on plausible levels of additional feedstock that this process may make available. EECA is carrying out additional research in this area, so future versions of TIMES-NZ will include more robust data on this topic.

Figure 13 shows biomass and biogas supply results. The availability of additional biogas feedstock in the Shift scenario leads to much higher biogas supply, while there is less variance in potential availability of woody biomass.

Figure 13: Biomass and biogas supply

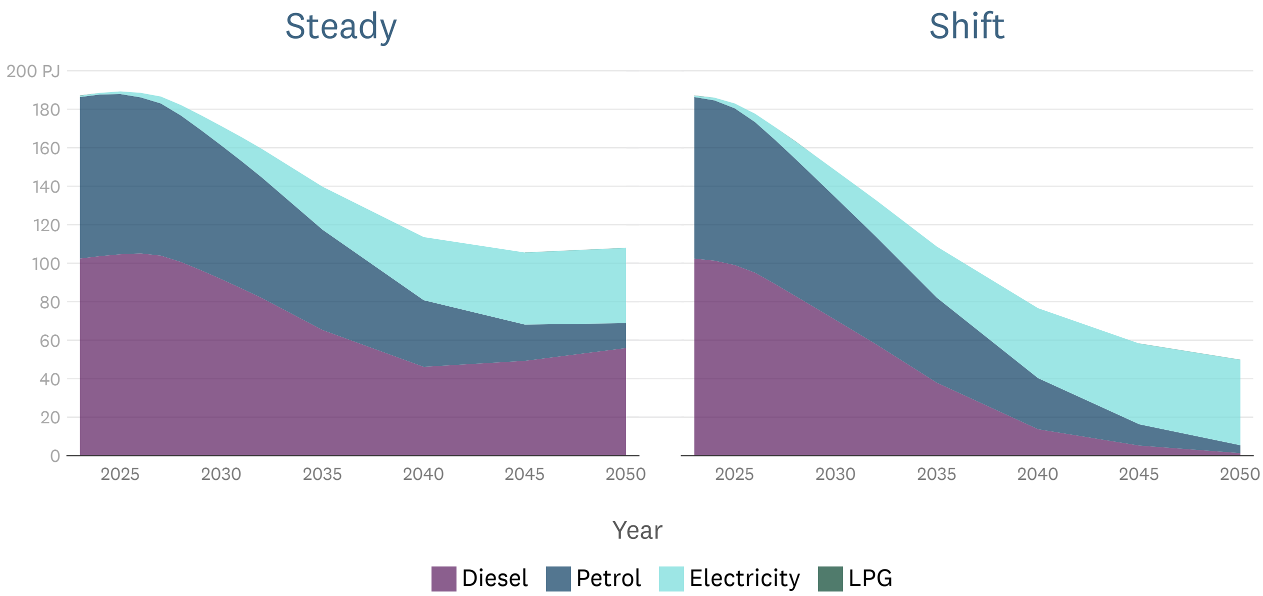


3.7 Road transport demand

This section explores how the road transport fleet adjusts over time in the two scenarios, which have different cost curves for vehicles, and different electricity systems resulting from the model responding to other scenario input variations. The impacts of electrification on the transport fleet could be profound for New Zealand's emissions, fuel sovereignty, and for the demand impact on the electricity grid. Uncertainty in future electric vehicle prices is a key driver of differences between scenarios.

Road transport demand for energy falls in both scenarios, as the greater efficiency of electric vehicles means much lower input energy is required for the equivalent transport requirements. Figure 14 shows how the composition of transport energy demand changes over time, with a notable difference between scenarios being that diesel use remains significant in Steady, but falls to nearly zero in the Shift scenario.

Figure 14: Road transport demand



Note that as the scenarios are intended to show a long-term view of the system, we do not currently implement fuel price impacts driven by the conflict in Iran. Oil price projections are instead based on long term IEA projections, set before the beginning of the conflict.[19]

19 More detail on TIMES-NZ oil product price assumptions can be found on the TIMES-NZ documentation site: https://times-nz-docs.readthedocs.io/en/latest/model_methodology/oil_gas/imported_oil_products.html.

Vehicle utilisation and driving behaviour

People use vehicles at different rates: a light passenger vehicle owner may have long, regular commutes, or only require small and infrequent journeys. When making a vehicle purchase decision, each of these types of drivers faces different trade-offs in terms of capital, maintenance, and fuel costs.

To reflect these trade-offs, TIMES-NZ models different utilisation categories among all road-user groups. This uses data sourced from the Ministry of Transport to categorise the existing utilisation rates of different vehicles as 'high', 'medium', and 'low'. This allows us to capture different uptake rates among different usage groups, as driven by total cost of ownership. For example, high utilisation drivers will have greater incentives to invest in vehicles with higher capital costs but lower fuel costs.

Table 2 shows a summary of usage bands used for selected vehicle types within the model.[20]

Table 2: Annual utilisation bands for selected road transport technologies.

	Low	Medium	High
Light passenger vehicle	3,500	8,500	17,500
Light commercial vehicle	5,500	12,500	23,500
Light Truck	2,000	7,000	19,500
Medium Truck	4,000	12,000	32,000
Heavy Truck	17,500	44,500	74,000

20 Numbers are rounded to the nearest 500 km for ease of reading; precise numbers are used in the model.

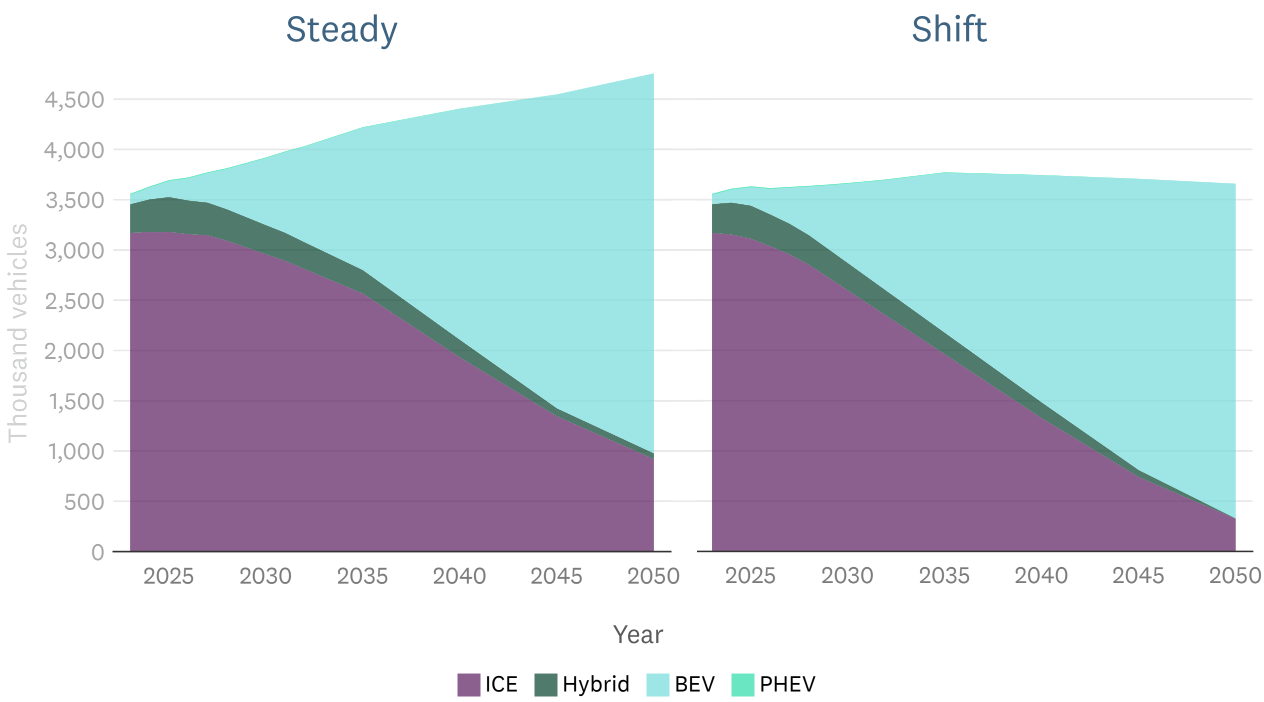
3.7.1 Light passenger vehicles

In both scenarios, the light passenger vehicle segment electrifies relatively quickly, as electric vehicle (EV) costs fall over time. The rate at which technology costs decrease is one of the key scenario uncertainties, and so we assume costs fall faster in the Shift scenario than in Steady. In both cases BEVs become a more attractive option across a greater share of the market due to lower running costs than traditional internal combustion engine (ICE) vehicles.

In Steady, total demand increases over time, as population grows and we assume per capita passenger transport demand follows existing trends. However, in Shift, we assume that per capita demand decreases slightly over time, which could be a result of greater urbanisation, increased use of public transport, or other factors. This roughly counteracts projected population growth, meaning that total passenger transport demand stays flat over the model horizon.

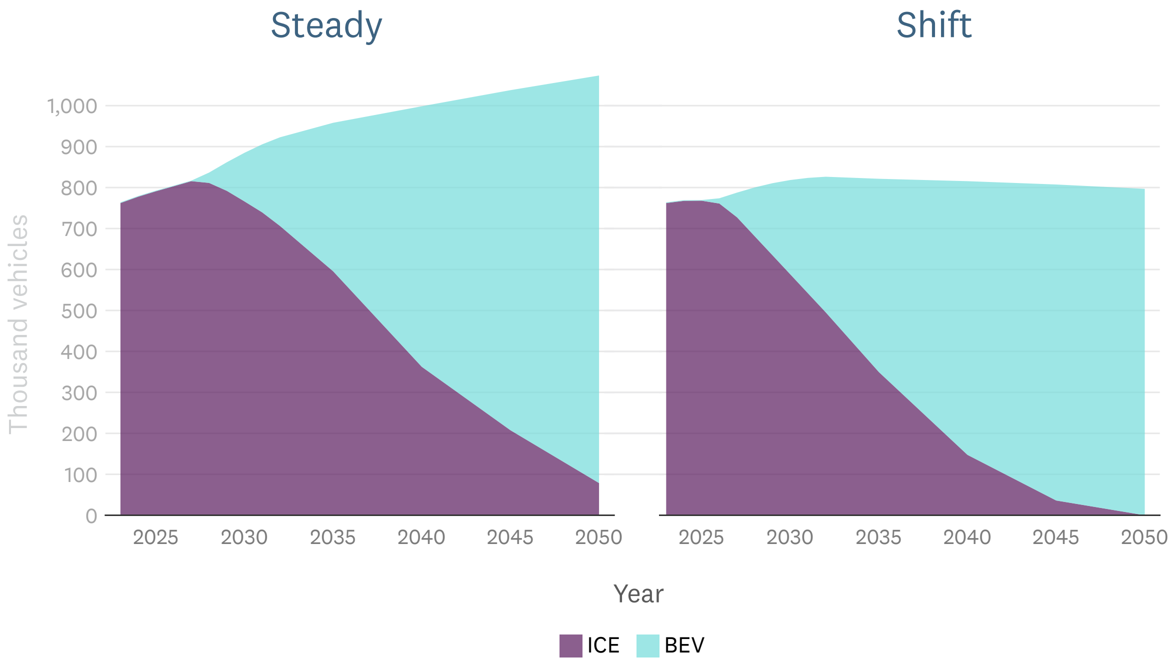
The overall trade-off for electric vehicles is that they are cheaper to run but come with higher up-front costs. While electric vehicles and batteries become cheaper faster in the Shift scenario, the fleet does not fully electrify, as older petrol or diesel vehicles are still used.

Figure 15: Light passenger fleet



3.7.2 Light commercial Vehicles

Figure 16: Light commercial vehicles



Light commercial vehicles include goods vans, utes, and motor caravans with a gross vehicle mass (GVM) of up to 3.5 tonnes.

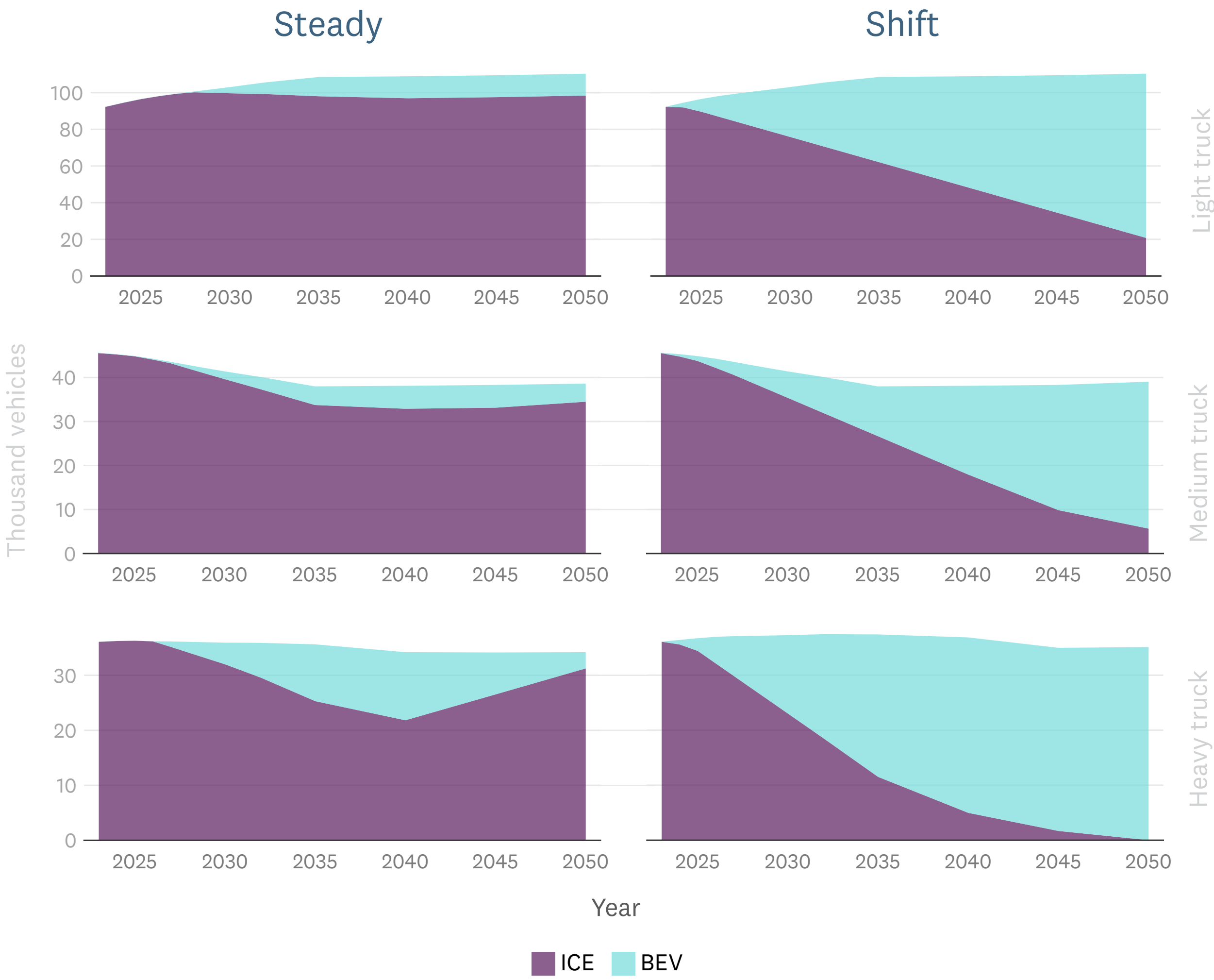
Light commercial vehicles, which include utility vehicles and vans, show similar patterns to light passenger vehicles. The cost curve scenarios for these vehicles do seem to slightly impact the timing at which electrification becomes cost effective, but these impacts appear marginal across our scenarios, and so significant electrification appears to be cost-effective in both scenarios.

While the modelling indicates that widespread electrification is cost-effective across all scenarios, real-world adoption may not follow the least-cost pathway. Vehicle purchasing decisions are influenced by factors beyond total cost of ownership, including capital constraints, charging availability, operational requirements, risk perceptions, and organisational procurement practices. Further work could identify barriers to electrification that are not captured in this modelling.

3.7.3 Trucks

Different rates of truck electrification drive some of the largest overall differences across the two scenarios. We see that in the Steady scenario, electrification across all truck types is limited to a small proportion of the fleet even in the longer term. However, in the Shift scenario, we assume faster cost declines as one of the key scenario characteristics. These declining battery and truck costs allow much greater uptake of electric trucks.

Figure 17: Truck fleet by technology group



The truck electrification results highlight several interesting dynamics at play in New Zealand's freight market. These work together to create very different electrification rates in our scenarios. Declining technology capital costs can have a very large impact on electric truck uptake, which has a large impact on New Zealand's overall emissions profile and electricity grid demand. However, utilisation and efficiency impact uptake in different vehicle classes in different ways.

Electric heavy trucks (over 30 tonnes GVM) are expensive and require large battery packs which decrease the potential load capacity per vehicle. However, their very high utilisation, or distance travelled per year, can make the reduced running costs attractive. As an illustration, and utilising current fuel cost data in the market, for a heavy vehicle travelling 74,000 km per year (high use), annual fuel cost would be approximately $59,000 for a diesel engine versus approximately $23,000 for a BEV.[21] We also note a lower variance in heavy truck utilisation: even low use heavy trucks have higher utilisation than high use light passenger vehicles.

Meanwhile, medium (between 10 and 30 tonnes GVM) and light trucks (below 10 tonnes GVM) are technically easier to electrify due to lighter load and reduced range requirements, but this class has lower utilisation across all usage bands. A high use medium truck has slightly less than half the utilisation of a high use heavy truck, at around 32,000 km per year. Utilising the same fuel costs as for the heavy truck example above, and noting that fuel consumption per km is also lower, annual fuel costs are approximately $21,000 for a diesel engine versus $7,000 for a BEV. For light trucks, the equivalent numbers are 19,500 km per year, $6,000 for diesel, and $2,000 for electric. This illustrates the importance of small capital cost differentials between diesel and BEVs for these segments.

When considering potential system impacts, the largest single individual uncertainty is the future capital cost of electric vehicles, particularly freight vehicles. Reducing the capital cost of heavy electric vehicles, in line with the National Laboratory of the Rockies (NLR)[22] more optimistic scenarios, could have one of the single biggest impacts on the makeup of our freight sector and our national energy emissions. It could also increase New Zealand's fuel resilience, as noted in a 2025 Fuel Security Study for MBIE.[23]

Another driver of different outcomes in the two scenarios is the discount rate assumed. In Shift, business owners and energy users are assigned lower discount rates for renewable or low-emission technologies. This represents greater access to capital, potentially through mechanisms such as discounted green loans from banks, or government loan subsidies. It can also represent a behavioural shift, where consumers may be more inclined to invest in more expensive low-emission technologies despite their short-term costs.

The model shows limited hydrogen uptake in either scenario. Factors at play include the inefficiency associated with electrolysis, the increased costs associated with fuel distribution, and the costs of new vehicles remaining less competitive with electric or combustion vehicles. However, much of the value of hydrogen comes from its ability to be used as storage, allowing for market arbitrage, and the current TIMES-NZ model uses a fairly simple day/night/peak system for representative days, so this may have an effect. Future model versions may increase the time period detail, which could provide more sophisticated and accurate results for arbitrage technologies such as hydrogen and batteries.

21 This example is indicative only, and includes a 10% efficacy penalty for the electric truck, as the weight of the battery reduces possible freight loads. For the purposes of this example, fuel costs are based on the latest available fuel costs from MBIE price data, at 62.82 NZD/GJ for electricity, and 39.74 NZD/GJ for diesel. In TIMES-NZ modelling, parameters such as efficiency, utilisation, operating costs, and battery weight penalty can change between usage groups and over time, and fuel costs can depend on the scenario or other system constraints. These are described more fully in Transport — TIMES-NZ v3.0.6 documentation. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/transport/index.html

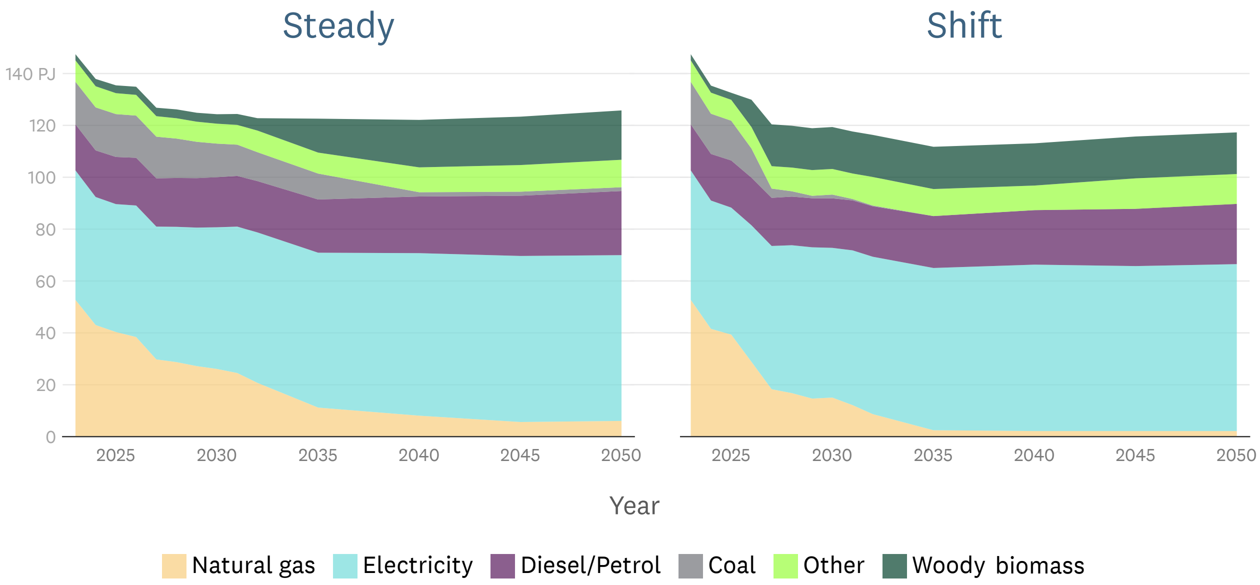
22 Formerly the National Renewable Energy Laboratory (NREL).

23 The Envisory/Castalia 2025 Fuel Security Study concluded that one of the most cost effective strategies for enhancing fuel resilience is "accelerating the transition to zero-emission vehicles" Fuel Security Study - https://www.mbie.govt.nz/assets/fuel-security-study.pdf

3.8 Industrial demand and the gas transition

Total industrial demand falls in both scenarios, driven in large part by falling domestic gas supply. In the specific cases of methanol and urea production, this results in industrial output falling with reduced natural gas availability. However, in others, increased efficiency from alternative fuels can mean that energy consumption falls while output remains steady.

Figure 18: Industrial demand



"Other" includes fuels such as LPG and geothermal heat.

3.8.1 Dairy processing and biomass uptake

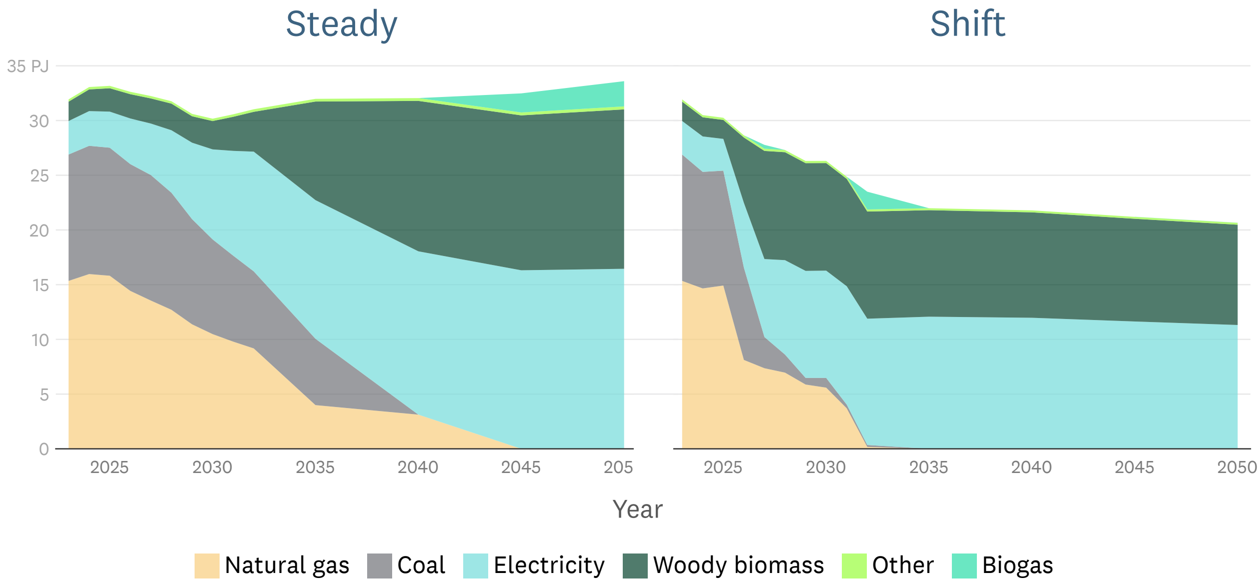
New Zealand's dairy processing sector is a large user of industrial energy, particularly in process heat for milk powder production and pasteurisation. This process heat is currently chiefly driven by natural gas and coal. In both scenarios, this coal and natural gas use falls, partly due to decarbonisation efforts already underway and falling domestic gas supply.

In the Steady scenario, increased milk product demand and reduced alternative energy sources mean that reductions in coal and natural gas use happen more slowly. In Shift, the transition is faster, partly due to dairy product demand reducing slightly over time, meaning less total energy requirements for the sector.

In both scenarios, a small amount of biogas heat, produced via onsite anaerobic digestion, acts as a bridging fuel when electricity or biomass availability is lower. The model finds this an effective solution to increase the useful life of existing natural gas process heat boilers. However, in the longer term, woody biomass or electric heating technologies (such as high temperature heat pumps) form a more cost-effective energy mix for the system.

The dairy sector's biomass demand in the long term, of over 10 PJ annually, consumes a significant share of the biomass available in both scenarios.

Figure 19: Dairy processing demand



"Other" includes fuels such as LPG and geothermal heat

3.8.2 Methanol and urea

Two of New Zealand's largest existing gas users are Methanex's methanol plant and Ballance's Kapuni urea plant.

Following recent announcements regarding the impending closure of the Maui gas field in Taranaki towards the end of 2026, we assume Methanex will close shortly afterwards in both scenarios.

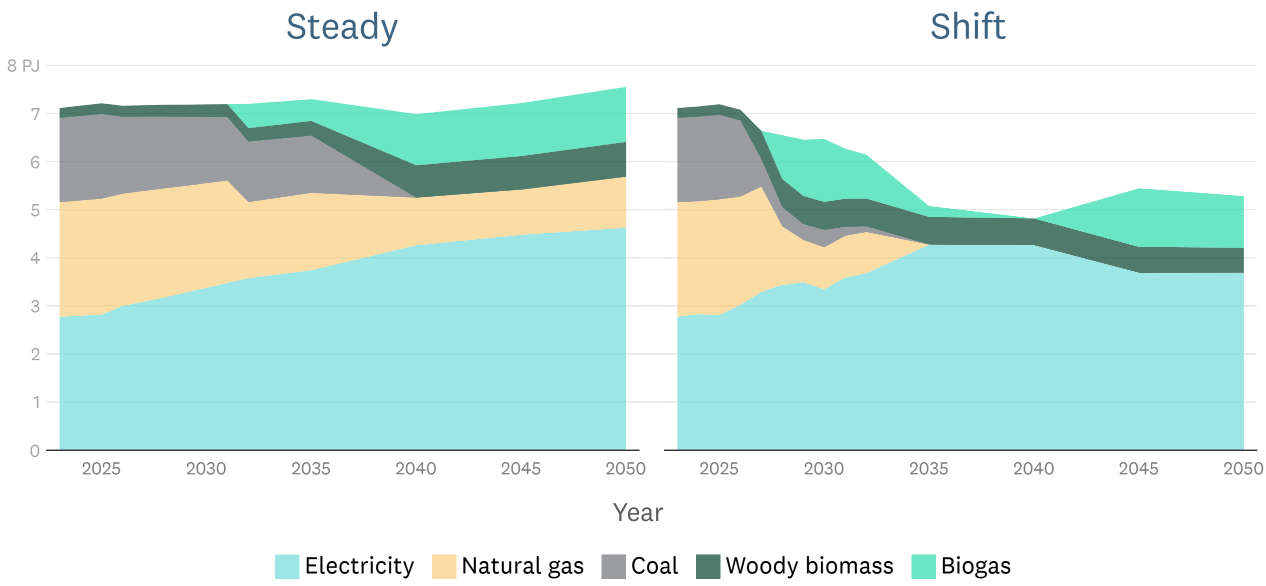
The Ballance urea plant, conversely, is modelled as exiting the market when natural gas prices rise above a specific breakpoint, currently set at $18/GJ in both scenarios. This value does not directly reflect the financial situation at Ballance, but simply allows the urea plant's demand to decrease plausibly based on the natural gas context in the model.[24] Given that the domestic natural gas supply projections are also the same in the two scenarios, and with the cost of LNG above the assumed breakpoint for urea production, there is little difference between the Steady and Shift scenario outcomes, which both show urea production ceasing in 2033.

24 Within TIMES modelling, the internal shadow price of any given commodity is a function of its availability, and the cost of demand falling (through fuel-switching or other behaviour) to free up demand, or the cost of raising production. For TIMES-NZ natural gas modelling, the internal price constraints are based on the limited availability of domestic gas production, meaning that the internal model's shadow price for natural gas rises as supply falls. This means we do not exogenously set the price of gas but rather allow the model to find the market-clearing price where supply meets demand. This market-clearing shadow price is what is used when determining Ballance's activity: it reduces its activity when the internal model price rises above $18/GJ.

3.8.3 Meat processing and heat pumps

The meat processing subsector, collectively, represents nearly 7 PJ of annual demand, mostly used for process heat for rendering. In many cases, temperature requirements are lower than other forms of process heat, which makes much of this sector's energy use suitable for replacing with electric devices, such as high temperature heat pumps. In both scenarios, biogas and woody biomass can provide some supplementary support, which marginally reduces investment costs in additional heat pumps and pressure on the electricity grid.

Figure 20: Meat processing demand

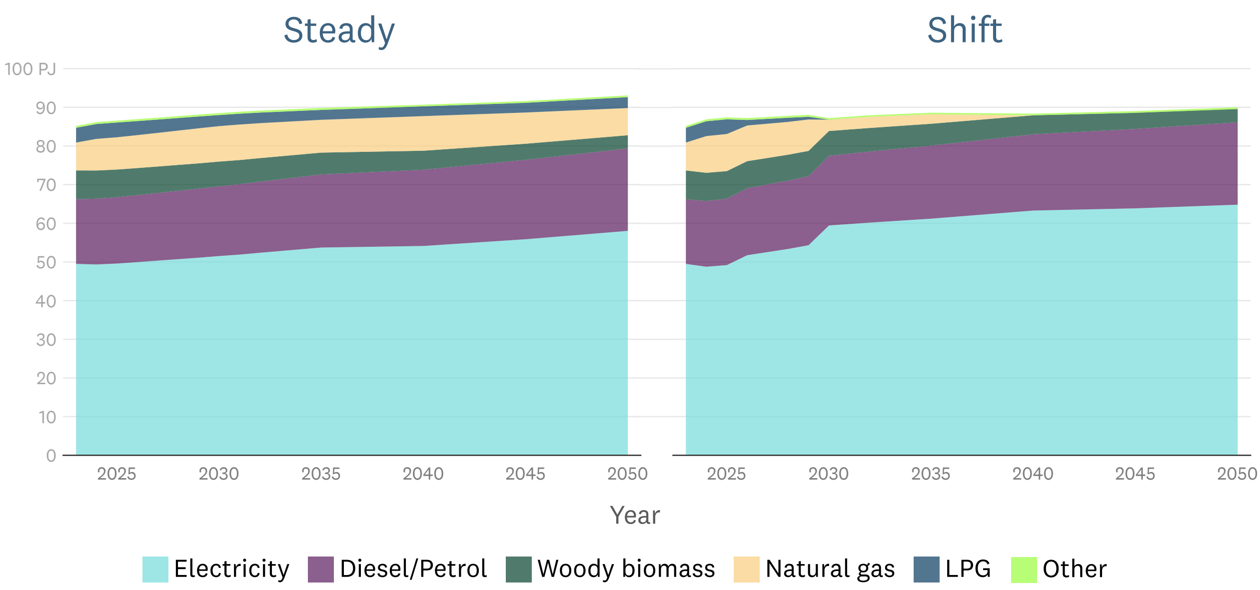


3.9 Residential demand

In both scenarios, residential energy service demand grows at the same rate, indexed to the same population projections. The North and South Islands are also assumed to grow at the same rate, for simplicity.

We assume no changes to heating demand from improved insulation, based on the assumption that efficiency improvements will be used to support improved quality of service (i.e., warmer homes). Residential sector petrol and diesel consumption, which is used almost entirely for recreational boating and is separate to that included in the transport sector, grows in proportion to service demand. Technology costs for devices such as heat pumps or LED lightbulbs are also the same in the two scenarios. However, parameters enabling flexible electricity use, such as ripple control or home batteries, are adjusted between scenarios.

Figure 21: Residential processing demand



"Other" includes fuels such as solar thermal and geothermal heat

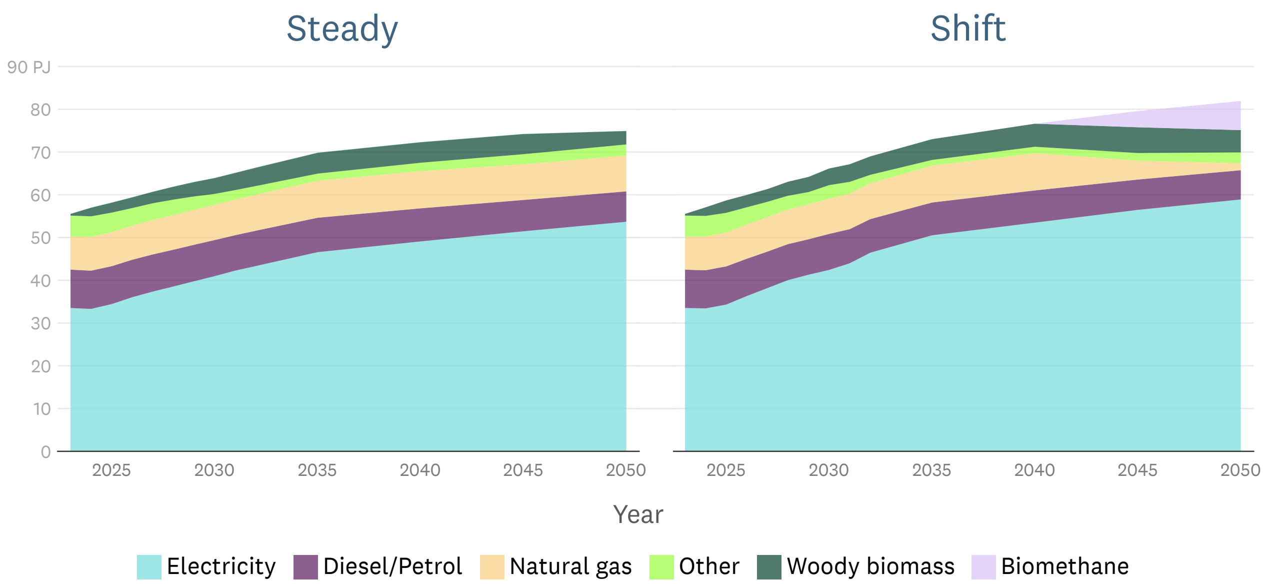
Given the consistent assumptions across scenarios, this means that differences in model results are due to either discount rates, distributed energy resources (such as rooftop solar and batteries), or system-wide effects such as lower electricity costs or more constrained gas supply. In Shift, there is very clearly faster switching off gas onto electric alternatives, as electricity becomes cheaper and more abundant, and homes can replace LPG or natural gas options without placing additional undue strain on the grid's ability to meet peak demand. In Steady, LPG remains a useful fuel for residential space heating, despite its expense, to reduce overall peak electricity load. Natural gas also remains for cooking and heating purposes, based on much reduced domestic output supported by LNG imports. These fuels are expensive, but the model considers them a good option to reduce pressure on the electricity grid's firming capacity, contributing to a more secure energy supply for users.

3.10 Commercial demand

Commercial energy demand, which includes education, healthcare, offices, wholesale and retail trade, data centres, and government demand, has minimal changes to demand assumptions between scenarios. The exception is data centre demand, which is expected to grow more rapidly and become more efficient in the Shift scenario.

Reflecting the relatively similar demand assumptions for this sector, the most obvious difference in fuel use is that Shift sees substitution of natural gas with biomethane, whereas Steady sees relatively constant use of natural gas. In both scenarios, diesel and petrol use is also relatively constant; this is partly due to limited information on the uses of these fuels and should be regarded as approximate.

Figure 22: Commercial processing demand



"Other" includes fuels such as LPG and geothermal heat

4 Demand flexibility and batteries: sensitivity tests

To assess the value of demand flexibility (DF) and battery technologies to the energy system, we have run the model with DF and battery technologies removed from the Steady and Shift scenarios. This uses the TIMES-NZ model in a predictive context: when a single specific change (or small group of changes) is made to a scenario, the outcome can be treated as a forecast within the broader context of that scenario.

We have found that while DF and battery technologies prove valuable to the energy system under both scenarios, they are especially valuable in the Shift scenario, given the higher potential for electrification.

This outcome results from the whole-system perspective of the TIMES-NZ model, where changes to the cost-effectiveness of the electricity system will impact the demand for electricity. For example, a reduction in peak demand driven by one technology might allow other end uses, previously priced out by high peak electricity costs, to electrify further.

The model finds that these technologies can provide between $5.4bn and $20.8bn of value over 2023-2050, depending on the scenario and which technologies are assumed to be available. These values relate to the operation of the entire energy system; not just electricity supply, but all forms of energy supply and use. The model finds that without these flexibility options, electrification beyond a certain point is simply not economically viable, and the efficiency benefits of electric technologies cannot be realised.

These DF and battery sensitivity tests in TIMES-NZ are complementary to previous demand flex modelling work, such as EECA's "The full potential of flexible electricity use in New Zealand".[25] This previous modelling found that DF and battery technologies could reduce national peak demand between 1.7 and 1.9 GW, leading to savings of around $3 billion.[26] Comparing this $3bn estimate with those from the TIMES-NZ scenarios ($5.4bn and $20.8bn) indicates a moderate to large system-wide effect.

25 EECA | The full potential of flexible electricity use in New Zealand (pdf) - https://www.eeca.govt.nz/assets/The-full-potential-of-flexible-electricity-use-in-New-Zealand-Summary-and-insights-report-2026.pdf

26 This utilises Transpower's estimate of $1.5 billion in system cost reduction for each GW of peak demand reduction.

This section details the findings and methods in more detail. For the purposes of this exercise, we perform several sensitivities. Initially, we simply remove all modelled DF and battery technologies from each scenario. Note the existing DF and battery parameters included in each scenario, summarised below in Table 3:

Table 3: Demand Flex scenario components - Steady

Technology		Steady	Shift
Demand flexibility	Ripple control	50% of capacity	50% of capacity
	Residential smart tech	Unavailable	20% of residential hot water and heat pumps might shift load, with associated costs and efficiency losses.
Batteries		Moderate cost declines	Faster cost declines

More detail on the implementation of ripple control, residential smart tech, and batteries can be found on the TIMES-NZ documentation site. For the first stage of the sensitivity, we remove all these options from each scenario to compare new results. Table 4 shows the impacts on total system costs required to meet energy service demand. This sums all appropriate costs, from device maintenance to import costs to carbon costs and everything in between, for the 27 years in the model period, expressed in 2023 NZD.

Table 4: Sensitivity testing system costs

	Steady (NZD bn)	Shift (NZD bn)
Original system costs	1,325.8	1,283.1
Costs without DF options (smart home tech and ripple control)	1,327.1	1,284.8
Costs without batteries	1,328.1	1,287.1
Costs without batteries or DF	1,331.3	1,304.0

Table 5 shows how these system costs are used to distinguish implied values of each technology:

Table 5: Implied demand flex system value.

	Steady (NZD bn)	Shift (NZD bn)
Demand Flex	1.3	1.6
Batteries	2.2	3.9
Additional system value	1.9	15.3
DF + Batteries (total)	**5.4**	**20.8**

The system values of batteries and demand flex technologies when combined are greater than the sum of their parts. They are complementary in the system, rather than substitutes. This leads to the additional system value that the model finds, which is $1.9bn in Steady, and $15.3bn in Shift.

4.1 Analysis of additional value to the Shift scenario

A key finding is that the total value of DF and battery technology is significantly higher in the Shift scenario, when compared to Steady. While it is to be expected that the total value to the energy system would be higher than the roughly $3bn estimated in electricity system-specific modelling, due to the wider scope of system costs, a total of $20.8bn was unexpected.

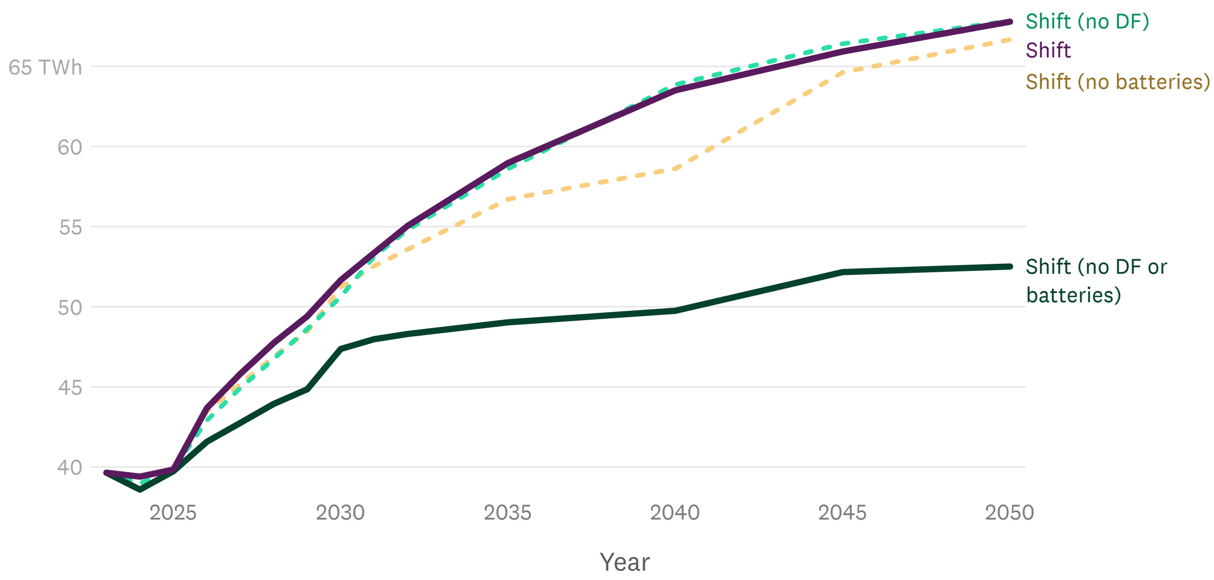
To explore why the Shift scenario's value for flexible electricity use is higher, we modelled two further scenario variations: the Steady scenario but with Shift DF and battery technologies and costs, and the Shift scenario but with Steady DF and battery technologies and costs. This allows us to isolate how much of the additional value is due to Shift's cheaper batteries and more prevalent demand-flex technologies, or Shift's technology value of demand flex. Any additional demand flex value in Shift, over and above this technology value, must be due to flow on impacts to the wider energy system.

Table 6: Demand flex: Shift's technology value

Base scenario	Objective function (NZD bn) under different DF options		Implied additional value of Shift DF and battery (NZD bn)
	Steady DF and battery	Shift DF and battery	
Steady	1,325.8	1,325.3	0.553
Shift	1,283.6	1,283.1	0.470

This technology value is only around 3-4% of the total additional value, which confirms that the true driver is instead based on the context of the system. To further explore this, Figure 23 shows how electricity demand changes in the Shift scenario, based on differing DF options:

Figure 23: Electricity demand sensitivity: Shift technologies



The impacts of DF and batteries on the system are significant. Shift's expanded electricity generation system, with its high uptake of wind and solar energy, needs abundant options for aligning intermittent generation with electricity demand curves. While removing DF technologies has limited impact ($1.6bn), and removing batteries has a moderate impact ($3.9bn), removing both combined means there is simply not enough flex in the system to support significant electrification, leading to the $20.8bn increase in whole system cost.

This drop in stable electricity supply has significant knock-on effects on the rest of the sector. Most importantly, without these combined options, it becomes no longer viable to electrify significant portions of road transport. This loss of efficiency means that the passenger and freight fleets remain mostly driven by internal combustion engines in this scenario, which leads to significant additional system costs from imported diesel and petrol. This alone drives much of the additional cost in this scenario. Recalling that a key component of the Shift scenario was freight electrification, then the value associated with this is largely lost if there is insufficient DF resource available.[27]

27 There is some sensitivity to the wider context: if the cost of electric heavy vehicles never becomes economically feasible, then the additional value unlocked by DF technologies can never be realised. However, if they do, the present analysis shows that significant costs savings can be unlocked if the system is resilient enough to affordably meet the additional electricity demand and enable this efficiency.

Appendix 1: Underlying data and assumptions

TIMES-NZ has been rebuilt for version 3.0, using fully updated energy supply and demand data.[28] The most important of these are summarised below.

Broad assumption/data group	Source
Base year energy demand	Energy End Use Database, Ministry of Transport, MBIE energy balance tables
Energy demand regional shares	EECA internal modelling, RETA database
Costs of demand technologies	EECA research, using publicly available data wherever possible.
Costs of electricity generation and battery storage	MBIE, NLR (NREL), and CSIRO scenarios
Costs of electricity transmission and distribution infrastructure	Transpower, EDB reports
Biomass, biogas, and natural gas supply	Scion, MBIE, EECA
Scenario assumptions	BusinessNZ Energy Council working groups

This list is not exhaustive. The full and complete documentation of underlying data and assumptions can be found on the documentation site.[29]

28 All data and insights in this report are based on version 3.0.8 of the model. This is referred to throughout as 3.0.
29 TIMES-NZ documentation - https://times-nz-docs.readthedocs.io/en/latest/

Appendix 2: Scenario parameters

A2.1 Economic structure and energy demand

Energy demand projections in TIMES-NZ are specifically for energy service demand. This is the useful service provided by the energy, such as kilometres travelled or water heating. For example, the model would not use projections of natural gas demand. It would instead use projections of space heating demand, then find the least-cost way of meeting this using available technologies and input fuels. One exception to this rule is for ‘new industries’ as discussed below.

Industrial

The table below reflects the current assumptions at a summary level.

Subsector	Steady	Shift	Notes
Aluminium	0%	Same as Steady	Assume Tiwai open across full model horizon.
Construction	1.9% per year	Same as Steady	Based on recent EEUD demand trends.
Dairy	Tracks ERP2 dairy cattle projections (high)	Tracks ERP2 dairy cattle projection index (low)	Steady assumption gives dairy herd growth of 30% to 5.92m by 2050. Shift gives fall of 19% to 3.7m by 2050.
Iron & Steel	EAF in 2026[30]	Second EAF from 2036	Steel demand assumed flat, but the demand structure is modified by EAF build timing assumptions
Meat	0.7% per year	-0.7% per year	Steady follows recent EEUD demand trends; Shift applies an alternative assumption.

30 We do not currently model the recently consented National Green Steel Limited EAF.

Subsector	Steady	Shift	Notes
Methanol	Closed from 2027	Same as Steady	Closure assumption based on Maui closure timing.
Non-Metallic Mineral Product Manufacturing	0%	-1.0% per year	Steady follows recent EEUD demand trends; Shift applies an alternative assumption.
Mining	1.2% per year	0%	Steady follows recent EEUD demand trends; Shift applies an alternative assumption.
Other Industry	-0.1% per year	Same as Steady	Based on EEUD trends.
Food and Beverage	-1.7% per year	1.7% per year	Steady follows recent EEUD demand trends; Shift applies an alternative assumption.
Chemicals (excl. Urea and Methanol)	0%	Same as Steady	Flat demand index
Urea	Flat demand index	Same as Steady	The Ballance Urea plant can endogenously shrink demand if costs rise above 18 NZD/GJ.
Wood Products	-1.8% per year	1.8% per year	Steady follows recent EEUD demand trends; Shift applies an alternative assumption.
Pulp and Paper	-2.0% per year	Same as Steady	Based on international trends.
New industries	No new industries	50 GWh of additional electricity demand growth per year from 2026	Generic additional demand intended to represent growth in other areas.

Residential

Residential energy service demand is projected from median Stats NZ national population projections in both scenarios. The main assumptions are that regional and joined/detached dwelling shares remain constant, residents per dwelling remain constant, and other non-technology parameters such as insulation quality or consumer behaviour do not change over time.

This means that any differences in modelled residential energy use between scenarios are driven by other factors, such as technology costs or discount rates, rather than adjustments specific to the sector.

Commercial

Commercial demand growth assumptions are split by subsector and listed in the table below.

Subsector	Steady	Shift
Data centres	NZTech 2025 Baseline pathway	NZTech Faster Uptake pathway
Education	Population growth index	Same as Steady
Healthcare	Population growth index	Same as Steady
Warehouses, Supermarkets, Retail (WSR)	GDP growth index	Same as Steady
Office Blocks / Professional Services	GDP growth index	Same as Steady
Other	GDP growth index	Same as Steady

Agriculture, forestry and fishing

Agriculture, forestry, and fishing demand projections are based on the government's ERP2 activity series[31], rather than simple constant growth rates. Most Steady sectors use ERP2 Baseline, while Shift generally uses ERP2 Baseline low. Dairy Cattle Farming is an exception, using Baseline high in Steady.

When comparing across scenarios, some sub-sectors within agriculture, forestry and fishing show opposite trends to their related industrial sector. For example, forestry and logging has higher activity in Steady relative to Shift, but wood products has lower activity in Steady relative to Shift. This is consistent with the overall scenario narratives, where Steady sees relatively higher activity in the primary sector, but relatively lower activity in more advanced manufacturing.

31 MFE | New Zealand's second emissions reduction plan 2026-30: Technical Annex (https://environment.govt.nz/publications/second-emissions-reduction-plan-technical-annex/) and Detailed Results (.xlsx) - https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fenvironment.govt.nz%2Fassets%2Fpublications%2Fclimate-change%2FERP2%2FDetailed-results-for-ERP2-projection-scenarios.xlsx&wdOrigin=BROWSELINK

Subsector	Steady	Shift
Dairy Cattle Farming	Baseline high – Total dairy cattle (ERP2)	Baseline low – Total dairy cattle (ERP2)
Livestock Farming	Baseline – Sheep and beef ‘stock units’	Baseline low – Sheep and beef ‘stock units’
Horticulture (Outdoor)	Baseline – Horticulture	Baseline low – Horticulture
Indoor Cropping	Baseline – Horticulture	Baseline low – Horticulture
Forestry and Logging	Baseline – Forestry (million m3) – Harvested timber (TRV)	Baseline low – Forestry (million m3) – Harvested timber (TRV)
Other Agriculture	Baseline – Other agriculture – Total	Baseline low – Other agriculture – Total
Fishing, Hunting and Trapping	Constant index = 1	Constant index = 1

A2.2 Technology costs

In the Shift scenario, we assume that improved global free trade, cooperation, and technological advancement increase the rate at which costs fall for various new technologies

Parameter	Steady	Shift
Generation technology (offshore/onshore wind, solar) and electric vehicle costs	Generation technology and BEV/Hybrid vehicle costs follow expected trends (Using NLR (NREL) Moderate scenario)	Generation technology and electric vehicle costs reduce faster (Using NLR (NREL) Advanced scenario)
Utility-scale and distributed battery technology	Costs follow expected trends, following the CSRIO Current Policy scenario	Battery costs reduce faster, following the CSIRO NZE by 2050 scenario
Process heat demand technologies	Existing process heat technology costs remain constant in real terms. New process heat technology costs reduce.	Same as Steady

A2.3 Climate policy and societal trends

Parameter	Steady	Shift
Carbon price	Reaches $52/tonne by 2035 then stabilises.[32]	Reaches $260/tonne by 2050, matching the Climate Change Commission's updated demonstration path.[33]
Consenting environment for electricity generation projects	Some community resistance to new generation. The electricity generation pipeline is slightly constrained, using the EDGS Reference scenario.[34]	No community resistance to new generation. More plants made available to the pipeline, using the additional plants from the EDGS Innovation scenario.
Travel mode shifting	Standard VKT demand projections (using MoT projections).	Passenger VKT per capita decreases by 1% annually. This leads to roughly flat passenger VKT demand over time.
Residential demand flexibility uptake	Some uptake of demand flex technologies, such as heat pump and hot water controllers.	Greater uptake rate of demand flex technologies.
Low Emission Heavy Vehicle Fund	Ends in 2028	Continues to 2032
Discount rate: Public sector[35]	8%	2%
Discount rate: Businesses[36]	10%	8% default rate and 5% for green investments. This reflects a longer-term view being taken across the economy, and a focus of global finance on green investments.
Discount rate: Households[37]	As per businesses	As per businesses

32 MFE | ERP2 Detailed results (https://environment.govt.nz/assets/publications/climate-change/ERP2/Detailed-results-for-ERP2-projection-scenarios.xlsx)

33 Climate Change Commission | Updated demonstration path and current policy reference settings (https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.climatecommission.govt.nz%2Fassets%2FAdvice-to-govt-docs%2FERP2%2Fdraft-erp2%2Fsupporting-documents%2FERP2-supporting-spreadsheet-Updated-demonstration-path-and-CPR-2022.xlsx)

34 EDGS 2024 generation stacks available at: Electricity Demand and Generation Scenarios (https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-modelling/electricity-demand-and-generation-scenarios)

35 The 8% and 2% rates are taken from Treasury's public sector discount rates (https://www.treasury.govt.nz/information-and-services/public-sector-leadership/guidance/reporting-financial/discount-rates). For ease of implementation in TIMES-NZ, these are applied to schools and hospitals only. This excludes defence (which sits within 'other'), other smaller categories, and the public sector vehicle fleet.

36 Private firm discount rates of 10% and 8% are representative of weighted average cost of capital (WACC) for different companies. See for example PWC's Cost of Capital Report 22 (https://www.pwc.co.nz/pdfs/2022/cost-of-capital-report-2022.pdf). The 5% rate is based on an assumed discounted rate for green finance (in the Shift scenario only).

37 We propose to use the same discount rates for businesses and households. This is contrary to the evidence that consumer decision making is generally based on higher discount rates. For example, the US Energy Information Administration's discount rate use for representing residential consumer behaviour is 20%. See: Residential Demand Module of the National Energy Modeling System: Model Documentation 2025 (https://www.eia.gov/outlooks/aeo/nems/documentation/residential/pdf/RDM_AEO2025.pdf). On the other hand, many consumers do have access to lower cost finance through mortgages and green loans (where the rate is lower than that for businesses). Our assumption of equivalent discount rates therefore implies a slightly higher risk premium being applied by households, relative to businesses, but not the full extent of 'hyperbolic discounting'.

A2.4 The role of gas

We assume that indigenous gas supply follows the latest MBIE 2P production profiles, with Maui assumed to close at the end of 2026. We also assume that investment uncertainty means that there is no successful exploration of new fields in either scenario.

In both scenarios, the production price of natural gas remains the same, at $9.30/GJ. However, the model's internal shadow price of gas will rise above this price as demand outstrips supply.

In the Steady scenario, we assume an LNG terminal is operational in 2027, with the CAPEX and ongoing OPEX treated as a sunk cost (i.e. these costs apply always). However, the model will only utilise LNG if it is the least-cost option for the energy system.

In the Shift scenario, we instead assume that investment is focused on sustainable alternatives, such as biomass, biogas, or hydrogen, and LNG is not an option.

Parameter	Steady	Shift
Proven plus probable reserves	Follows availability and deliverability of the latest MBIE 2P production profiles.	Same as Steady
LNG supply	LNG terminal operational in 2027.	LNG not available in Shift scenario.
Biogas supply	Base bioenergy supply assumptions. Municipal organic waste fixed at 5.035 PJ/year and animal manure fixed at 7.56 PJ/year; additional biogas potential remains limited by current recovery settings.	Higher bioenergy supply assumptions. Municipal organic waste and animal manure supply[38] each scale significantly from 2026 onward, assuming the market allows for much greater collection rates.
Biomass supply	Woody residues, agricultural residues, and municipal wood waste use Scion regional biomass projections[39] scaled with the lower recoverability factor.	The same feedstocks use the higher recoverability factor, increasing accessible biomass supply from 2026 onward.
Hydrogen supply[40]	Hydrogen is produced only via electrolysis, using Proton Exchange Membrane (PEM) or alkaline methods. Projections for future costs use the GenCost[41] model, and specifically the "Current Policies" scenario.	As steady, but future cost projections follow the "Post 2050 net zero" scenario.

38 We assume that any change to regulations enabling greater manure collection rates for biogas will mitigate potential stock reductions in this scenario.

39 IEA Bioenergy | Residual biomass fuel projections for New Zealand; 2024. Peter Hall, Scion. https://www.ieabioenergy.com/wp-content/uploads/2024/11/NZ-Woody-Biomass-Residues-and-Resources-2024.pdf

40 See more detail on hydrogen modelling in TIMES-NZ documentation: hydrogen. https://times-nz-docs.readthedocs.io/en/latest/model_methodology/hydrogen/index.html

41 CSIRO | GenCost 2024-25 - Consultation draft, pg. 67) https://www.csiro.au/-/media/Energy/GenCost/GenCost2024-25ConsultDraft_20241205.pdf

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