TRANSPOWER

A future grid blueprint for Aotearoa

Consultation 3:

Future Direction – Our Energy Scenarios

March 2026

Te Kanapu
Future Grid Blueprint

Overview

This is the third in a series of consultations we are running, to support us in gathering information and feedback on the future of Aotearoa New Zealand and its energy system.

In this consultation we present our final scenarios, revised following stakeholder feedback received in Consultation 2: Potential Scenarios; the generation mix that could appear in each scenario assuming an unconstrained grid; and the assumptions we have used in our modelling.

The aim of this consultation is to firm up each of our scenarios, the role of electricity, the generation mix and the key assumptions we have made.

We welcome your feedback on this work as we begin to model our draft future grid blueprint.

Consultation closes at 5pm, Monday 30 March, 2026.

We are only asking three questions in this consultation:

1. Regarding our scenarios, do you have any further observations you wish to raise?
2. Regarding our assumptions, do you have any observations or feedback you wish to raise?
3. What sort of information would you like to receive from us over the coming months as we develop our draft future grid blueprint, and how would you like to receive that information?

At this stage in our work, we are seeking broad feedback on the information presented here. Regardless, you are welcome to raise other issues you believe might be relevant.

You can:

- **Complete this survey form here**, or
- Provide your feedback directly by emailing **feedback@transpower.co.nz**

Everyone is welcome

We're interested in a wide range of views on the future of Aotearoa New Zealand, how we might grow to realise this future, and the role that electricity will play.

You don't need to be an energy expert to provide valuable insights.

Publishing submissions

We may publish a summary of submissions on **www.transpower.co.nz/our-work/te-kanapu**

Transparency is important in this process. If there is any aspect of your submission that is confidential, please clearly mark the sections you consider confidential and indicate why.

Contact us

If you want to get in contact directly, email **feedback@transpower.co.nz**

For more information

Visit the Te Kanapu section on the Transpower website to read more. There you will find the background to our work, previous and current consultations and additional data and analysis that has been used in our work to date.

www.transpower.co.nz/our-work/te-kanapu

Introduction: Shaping our energy future together

Transpower is a state-owned enterprise. We build, maintain and run the country's national electricity grid; the infrastructure that transports electricity from where it is generated to where it is used. We also operate the electricity market system, but we don't own, generate or sell electricity.

Through our Te Kanapu initiative, we are building a future grid blueprint for Aotearoa New Zealand to guide investments in the grid up to and beyond 2050, supporting the country's future economic growth and net-zero aspirations.

We expect that in 2050, the way our nation produces and consumes energy and electricity will be different from today and that change will play out differently in different regions. While the potential for change is vast, no one individual can possibly know, or predict, exactly what 2050 will hold. This is why we need knowledge and insights from others.

When complete, Transpower's future grid blueprint will make the case for what investments are needed to meet future demand and unlock growth; and it will help both Transpower and the industry plan across a longer time frame.

The blueprint will contain future scenarios and development opportunities that are common across these scenarios, establishing what could be our next steps, 'low regrets' investments for the 2030s; options that will deliver a resilient and reliable, optimal future grid for everyone at the lowest overall system cost while retaining the flexibility needed to meet future needs despite current uncertainties.

Te Kanapu means both 'lightning' and 'bright', so it speaks to both the electrification and illumination of our country, and Transpower's goals for a bright, energised future.

Developing a future grid blueprint

There are four main parts to developing the future grid blueprint:

1. finding out as much as we can about the future economy, energy supply and use, technology advances and megatrends, before using that information to develop potential future scenarios,
2. developing electricity forecasts for each of those scenarios and the corresponding generation needs,
3. analysing and identifying what the grid needs to look like by 2050 under each of these scenarios, by identifying the priorities that are common across them, and then,
4. confirming any near-term grid upgrades needed in the 2030s to deliver on these common priorities.

The approach we are taking is collaborative. Since the start of 2025, we've been meeting with many people to hear their thoughts on Aotearoa New Zealand 2050 and how Transpower, and the electricity system, will need to respond to meet the needs of the future. These conversations are ongoing.

We are also seeking feedback through a series of consultations.

- **Consultation 1: Imagining Aotearoa in 2050** sought views on our economy in 2050.
- **Consultation 1: Imaging Aotearoa in 2050. Summary of survey responses** outlines what we heard during that consultation. This information was used to support the development of our potential future scenarios.
- In **Consultation 2: Potential scenarios**, we sought your views and feedback on these potential scenarios.
- **Consultation 2: Potential scenarios. Summary of submissions** outlines what we heard during that consultation and our response to this.
- We have also released our **Te Kanapu technical approach suite of documents** describing the methodology we are using for building the future grid blueprint.

Now, in this document, *Consultation 3: Future Direction - Our Energy Scenarios*, we present:

- our final scenarios and demand profiles, revised following Consultation 2: Potential Scenarios;
- the generation mix for each scenario that is resource adequate (can reliably meet total annual, and peak, demand), and
- further background information on the generation and demand assumptions we have used in our modelling.

It is important to note that the generation mix presented for each scenario has been modelled in the context of an unconstrained grid. This is a first step in modelling the generation mix. As we optimise the benefits of adding grid capacity to enable the least cost generation, the generation mix will change.

In addition, the data we present should be considered indicative, rather than final. It is the nature of this work that inputs are continually changing, impacting our data. Please keep this in mind as you consider our work. We will share material changes when they occur, and our updated findings will be published in the draft future grid blueprint.

Completing and publishing the future grid blueprint

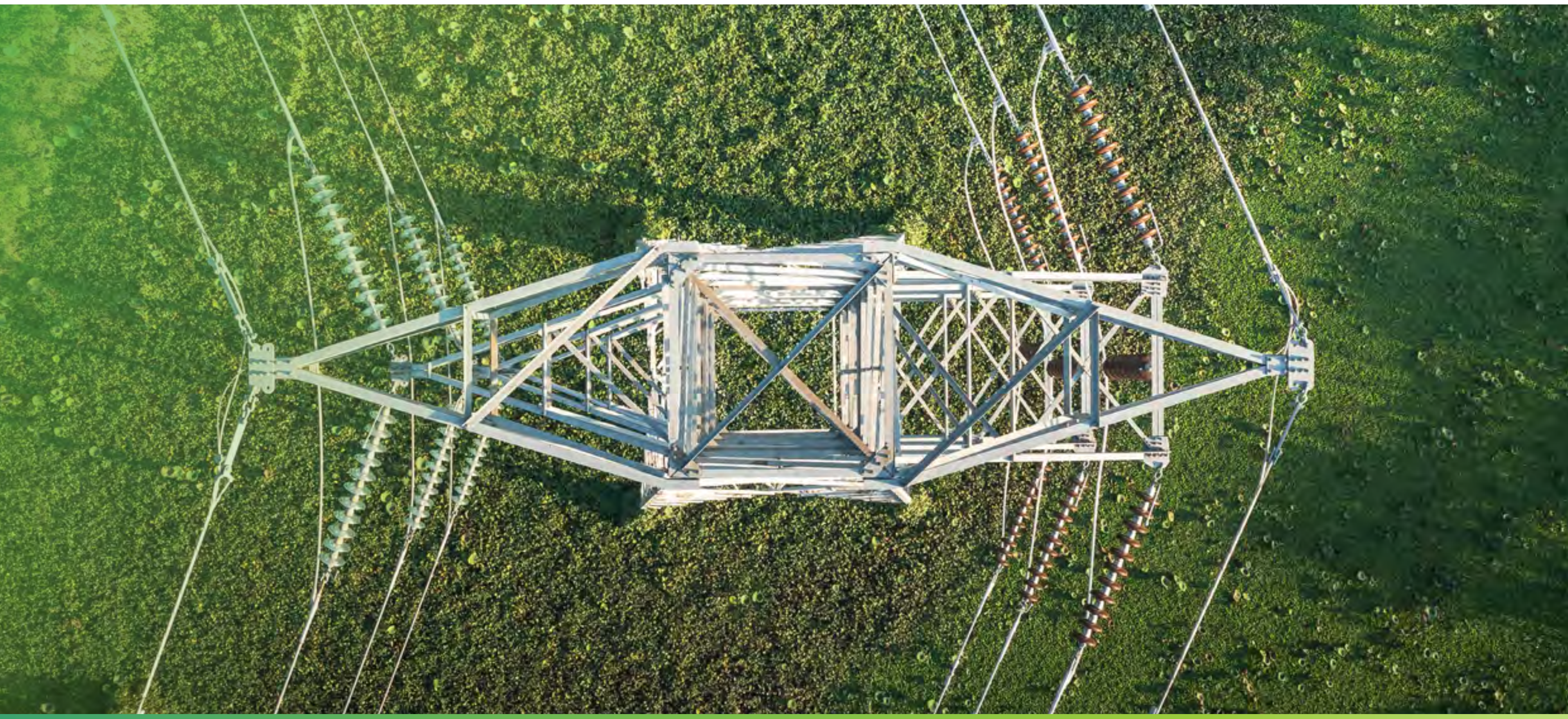
Our intention is to release a draft future grid blueprint later this year for feedback before subsequently releasing the first future grid blueprint, outlining the opportunities that exist for investment in, and development of, the national electricity grid through to 2050 and beyond. Our focus is on identifying the major, low regrets grid investments we can make in the 2030s, that are valid across most scenarios.

Given the dynamic sector environment both nationally and internationally, wherever possible, we want to capture any shifts in the key inputs we are using; we also anticipate our assumptions could change during this process. Our plan is to publish regular updates on how our modelling is progressing and to highlight where changes have occurred.

Your feedback is always welcome.

Our draft future grid blueprint will present the network development plan drawn from our analysis of our scenarios. This will enable us to model the opportunities that present the lowest total system cost for ensuring a reliable and resilient, optimal future grid for everyone.

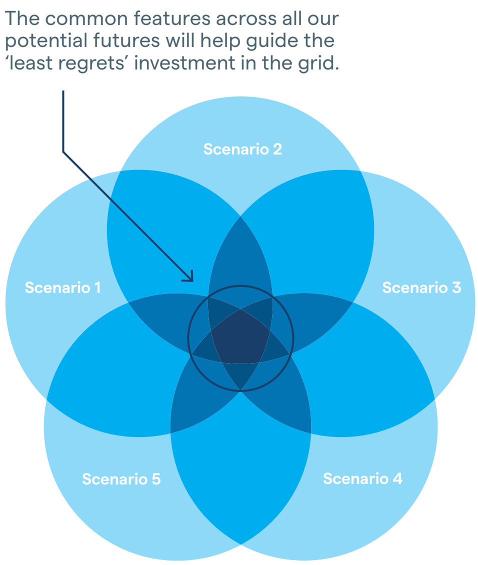
Our first future grid blueprint will not be our last. We will continue to review and revise this work as we gather feedback and will update the blueprint regularly to ensure it remains current.



Future scenarios

To produce the future grid blueprint, we need to understand the different possible futures that lie ahead out to 2050 and beyond. Scenarios provide a way to do this by examining future trends. They are not forecasts; they are plausible, coherent stories about the future, used to test plans against a wide range of uncertainties.

By developing a suite of potential future scenarios, we can explore the electricity generation and demand assumptions that come with them. Then we use extensive power system and market modelling (our **Te Kanapu technical approach**) to understand what we need to do, to enable these scenarios.



The country's energy future is marked by significant uncertainty due to a complex interplay of factors such as technological advancements and the pace of adoption; evolving policy landscapes; shifting consumer behaviours, and global economic trends.

As a result, our scenario planning must remain flexible and responsive to change, without losing sight of the two key assumptions we are working with, which are: that in 2050, Aotearoa New Zealand:

1. remains committed to achieving net-zero carbon emissions, and
2. has a growing and thriving economy.

In the background section to this document and the companion **Future Direction - Data Book**, you can explore a wide range of assumptions and corresponding data that we have used to create our scenarios and the unconstrained generation mix for each.

Presenting our revised scenarios

In **Consultation 2: Potential scenarios** we outlined five potential future scenarios. Your feedback on these, and how we have incorporated that feedback, is detailed in our **Consultation 2: Potential scenarios. Summary of submissions**.

Most critically, feedback we received was that our electricity demand growth projections were overly ambitious. As a result, key changes we have made are:

- a reduction in the potential demand growth in sustainable aviation fuels, both domestic and international,
- lower forecast uptake of electric vehicles (EVs), and
- reduced demand growth from data centres.

In the next section we dive deeper into our revised scenarios and for each, provide data on:

- the energy mix,
- a breakdown of electricity demand,
- the emissions profile,
- the generation mix, and
- the capacity mix showing peak demand.

These figures incorporate both stakeholder feedback and updated data identified after Consultation 2 was issued.

We also present scenarios side-by-side for key comparisons of:

- annual, peak and daily demand,
- regional breakdowns, and
- wholesale market outcomes.

The generation profiles, build costs and related information shown in the sections that follow, are based on an unconstrained grid. As we optimise the transmission build required to meet the demand in each scenario to achieve the lowest overall system cost, this mix may change. For instance, our modelling may determine that in some cases, building more distributed solar and batteries is more optimal than providing additional grid capacity to unlock further grid connected generation. The updated generation profiles and related information will be shared when we release the draft grid blueprint.

Scenario one: Patchwork Nation

In a world of sluggish growth and unclear direction, Aotearoa makes do with what it has. Communities, businesses, and industries rely on creativity, adaptability, and practicality to keep the economy moving.

Global context

The global landscape is one of fragmentation and weak climate action, with warming tracking towards 2.7°C by 2100. This results in more frequent and severe weather events, causing global economic disruption.

Local context

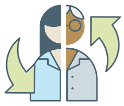
Successive governments struggle to establish a clear, long-term strategic direction and take a hands-off approach. The Emissions Trading Scheme (ETS) drives decarbonisation without picking winners or providing government subsidies for emerging technologies. A lack of direction leads to a disorderly transition and unclear roles for gas, biofuels, electricity, and other sustainable fuels within the economy.

The economy

A slow but persistent shift towards a service-based model, accompanied by gradual deindustrialisation. Without a cohesive policy to support their transition, legacy industries decline and new large-scale industries struggle to find a foothold here. With limited climate action, the country's clean, green image suffers with the nation becoming less attractive as a destination to live, work, and visit.

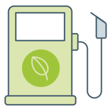
Through a focus on kaitiakitanga, reciprocity and intergenerational wellbeing, the Māori economy demonstrates strong regional resilience despite slow national growth. Iwi and Māori-led enterprises continue to generate growth in horticulture, fisheries, and primary production, alongside diversification into energy and professional services.

Total annual GDP[1] rises from $364B to $546B by 2050 (in real NZD). GDP per capita rises from $68k to $82k. Deindustrialisation and the shift towards a service-based model drops the economy's useful energy intensity from 0.88 MJ/$ to 0.65 MJ/$.



Social and demographic shifts

Low economic growth and a deteriorating environmental image offers little incentive for skilled workers to stay or for new migrants to arrive, leading to an aging population. Urban centres continue to grow at the expense of regional economies. The population rises from 5.3 million today to 6.6 million by 2050.[2]



Electrification and energy choices

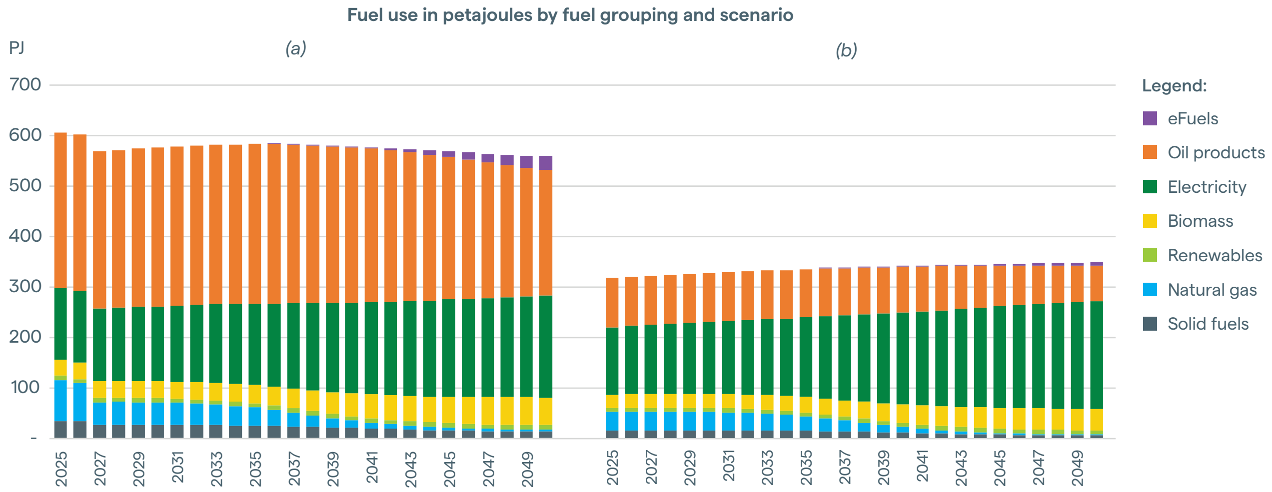
Aotearoa is caught in a holding pattern. Due to high costs and a weak economy, investment in new infrastructure is sluggish. The energy system relies heavily on 'life extension', squeezing every last drop out of aging assets.

1 Source: Future Grid Scenario Modelling: Visions of the New Zealand Economy to 2050.pdf

2 Aligned to Statistics New Zealand data

Figure 1 shows the total energy mix measured by (a) *total consumed energy*[3] and (b) *useful energy*[4]. Useful energy slowly rises from 322 PJ today to 353 PJ in 2050, while consumed energy slowly declines, reflecting the higher efficiency of electric engines, heat pumps, and other new technologies. The energy mix moves slowly through the transition. Oil, gas, and coal, which make up 70% of the current total energy mix, fall to 48% by 2050 (measured by consumed energy). Electricity rises from 23% to 36%; and biomass from 5% to 10%. Total useful energy per capita drops from 60 PJ per million people to 53 PJ per million people in 2050. In 2050, 50% of our energy requirement is imported compared with 52% today.

Figure 1: Total energy mix split by fuel, measured by a) consumed energy and b) useful energy – Patchwork Nation



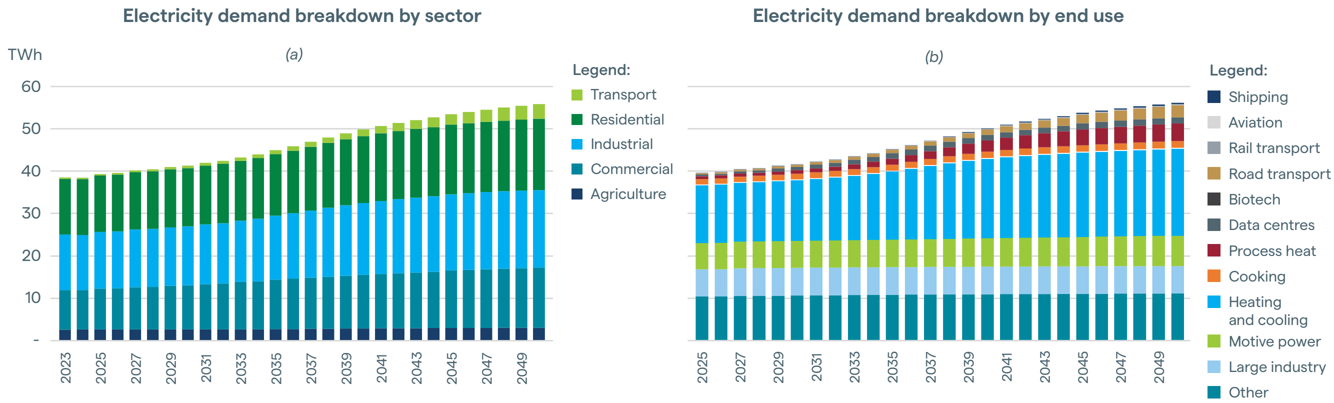
3 To compare our total consumed energy with the primary energy supply numbers reported by MBIE (Energy in New Zealand 2025), the losses in electricity production, particularly in geothermal generation, need to be accounted for.

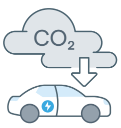
4 Useful energy is the portion of consumed energy that performs the intended work. Consumed energy includes both the useful part and the losses that, due to inefficiency, occur during conversion.

Figure 2 shows how demand for electricity shifts materially between (a) *sectors* and (b) *end use*. Transport sector demand grows from 0.4 TWh to 3.5 TWh (driven by EVs); residential demand grows from 13.4 TWh to 17.0 TWh (driven primarily by the electrification of space and water heating); commercial grows from 9.6 TWh to 14.3 TWh (a combination of data centres and heating); industrial grows from 13.5 TWh to 18.5 TWh (heating and motive power), and the agricultural sector stays reasonably flat at 3 TWh.

Electrification of the vehicle fleet moves slowly due to a lack of incentives, affordability challenges, and a slow global EV market: EVs make up 28% of light passenger vehicles (LPV) in 2050.

Figure 2: Annual electricity demand split by a) sector and b) end use – Patchwork Nation



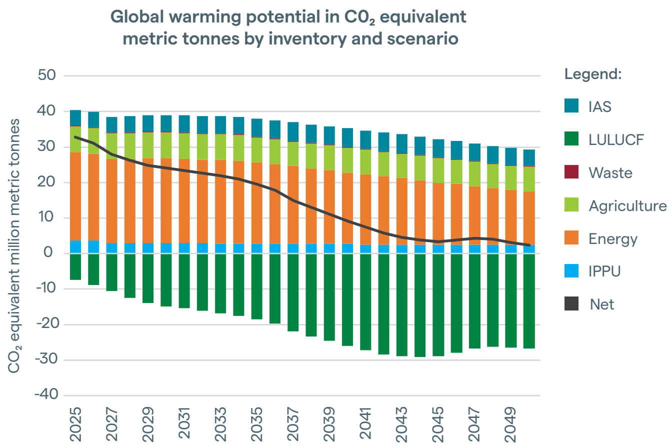


Emissions

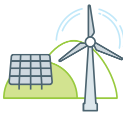
The nation's pursuit of net-zero is driven by brute force rather than innovation. Figure 3 shows how and when it reaches net-zero emissions, leaning heavily on industrial closure, emissions reduction in the energy sector and sequestration from forestry. Energy sector emissions fall from 25 million metric tonnes of CO_2 equivalent today to 15 million by 2050. Forestry sequestration (Land Use, Land Use Change and Forestry - LULUCF) rises from 7 million metric tonnes of CO_2 equivalent today to 27 million.

International Aviation and Shipping (IAS) and Industrial Processes and Product Use (IPPU) are also noted in Figure 3.

Figure 3: Emissions split into greenhouse gas inventory sectors[5] - Patchwork Nation



5 These emissions exclude biogenic methane as these are not part of the net-zero target. We use the Government's latest projections for emissions in non-energy sectors. The IAS category represents emissions from international aviation and shipping which are not included in the net-zero target.



Generation mix

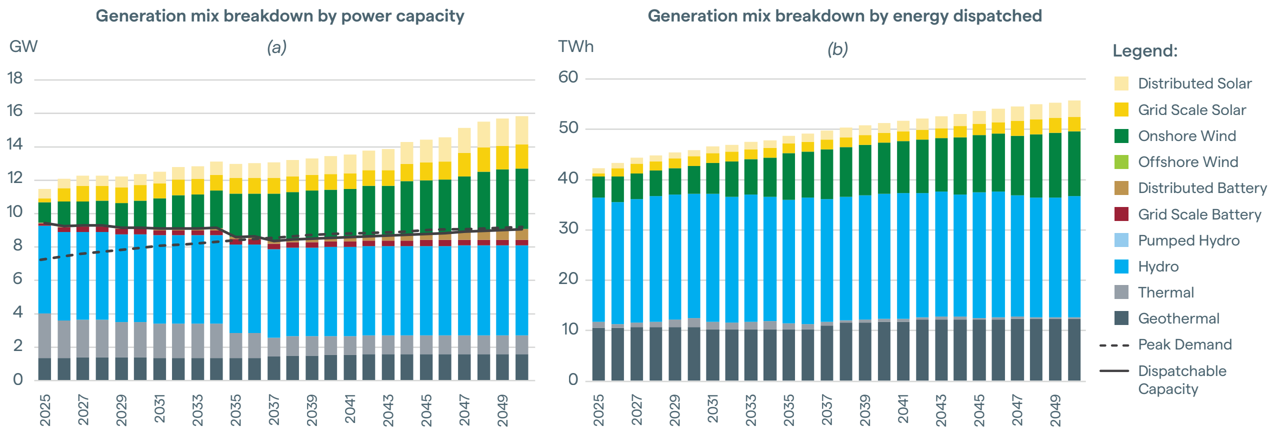
Some $11.4B (present value) of capital investment in new generation is required to meet demand.

Figure 4 shows how the mix of generation changes according to a) *power capacity* and b) *annual dispatched energy*. Wind and solar dominate supply-side development, along with some additional geothermal. Total capacity increases from 11.5 GW today to 15.9 GW by 2050, driven by material increases in wind (2.4 GW), solar (2.4 GW), and batteries (0.8 GW); in 2050 45% of solar and 36% of batteries are grid-scale with the rest being residential and community-scale. Wind increases from 4.3 TWh of energy today to 13 TWh by 2050, rising to 23% of the overall mix. Solar increases from 1.5 TWh to 6.2 TWh; 11% of the overall mix. Geothermal increases from 10.5 TWh to 12.3 TWh; 22% of the overall mix. The electricity sector is 99% renewable (by annual energy dispatched) by 2050.

Figure 4a) also shows dispatchable capacity[6] (including geothermal) which, when compared to peak demand (also shown), provides insights into system reliability. Dispatchable capacity dips slightly in the mid-2030s as some thermal generation retires, compared with a moderate increase in peak demand, from 7.3 GW today to 9.2 GW in 2050. Smart vehicle charging, 20% of total EV charging in 2050, and other residential and community-scale flexibility mean that peak demand grows by only 26% between now and 2050, compared with total electricity demand which grows by 42%. Demand response makes up the gap between dispatchable capacity and peak demand when required.

Existing hydro and thermal assets act in a combination of roles across baseload, mid-merit, and peaking. Thermal plants at Huntly and in Taranaki continue to provide peaking and dry year reserve capability in the absence of any clear incentive to replace them.

Figure 4: Generation mix split by technology and shown by a) power capacity and b) annual energy dispatched – Patchwork Nation



6 Dispatchable capacity is the electricity generation that can be turned on, off, or adjusted as needed to reliably meet demand. In contrast, wind and solar are intermittent and cannot reliably meet demand.

Scenario two: Aotearoa Electrified

In a world where global priorities shift with each electoral cycle, Aotearoa New Zealand chooses a steady, long-term path towards a low-carbon economy. By committing to a consistent strategy, the country leads by example, reducing emissions where possible and building enduring relationships. Aotearoa demonstrates that small nations can punch above their weight by staying the course and embodying the change they want to see in the world.

Global context

The world is divided into competing geopolitical blocs; climate action is inconsistent, with some regions making strong efforts while others lag. Global warming tracks toward 2.5°C by 2100. Global trade becomes more regionalised and politically conditioned, marked by shorter supply chains, strategic decoupling in critical sectors, carbon border adjustments, and parallel standards.

Local context

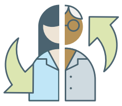
Aotearoa focuses on strategic partnerships, strengthening trade with APAC and India, and remaining neutral amidst the tensions between larger powers. Government and businesses address critical decarbonisation challenges to support energy security in an unstable world and provide targeted support for industrial electrification, EV charging networks, and critical infrastructure.

The economy

A slow shift to a service-based economy. Hard to abate industries, such as pulp and paper and some chemical production, cease operations as gas supplies diminish. However, with targeted support, many other industrial sectors successfully decarbonise and remain competitive. The dairy industry continues to innovate in carbon and methane reduction, providing high-value products to new and existing trading partners.

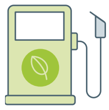
The Māori economy deepens its role as a values-led contributor to national growth. Building on its presence in primary industries, fisheries, forestry, and tourism, it leverages kaitiakitanga to align with the country's emissions reduction agenda. This alignment supports a shift toward high-value, low-emissions production, premium branding in environmentally conscious markets, and expanded participation in renewable energy, carbon forestry, and climate-resilient infrastructure.

Total annual GDP rises from $364B to $591B by 2050 (in real NZD). GDP per capita rises from $68k to $89k. The economy's useful energy intensity drops to 0.70 MJ/$, driven by a shift towards services.



Social and demographic shifts

Urbanisation continues at a slow but steady pace. Electrification of some regional processing facilities helps to keep the regions active, even if some traditional heavy industry closes. Migration levels remain low and the population continues to age. Changing lifestyles and mode shifting in transport (for example, from private car use to public transport, walking/cycling, and shared mobility) complement electrification. Public opinion regarding electrification varies; while there is general support, resistance to more infrastructure remains a strong and a persistent challenge. The population rises from 5.3 million today to 6.6 million by 2050.



Electrification and energy choices

A steady, orderly transition occurs. Electrification of transport and industry is widely seen as the economic and logical choice. Biomass emerges as a replacement for coal in some industrial processes.

Figure 5 shows the total energy mix by (a) *total consumed energy* and (b) *useful energy*. Useful energy rises more rapidly than in other scenarios, reaching 411 PJ in 2050. Consumed energy stays relatively flat. Consumed energy from oil, gas, and coal falls to 37% by 2050, while electricity and biomass rise to 40% and 13% of the total, respectively. Total useful energy per capita rises slightly from 60 PJ per million people to 62 PJ. In 2050, 44% of our energy requirement is imported compared with 52% today.

Figure 5: Total energy mix split by fuel, measured by a) consumed energy and b) useful energy – Aotearoa Electrified

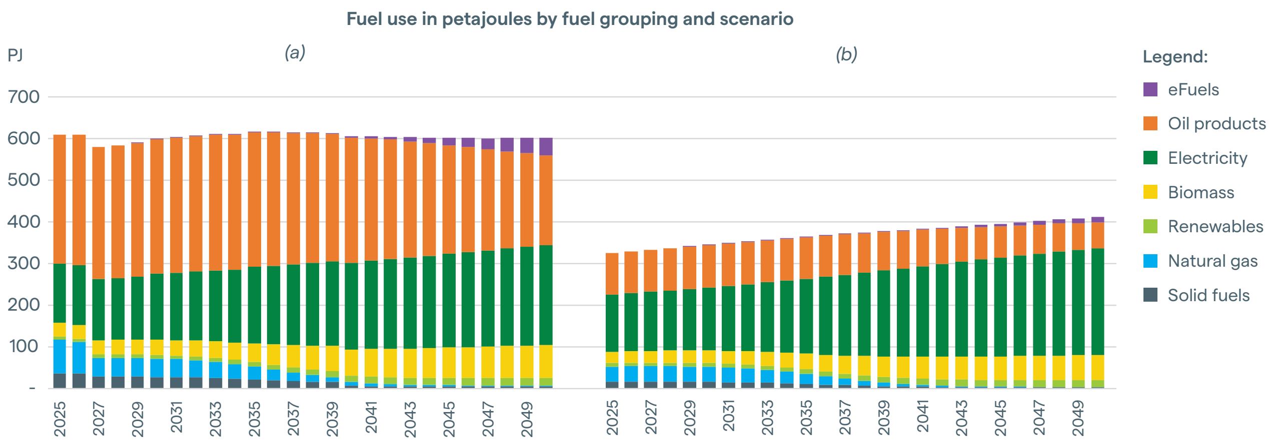
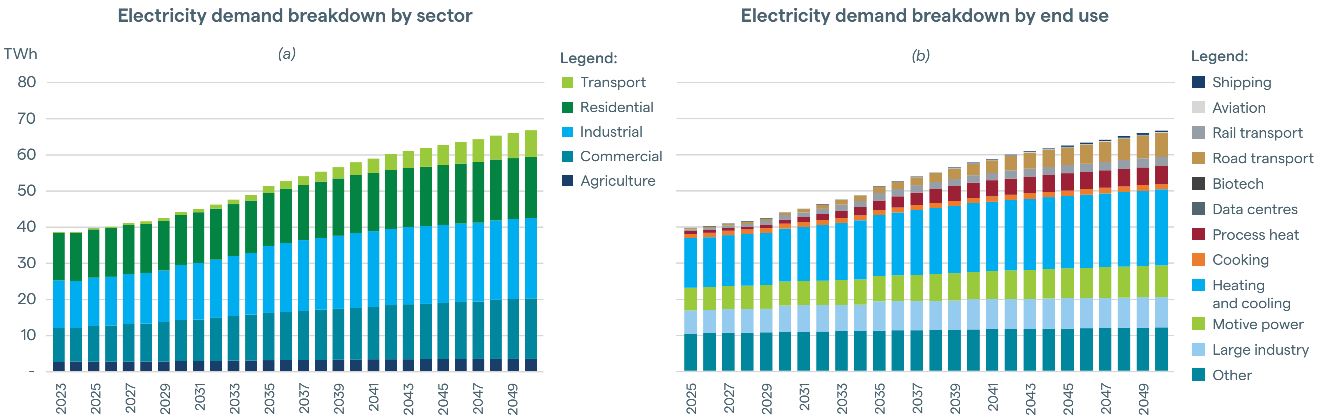
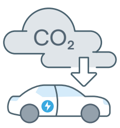


Figure 6 shows the demand for electricity, disaggregated into (a) *sectors* and (b) *end use*. Total demand grows to 67 TWh in 2050, driven by more demand for road transport, data centres, heating and cooling, and electrification of industry and motive power.

Due to a focused rollout of vehicle charging infrastructure, transport electrification moves more rapidly. However, the global EV market remains slow: EVs make up 54% of light passenger vehicles in 2050.

Figure 6: Annual electricity demand split by a) sector and b) end use – Aotearoa Electrified



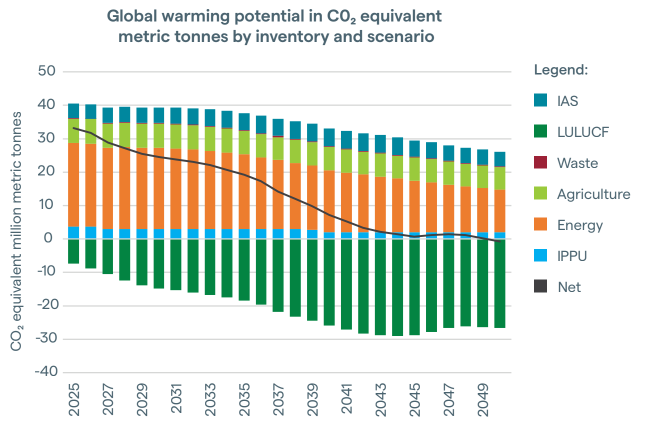


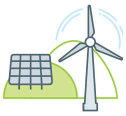
Emissions

The country's push toward electrification helps in the pursuit of net-zero emissions. Forestry sequestration still plays an important role, but with energy sector emissions falling faster and deeper, it is no longer the critical enabler of net-zero.

Figure 7 shows energy sector emissions falling 49%, to 13 million metric tonnes of CO_2 equivalent by 2050, driven by the electrification of transport, heating, and industry.

Figure 7: Emissions split into greenhouse gas inventory sectors - Aotearoa Electrified





Generation mix

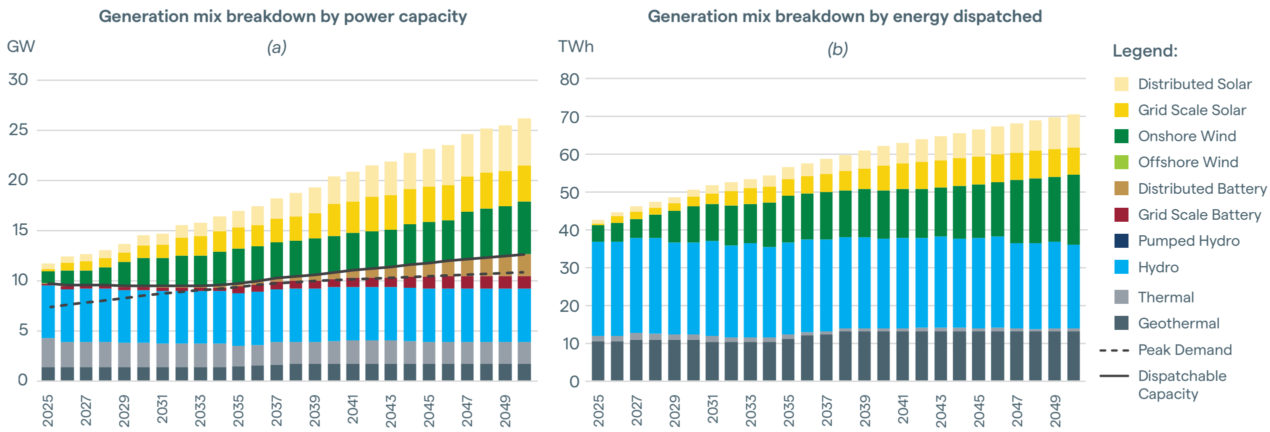
Some $18.0B (present value) of capital investment in new generation is required to meet demand.

Figure 8 shows the mix of generation according to a) *power capacity* and b) *annual dispatched energy*. Wind and solar dominate supply-side development, supported by a substantial increase in battery storage to firm supply. Additional geothermal makes up the total. Total capacity increases to 26.2 GW by 2050, driven by material increases in wind (4.1 GW), solar (7.5 GW), and batteries (3.3 GW). Wind increases from 4.3 TWh of energy today to 18.5 TWh by 2050, rising to 26% of the overall mix. Solar increases from 1.5 TWh to 16.1 TWh; 23% of the overall mix. Geothermal increases from 10.5 TWh to 13.0 TWh; 18% of the overall mix.

The system is balanced between centralised and decentralised; in 2050 43% of solar and 38% of batteries are grid-scale with the rest being residential and community-scale.

Higher uptake of rooftop/community-scale solar and batteries enables greater demand response. Gas (including LNG) and coal remain in the mix but, with an overbuild of renewables, are limited to the provision of peaking and dry year solutions. The electricity sector is 99% renewable (by annual energy dispatched) by 2050.

Figure 8: Generation mix split by technology and shown by a) power capacity and b) annual energy dispatched – Aotearoa Electrified



Scenario three: Global Green Rush

Global coordination towards reducing emissions accelerates, driving down the cost of clean technologies and improving efficiency worldwide. Global warming is tracking towards 1.5°C by 2100. Aotearoa rides this momentum, finding its path to net-zero made cheaper and easier. By leveraging international advances and aligning with global action, the country achieves deep emissions reductions while strengthening key sectors of our economy, such as manufacturing, transport, and farming.

Global context

Around the world, nations take action to mitigate climate change, such as returning to the Paris Accord and the establishment of international carbon markets. Global investment in decarbonisation technology increases materially. From renewables and EVs to nuclear power and battery energy storage systems (BESS), scale and innovation drives down the costs. Carbon Border Adjustment Mechanisms (CBAMs[7]) emerge and influence how other countries approach their transition. The global marketplace is full of environmentally conscious consumers.

Local context

Aotearoa New Zealand is motivated to ramp up its transition efforts in the early 2030s. A durable, bipartisan consensus for electrification emerges, with the government shifting its policy focus towards a supply-led approach to make electricity cheaper and more abundant. Most energy uses switch to electricity because policy shifts make it more accessible, affordable and reliable. The country enjoys benefits of relative energy sovereignty, while also maintaining existing, and opening new, strategic relationships.

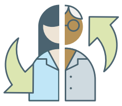
The economy

The economy evolves to become more insular in a positive way, focused on meeting its own needs well and becoming a leader in sustainable domestic production. This is a story of value over volume where a thriving ecosystem of decentralised small-to-medium enterprises incubate innovative ideas and succeed in a more virtualised, modern economy. Biotech developments drive next-generation farming techniques to support a vibrant, low carbon farming and food production sector.

Grounded in rangatiratanga, the Māori economy shifts toward energy sovereignty. Using iwi owned land, capital, and governance structures, local renewable generation is developed that meets the needs of whānau, businesses, and regions first.

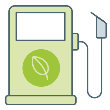
Total annual GDP rises from $364B to $639B by 2050 (in real NZD). GDP per capita rises from $68k to $96k. The economy's useful energy intensity drops from 0.88 MJ/$ to 0.64 MJ/$, driven by a shift towards services.

7 Where a fee or tariff is levied on imported goods based on the greenhouse gases emitted during their production.



Social and demographic shifts

Aotearoa is transformed. The affordability of EVs enables a 'hub-and-spoke' model of living, where people live in smaller towns and commute to major urban centres. There is strong public support for the transition, seen as a matter of economic opportunity and social necessity. With the cost effectiveness of electric alternatives, decarbonisation becomes the status quo. The nation's increasing dependence on electricity also fosters strong public support for a secure and reliable electricity system. The population rises from 5.3 million today to 6.6 million by 2050.



Electrification and energy choices

Driven by a global manufacturing boom and cost reduction, this scenario sees Aotearoa aggressively decarbonising with renewables dominating. High carbon prices in the ETS help to stimulate the transition, although they are not the primary driver.

Figure 9, displaying the total energy mix, shows a rapid and deep energy transition, firmly removing oil, gas and coal from all but the hardest-to-abate end uses. Electrification becomes the clear preference due to both technical and economic advantages. Useful energy rises to 406 PJ in 2050, more than Patchwork Nation but slightly less than Aotearoa Electrified. Consumed energy from oil, gas, and coal falls to 12% by 2050, while electricity and biomass rise to 57% and 10% of the total, respectively. eFuels are a small but growing sector, gaining momentum in the 2040s, with New Zealand producing some of its own sustainable aviation fuel for domestic travel. Total useful energy per capita stays flat at 61 PJ per million people. In 2050, 30% of our energy requirement is imported compared with 52% today.

Figure 9: Total energy mix split by fuel, measured by a) consumed energy and b) useful energy – Global Green Rush

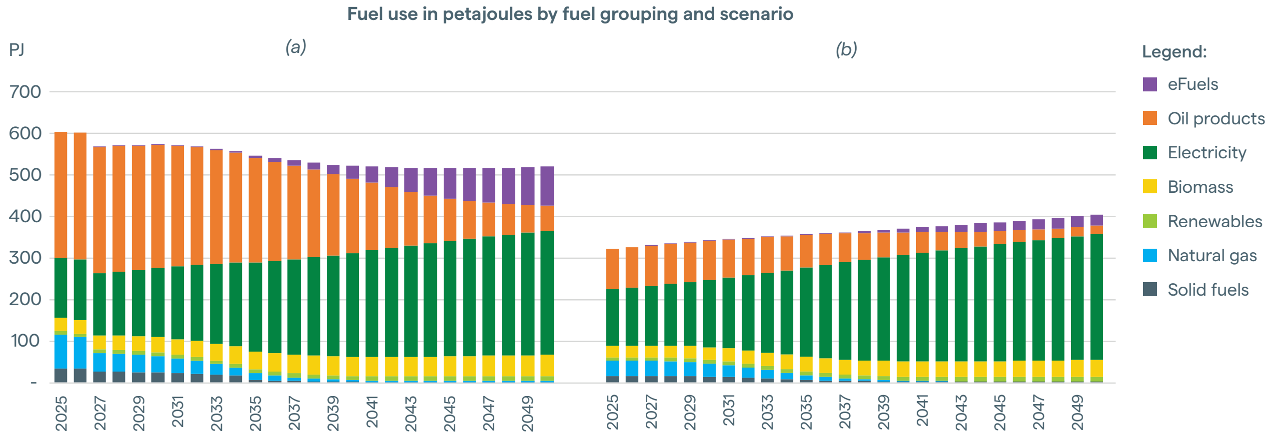
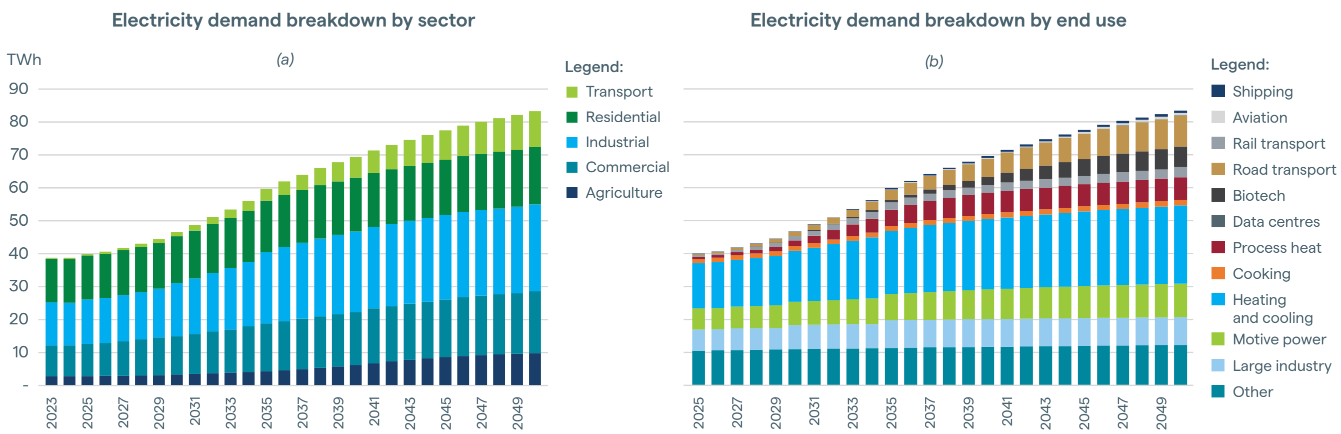
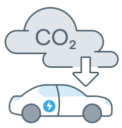


Figure 10 shows the demand for electricity, disaggregated into (a) *sectors* and (b) *end use*. Total demand grows to 83 TWh in 2050. This is driven by higher electrification rather than higher energy demand with more electricity used for road transport, data centres, biotech, and electrification.

Technology uptake is ubiquitous. Household battery and solar panels are widely adopted and the grid is bolstered by massive offshore wind farms. Renewable energy is widely viewed as a national high-tech commodity.

Figure 10: Annual electricity demand split by a) sector and b) end use – Global Green Rush



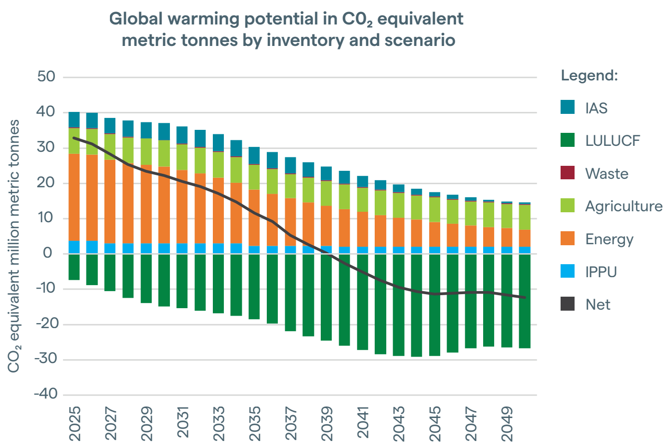


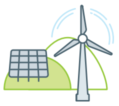
Emissions

Aotearoa creates value through international carbon markets by generating high-integrity emissions reductions and removals that attract foreign investment, earn export revenue, and strengthen its clean, green competitive advantage.

Figure 11 shows energy sector emissions falling 80%, to 5 million metric tonnes of CO_2 equivalent by 2050. Forestry sequestration drives export revenue in international carbon markets, supporting decarbonisation of fossil-locked economies.

Figure 11: Emissions split into greenhouse gas inventory sectors - Global Green Rush





Generation mix

Around $24B (present value) of capital investment in new generation is required to meet demand.

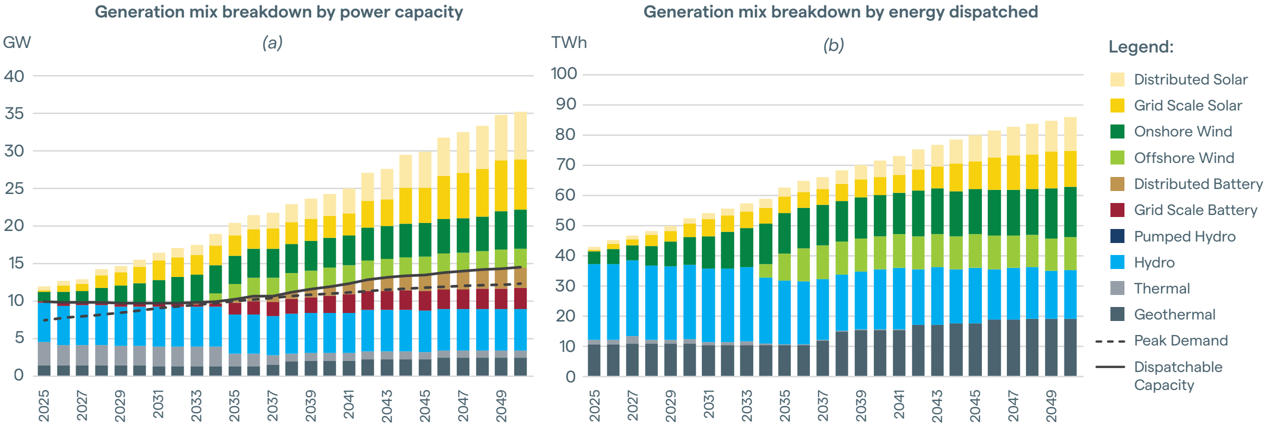
Figure 12 shows the mix of generation according to a) *power capacity* and b) *annual dispatched energy*. Wind, solar, and geothermal dominate supply-side development, supported by a substantial increase in battery storage to firm intermittent generation. Total capacity increases to 35.2 GW by 2050, driven by material increases in onshore wind (4.0 GW), solar (12.3 GW), geothermal (1.1 GW), and batteries (5.4 GW). Wind increases from 4.3 TWh of energy today to 27.6 TWh by 2050, rising to 32% of the overall mix. Solar increases from 1.5 TWh to 23.2 TWh; 27% of the overall mix. Geothermal increases from 10.5 TWh to 19.1 TWh; 22% of the overall mix.

Globally, offshore wind is a cornerstone of electricity markets, providing large-scale renewable generation to regions with limited onshore resources. In New Zealand, abundant onshore wind, hydro, and geothermal mean only 2.5 GW of offshore wind is built.

The system is balanced between centralised and decentralised. Around 51% of solar and 50% of batteries in 2050 are grid-scale. The rest is residential and community-scale.

The large penetration of wind and solar, combined with renewable overbuild, means hydro plays a high-value, low-volume role within the system. Biomass and overbuild in renewables, including offshore wind, provides dry year reserve. Batteries provide most of the peaking capacity. The electricity system is 100% renewable (by annual energy dispatched) by 2050.

Figure 12: Generation mix split by technology and shown by a) power capacity and b) annual energy dispatched – Global Green Rush



Scenario four: Made in Aotearoa

A large expansion of goods production across the primary and manufacturing sectors drives growth. Aotearoa has historically been a strong producer of key products, especially food. This scenario explores the advantage gained from producing more high-value, clean, green products for the world.

Global context

Aotearoa takes advantage of uncoordinated global political action on climate change. Emissions reduction remains an enduring goal, but its priority varies over time as circumstances and trade-offs shift. Wealthier economies and large corporations increasingly demand high-value, green products and are willing to pay a premium. Global warming is tracking towards 2°C by 2100.

Local context

Aotearoa capitalises on this by focusing on its traditional strengths combined with a highly renewable electricity system. The country's 'clean green' image is amplified and becomes a major driver for businesses seeking to access lucrative export markets. A national energy strategy is redesigned to support heavy industry and drive export growth. A surplus in the country's balance of trade supports a stronger currency, reduces borrowing costs and improves the government balance sheet.

The economy

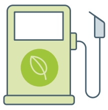
Aotearoa experiences a market-driven expansion of existing industries leveraging the country's clean energy to secure a 'green premium'. Policies designed to create favourable business environments achieve rapid growth and attract international investment. The country makes a strategic entry into new industries, particularly green fuels for both domestic use and export.

The Māori economy stands as a global exemplar for indigenous economic development, showing how prosperity can be built through values-led enterprise rather than extractive growth.

Total annual GDP rises from $364B to $660B by 2050 (in real NZD). GDP per capita rises from $68k to $100k. The economy's useful energy intensity drops from 0.88 MJ/$ to 0.72 MJ/$ but stays relatively high due to the ongoing presence of heavy industry within the economy.

Social and demographic shifts

Regional centres strengthen, particularly those with a strong manufacturing or industrial base. While urbanisation continues, the revitalisation of these industries creates jobs and opportunities outside of the main centres. Decarbonisation is generally supported, viewed through the lens of economic benefit, with people accepting the transition as a pathway to a higher standard of living. The population grows to 6.6 million by 2050, thanks to the strength of our economy and the emergence of new opportunities.

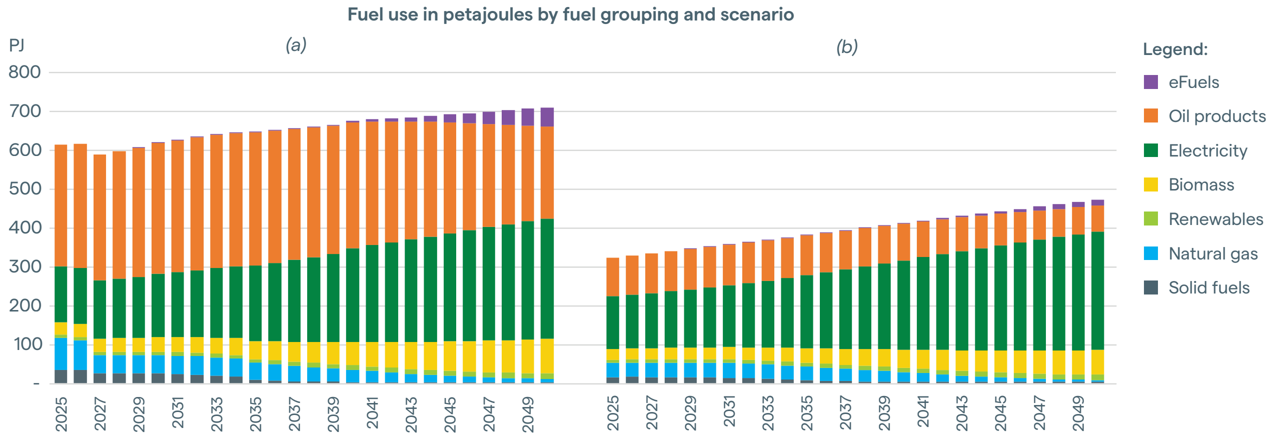


Electrification and energy choices

This is a future where energy is a tool for economic sovereignty and manufacturing strength. 'Energy precincts', such as at Marsden Point and Taranaki, are established to facilitate coordinated industrial development. This lends itself to the development of Renewable Energy Zones (REZ) or strategic energy hubs, with dedicated government policy designed to coordinate and accelerate the supply of clean electricity to centres of industrial demand.

Figure 13 shows the total energy mix measured by (a) *total consumed energy* and (b) *useful energy*. In contrast to previous scenarios, growth in electricity demand is driven by a combination of increasing total energy consumption and electrification. Useful energy rises to 475 PJ in 2050, materially higher than other scenarios. Even consumed energy shows a modest increase due to residual oil and gas demand and eFuel production. Consumed energy from oil, gas, and coal falls to 35% by 2050, while electricity and biomass rise to 44% and 13% of the total, respectively. eFuels provide an export opportunity, with 1% of our total energy production exported by 2050. Total useful energy per capita rises to 72 PJ per million people. In 2050, 39% of our energy requirement is imported compared with 52% today.

Figure 13: Total energy mix split by fuel, measured by a) consumed energy and b) useful energy – Made in Aotearoa



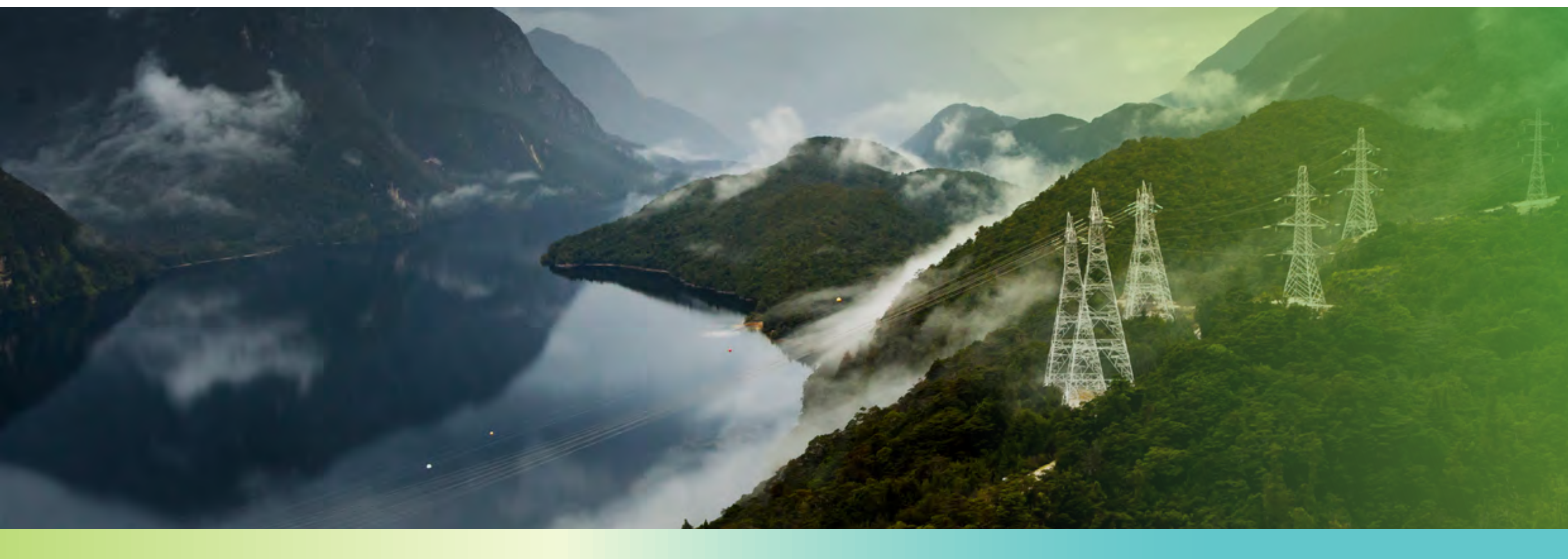
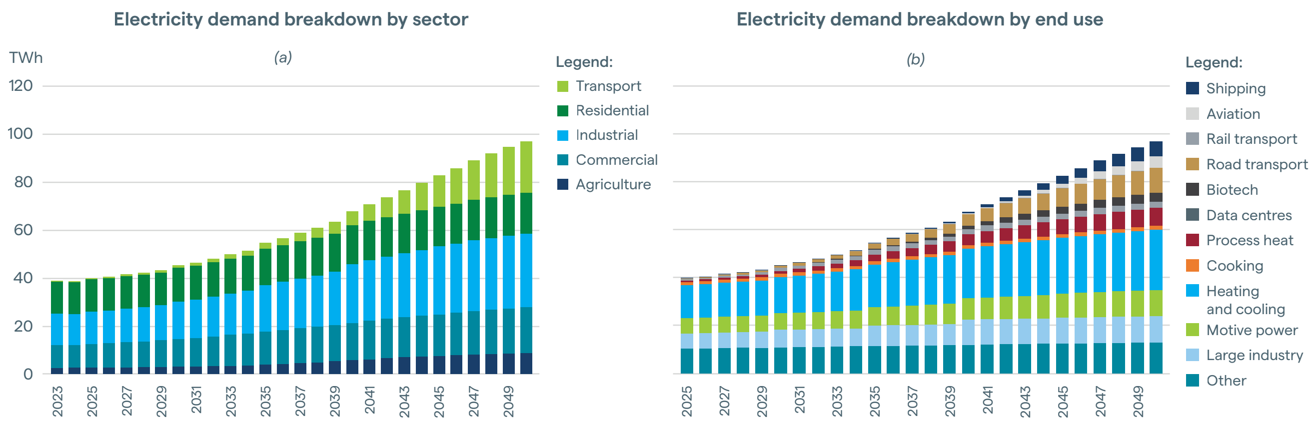
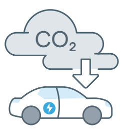


Figure 14 shows the demand for electricity, disaggregated into (a) *sectors* and (b) *end use*. Total demand grows to 97 TWh in 2050. This is driven by a combination of higher energy demand and electrification. Shipping, aviation, and large industry drive material demand growth.

Figure 14: Annual electricity demand split by a) sector and b) end use – Made in Aotearoa

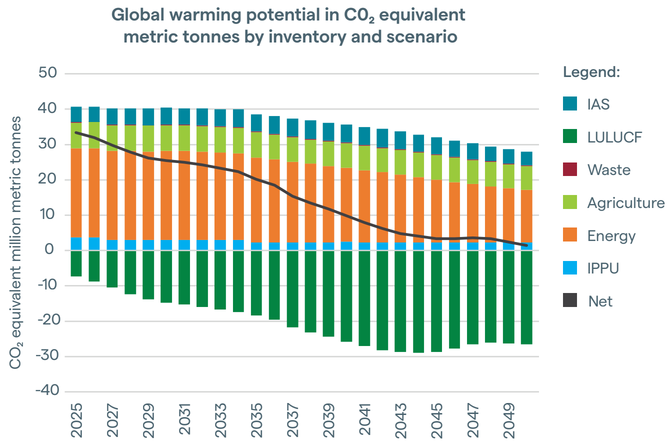


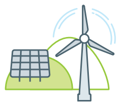


Emissions

The strong focus on economic growth comes at a cost for our emissions reduction. Nonetheless, a viable pathway to net-zero is achieved without purchasing international offsets. The country uses forestry sequestration to offset residual emissions. Figure 15 shows energy sector emissions falling 41%, to 15 million metric tonnes of CO_2 equivalent by 2050.

Figure 15: Emissions split into greenhouse gas inventory sectors – Made in Aotearoa





Generation mix

Some $31B (present value) of capital investment in new generation is required to meet demand.

Figure 16 shows the mix of generation according to a) *power capacity* and b) *annual dispatched energy*. The nation's geothermal and hydro strengths are maximised to provide steady power for industry. Grid-connected wind (including offshore), solar, and batteries also make a sizable contribution to the total overall mix. Total capacity increases to 37.7 GW by 2050, driven by material increases in onshore wind (4.4 GW), solar (14.0 GW), geothermal (1.1 GW), and batteries (4.8 GW).

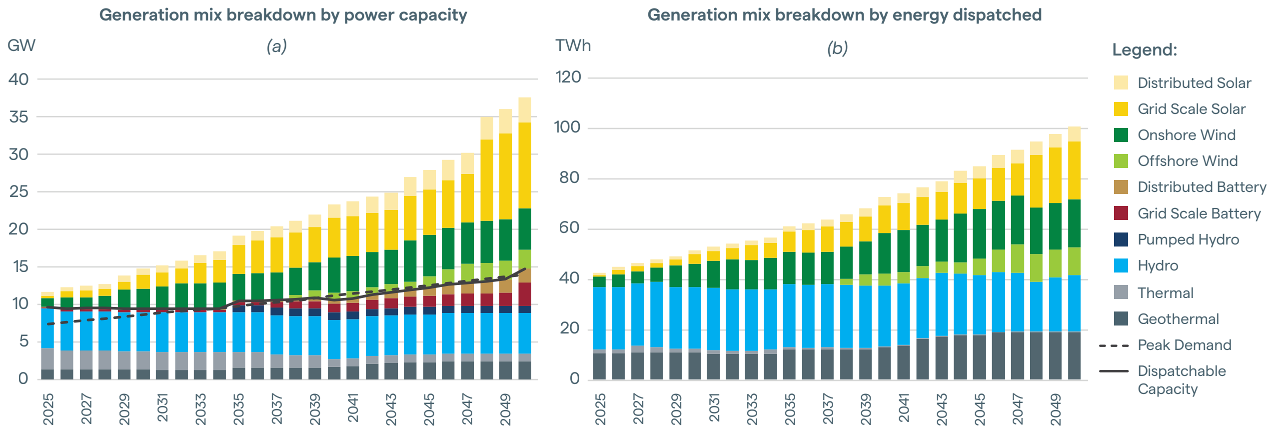
Wind increases from 4.3 TWh of energy today to 30.3 TWh by 2050, rising to 30% of the overall mix. Solar increases from 1.5 TWh to 28.8 TWh; 29% of the overall mix. Geothermal increases from 10.5 TWh to 19.0 TWh; 19% of the overall mix.

New domestic natural gas reserves are uncovered. LNG imports ensure energy security for the industrial sector.

This is a centralised world. Huge solar and offshore wind farms feed industrial centres. Homes and small businesses benefit from large-scale generation as the economies of scale and system stability provided, help to lower wholesale electricity costs.

Gas provides the immediate peaking solution however, in the 2040s, new hydro is developed, including pumped hydro for long-duration energy storage, eventually displacing gas from the supply mix. This pumped hydro solves the issue of dry year alongside LNG.

Figure 16: Generation mix split by technology and shown by a) power capacity and b) annual energy dispatched – Made in Aotearoa



Scenario five: Aotearoa Intelligence

A pivot toward digitalisation and artificial intelligence (AI) where Aoteaora New Zealand leverages its strong advantage for data centres, given its highly renewable electricity system and low air temperatures.

The country targets growth in high-tech sectors, such as creative industries, healthcare, space, and services. Its population grows as more people choose to live here in a perceived safe haven.

Global context

The rise of AI, combined with advanced robotics and automation, becomes the primary driver of global growth. More chip manufacturing leads to more data centres which leads to more demand for electricity. However, productivity and value creation is marred by job losses, leading to civil unrest.

An unsettled global environment sees Aotearoa viewed as a protected paradise: a haven for those seeking stability and opportunity, particularly attractive to highly skilled professionals. This drives high levels of migration. Global warming is tracking towards 2°C by 2100.

Local context

The government prioritises investment in digital infrastructure and education, while a national focus on economic growth takes precedence over solely climate-focused policies.

Complementary policies are enacted to attract and retain high-skilled migrants, with a particular emphasis on the technology sector, helping to fill critical skill gaps in AI, software development and emerging tech industries, and to foster a dynamic, multicultural workforce that drives innovation and economic growth.

The economy

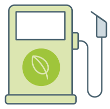
The focus is on growth in high-value digital services, the establishment of new data centres, and niche industries. The government offers renewable energy subsidies, special electricity rates for data infrastructure, and streamlined approvals for energy projects. Tax incentives and grants further lower barriers for global technology companies. These measures make energy more accessible and position Aotearoa as a top destination for digital investment and innovation.

Total annual GDP rises from $364B to $732B by 2050 (in real NZD). GDP per capita rises from $68k to $104k as migration drives higher population growth. The economy's useful energy intensity drops from 0.88 MJ/$ to 0.58 MJ/$, declining due to strong growth in light-weight services.

Social and demographic shifts

High migration results in a growing and younger population. Migration sees the population grow to 7.1 million by 2050. Urbanisation accelerates and an influx of people, coupled with high-density housing and public transport enhancements, boosts system efficiency in residential and commercial sectors.

People value the natural environment and support clean and green initiatives. Decarbonisation is seen as a positive side-effect of a focus on a high-tech, high quality-of-life economy.



Electrification and energy choices

This is a future defined by local resilience and the integration of energy with the digital economy. The grid is no longer a one-way street; it's a smart network of producers and consumers, (prosumers) with heavy reliance on consumer energy resources (CER).

Figure 17 shows the total energy mix measured by (a) *total consumed energy* and (b) *useful energy*. Useful energy rises to 426 PJ by 2050, with electricity and biomass making up 69% and 11% of the mix, respectively. Consumed energy remains relatively steady. Consumed oil, gas, and coal drops by 46%.

Figure 17: Total energy mix split by fuel, measured by a) consumed energy and b) useful energy – Aotearoa Intelligence

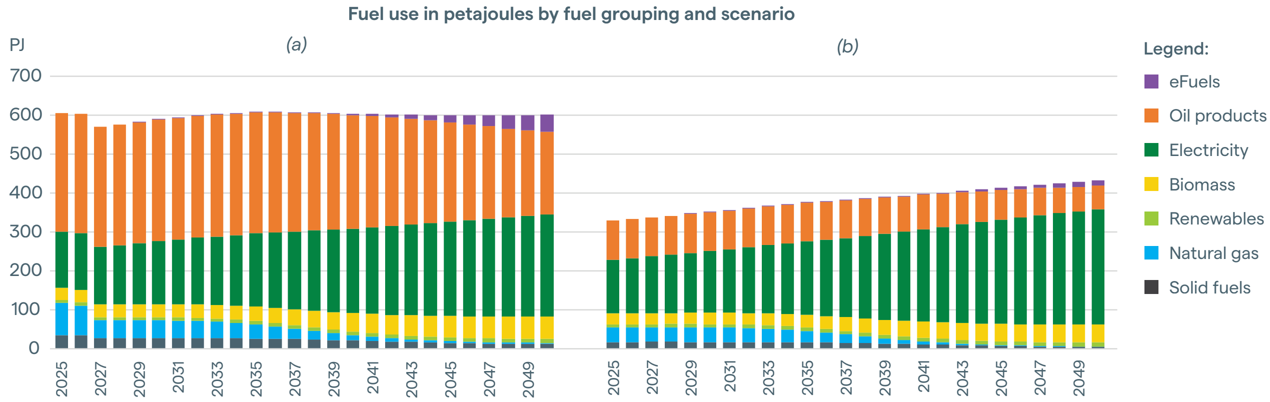
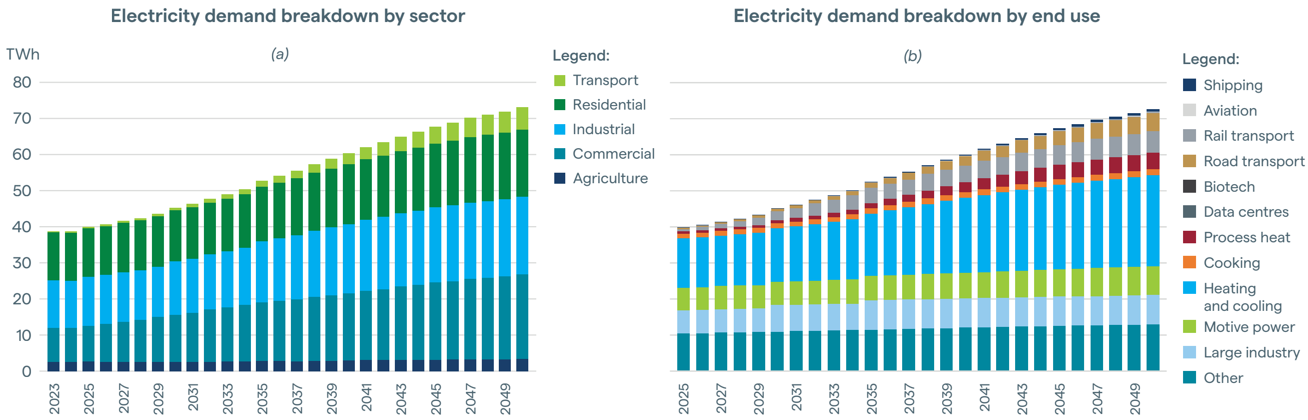
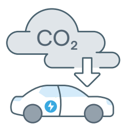


Figure 18 shows the demand for electricity, disaggregated into (a) *sectors* and (b) *end use*. Total demand grows to 73 TWh in 2050. Data centres can be seen as a major component of demand growth. The shift to less energy-intensive manufacturing and services enables space to utilise the country's renewable abundance to support this growth. Electrification is common, as is energy efficiency, driven primarily by economics and the supply risk of gas. A more concentrated urban population enables some biogas production to help the gas network persist.

Figure 18: Annual electricity demand split by a) sector and b) end use – Aotearoa Intelligence

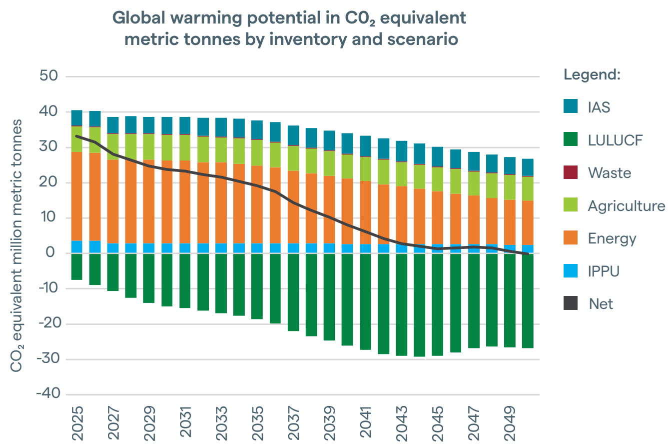




Emissions

Domestic emissions reduction is made easier by offshoring emissions intensive industry. Figure 19 shows energy sector emissions falling 51%, to 12 million metric tonnes of CO_2 equivalent by 2050. Forestry sequestrations ensure a rapid path to net-zero emissions.

Figure 19: Emissions split into greenhouse gas inventory sectors – Aotearoa Intelligence



Generation mix

Roughly $20.5B (present value) of capital investment in new generation is required to meet demand.

Figure 20 shows the mix of generation according to a) *power capacity* and b) *annual dispatched energy*. Distributed (rooftop) solar generation is the single largest contributor of increased capacity (25% of households have solar). Total capacity increases to 31.2 GW by 2050, driven by material increases in onshore wind (5.6 GW), solar (11.1 GW), and batteries (3.5 GW). Wind increases from 4.3 TWh of energy today to 22.8 TWh by 2050, rising to 29% of the overall mix. Solar increases from 1.5 TWh to 21.4 TWh; 27% of the overall mix. Geothermal increases from 10.5 TWh to 13.0 TWh; 16% of the overall mix.

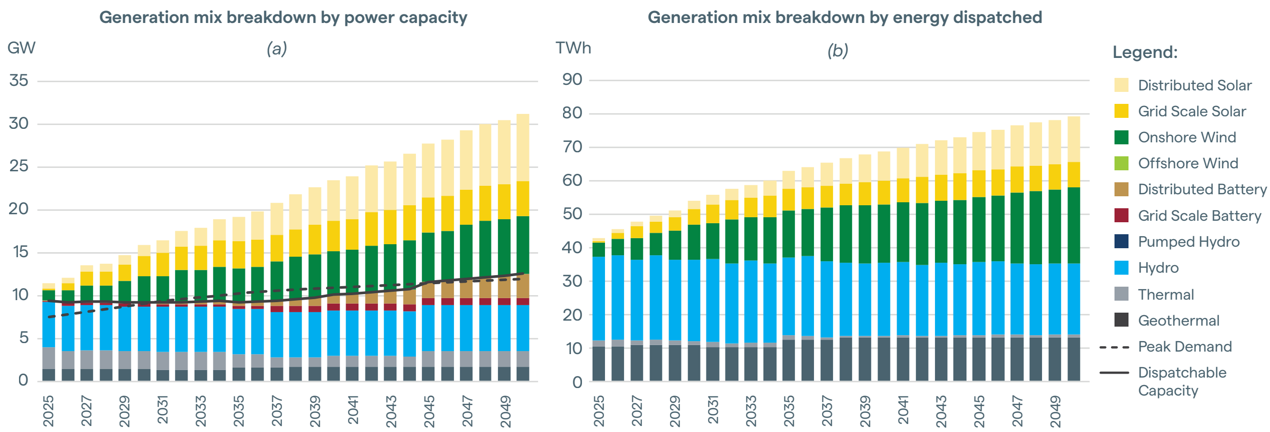
Decentralised solar and batteries dominate, while grid-scale centralised resources, such as geothermal and large wind farms plus batteries, are specifically designed to support the power needs of data centres.

Rooftop solar is dominant with a high uptake of batteries; high-tech homes and businesses are self-supplying. Large-scale utility solar is niche compared to the sheer volume of CER.

While thermal plants continue to run until 2050, the real power lies in decentralisation. Batteries lead the solution to peaks while LNG, demand response and a minor overbuild of renewables, provide the dry year solution.

There is some investment in gas, driven by LNG imports and increased domestic production.

Figure 20: Generation mix split by technology and shown by a) power capacity and b) annual energy dispatched – Aotearoa Intelligence



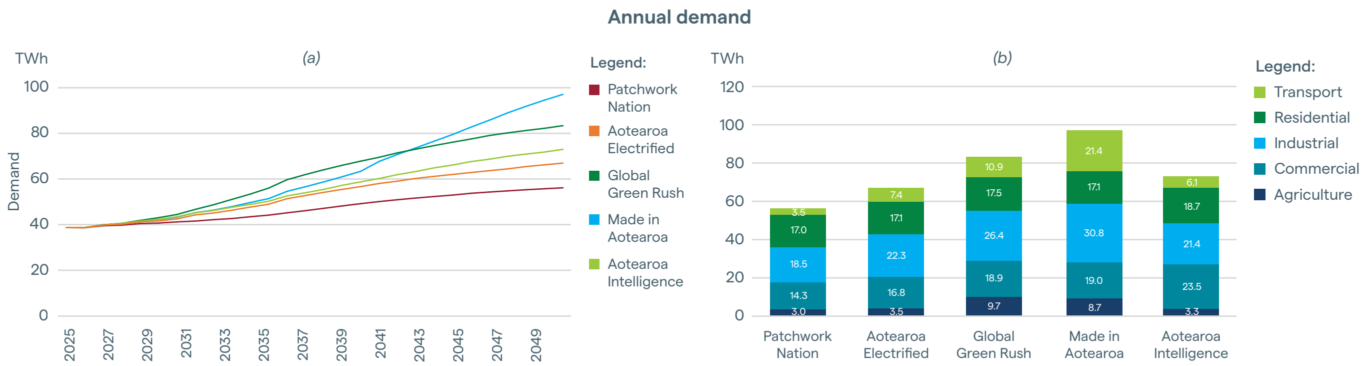
Comparing scenarios side by side

Comparing scenarios side by side is essential to confirm the diversity of possible futures and ensure the full spread of uncertainty is covered. This enables better decision making, ensuring the grid blueprint remains robust across a broad range of possible futures.

Annual demand

Annual demand is the total cumulative demand across the year. Figure 21 shows demand for each scenario, as a) total annual demand throughout the forecast horizon and b) total demand in 2050 broken down across sectors. Scenario demand in 2050 is spread from 56 TWh in Patchwork Nation to 97 TWh in Made in Aotearoa. Variability across sectors is also high, driven by uncertainty in the underlying end use for electricity.

Figure 21: Comparison of scenario annual electricity demand by a) TWh in each year and b) broken down by sector in 2050

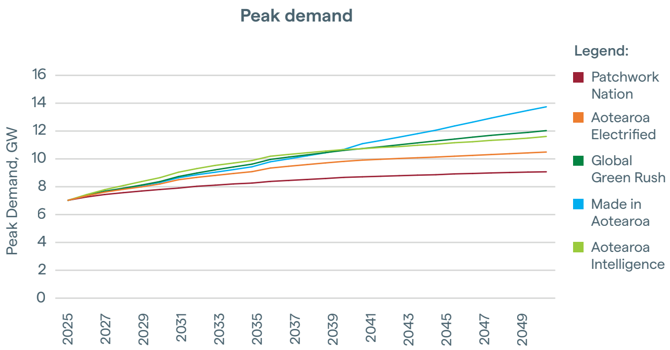


Peak demand

Peak demand is the highest level of electricity consumption reached over a given period; typically measured for a day, season, or year. It represents the moment when consumers collectively place the greatest load on the grid and is a critical driver of generation and transmission investment planning. It influences how much firm capacity and network capability are required to maintain reliability.

Figure 22 shows the annual national peak demand for each scenario. Material variability exists across scenarios, ranging from 9.1 GW in Patchwork Nation to 13.7 GW in Made in Aotearoa. The variability is driven in part by different growth in total energy, but also due to different levels of smart load management, technology, and alternative patterns of consumer behaviour. The following section outlines our daily demand profiles, which highlight these differences.

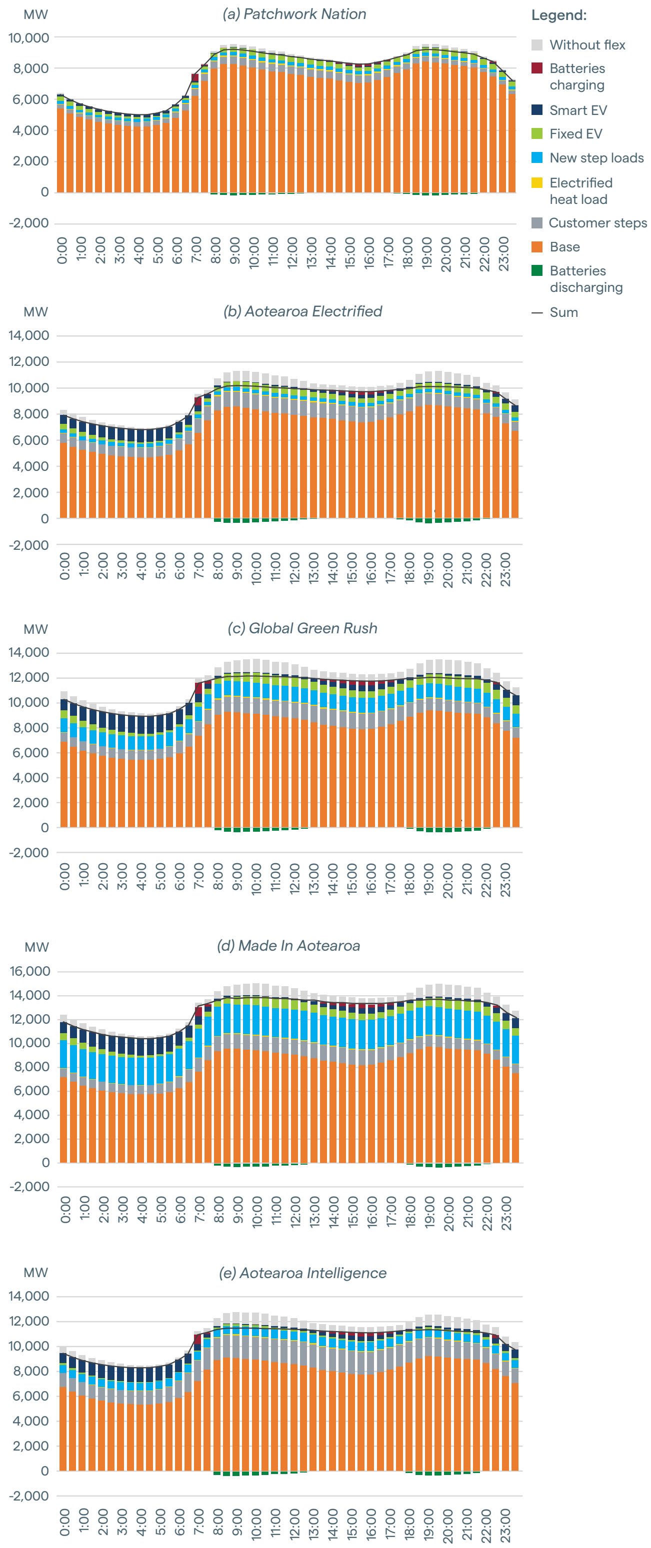
Figure 22: Comparison of annual peak demand per scenario



Daily demand profiles

Daily demand profiles represent the shape of electricity demand. Changes in technology, end use, and consumer behaviour will drive changes to that shape in the future. Figure 23 shows the daily profiles for each of the scenarios. Demand components show up differently during the day, determining how peak demand can scale differently from total annual demand. Charging of distributed batteries occurs during the day, aligned with peak distributed solar output. They discharge into the evening and morning peaks. The charts highlight the contribution of flexibility and consumer energy resources (CER) in reducing peak demand. Coordinated flexibility reduces peak demand by as much as 1.2 GW *(without flex)*.

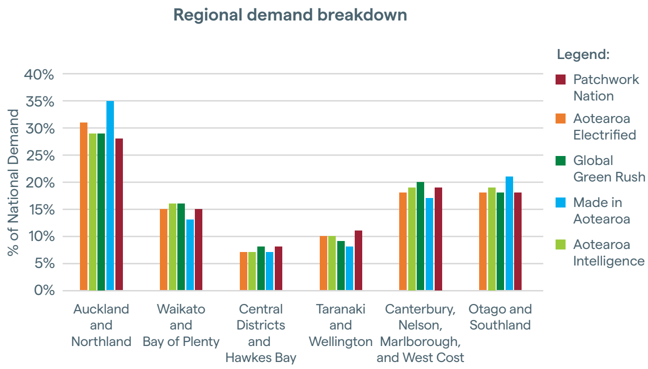
Figure 23: Daily profile in 2050 broken down into demand components for each scenario



Regional demand breakdown

Regional demand breakdown is highly relevant to how the transmission network needs to connect between regions. Figure 24 shows this breakdown across major regions in each scenario. Combined with total national annual demand, substantial variation exists across scenarios regional demand growth.

Figure 24: Comparison of regional demand breakdown per scenario (2050)



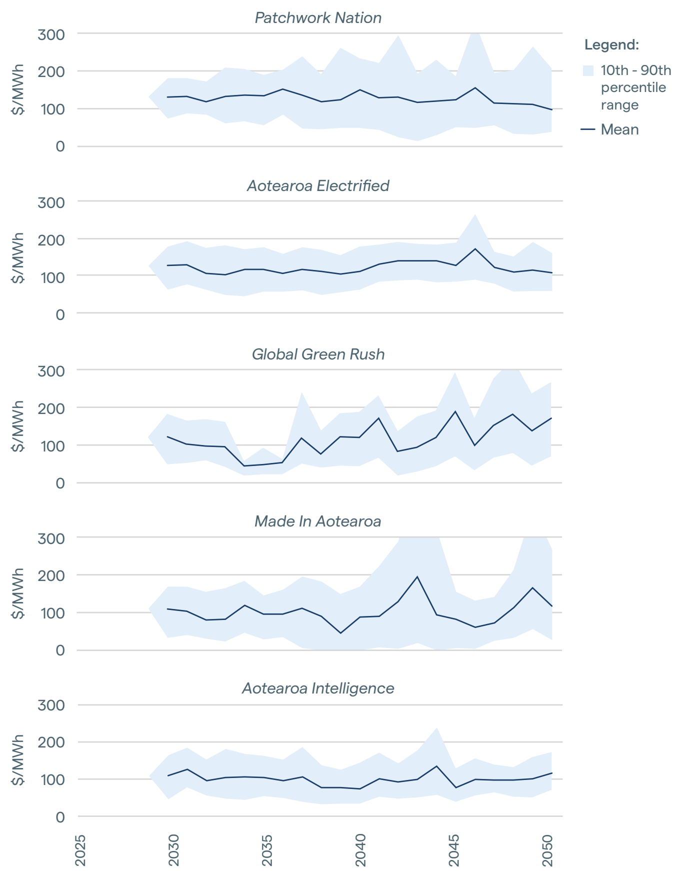
Average generation pricing trends to 2050

Wholesale electricity market prices are a key outcome within the scenarios because they signal the efficient balance of supply and demand. The outcomes highlight the competitive nature of the country's electricity market relative to international comparators, due to high quality renewable resource, even in a nearly 100% renewable future. The outcomes confirm the potential for strong demand growth assumed in the scenarios, due to high global demand for renewable electricity and the strong value proposition of the market.

Figure 25 shows indicative wholesale electricity spot price calculated for each scenario. These prices do not include the added costs of investment in networks including transmission, nor do they include any levies, taxes or retail margins. They may change if, in our analysis of the optimal transmission investment, a lower overall system cost is achieved by dispatch of a different mix of generation sources. These prices reflect dynamics of short run marginal cost offers for generation dispatch, combined with a revenue adequacy test[8] against long run capital costs[9]. A separate premium is calculated to account for the capital investment in firm capacity, which is required as some sources of firm capacity can have very low utilisation. This firm capacity premium is included in Figure 25 and depends on scenario and year. It is generally between $10/MWh and $30/MWh.

The calculated wholesale market spot price over the 25-year horizon varies considerably depending on the hydro, wind, and solar conditions. This variation is shown in the blue band of Figure 25, which marks the 10th and 90th percentile indicative prices observed in our assessment. The timing of new generation and retirements also creates some of the variability from 2025 to 2050. On average, over this period the modelling shows annual mean price varying from $90/MWh and $130/MWh across the scenarios.

Figure 25: Wholesale electricity spot price ($/MWh in real 2025 dollars) with variability due to hydro, wind, and solar



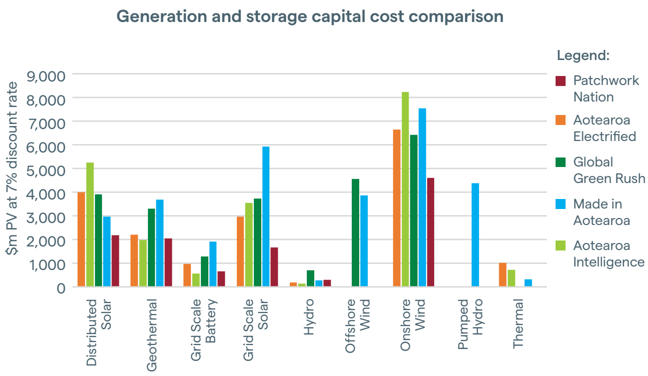
8 A revenue adequacy test confirms whether the total cost of new generation or storage, as per the **2025 Generation Stack Report**, is forecast to be recovered in the long-term through earnings in the spot market.

9 Prices have not been reconciled against current spot or futures prices. Our methodology is not suitable as an indicator of near-term prices where very high and low prices can occur due to supply/demand imbalances that can occur.

Generation and storage capital cost comparison

Significant investment in new generation and battery storage underpins these scenarios. Figure 26 shows the total investment cost broken down across each generation type in present value (PV) terms. Onshore wind and solar costs dominate the cost. Grid scale batteries, driven by the need for firm capacity, also carry significant costs.

Figure 26: Comparison of capex present value broken down by generation and storage technology



Background information: Input assumptions

The country's energy future is marked by significant uncertainty due to a complex interplay of factors such as technological advancements and the pace of adoption; evolving policy landscapes; shifting consumer behaviours, and global economic trends.

To create a draft future grid blueprint we need to manage this uncertainty by drawing on a range of information sources and assumptions.

In this section we provide more detailed information on the assumptions we have made in the creation of our scenarios and the data that sits behind them. You can explore our data in **Future Direction - Data Book**.

Input assumptions

Uptake of consumer energy resources

What is this?

Consumer energy resources (CER) are the technologies and devices in households and businesses that can produce, store, or actively manage electricity and include rooftop solar panels, household batteries, electric vehicles, smart chargers, and flexible loads.

Why is it important?

CER fundamentally change how electricity is produced, stored, and consumed at the household and business level. As uptake grows, CER shape demand patterns, contribute local generation and storage, and enable consumers to participate more directly in energy markets.

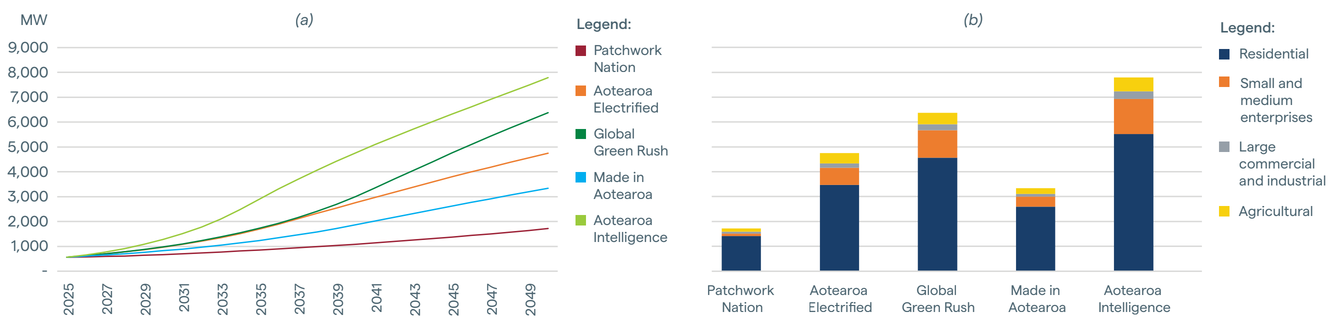
Because CER operate behind the meter and respond to consumer preferences, they introduce both new opportunities – such as flexibility and reduced peak demand – and new challenges for system visibility, forecasting, reliability, and market integration.

Our assumptions

Rooftop and distributed solar

Figure 27 shows how rooftop and distributed solar varies across the scenarios. Figure 27 (a), shows how 2050 capacity reaches between 1.7 GW (in Patchwork Nation) and 7.8 GW (in Aotearoa Intelligence). As seen in Figure 27 (b), shows how this uptake includes between 1.4 GW of residential solar (9% of all residential dwellings) in Patchwork Nation and 5.5 GW in Aotearoa Intelligence (25% of all residential dwellings), as well as uptake from businesses and farms.

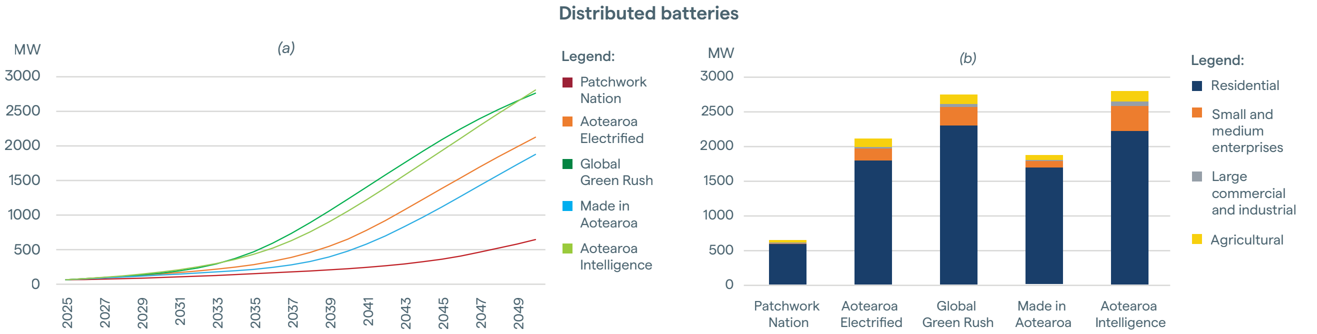
Figure 27: Uptake in total rooftop and distributed solar. The total installed capacity shown by (a) uptake over time across the five scenarios and (b) the breakdown across sectors in 2050



Distributed batteries

Figure 28 shows distributed batteries, including vehicle-to-grid technology, across the scenarios. Figure 28 (a) shows the 2050 total capacity, reaching between 0.6 GW (in Patchwork Nation) and 2.8 GW (in Aotearoa Intelligence). Figure 28 (b) shows the uptake includes between 0.6 GW of residential batteries (3% of all residential dwellings) in Patchwork Nation and 2.2 GW in Aotearoa Intelligence (8% of all residential dwellings), as well as uptake from businesses and farms. Our forecasts are based on Concept Consulting publication **Powerful potential. New Zealand's vehicle-to-grid opportunity** and internal Transpower analysis.

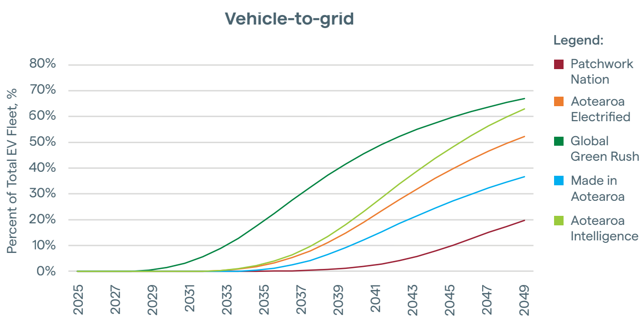
Figure 28: Uptake in total distributed batteries. The total installed battery capacity shown by (a) uptake over time across the five scenarios and (b) the breakdown across sectors in 2050



Vehicle-to-grid

Figure 29 shows how the uptake of vehicle-to-grid technology varies, reaching between 20% of the vehicle fleet in Patchwork Nation and 67% in Global Green Rush.

Figure 29: Uptake in vehicle-to-grid technology as a percentage of the total light passenger vehicle fleet



Smart vehicle charging

What is this?

The managed, flexible charging of EVs using technology that can control when and how quickly a vehicle charges in response to price signals, grid conditions, or user preferences. Smart charging systems shift EV demand to times when electricity is cheaper, cleaner, or more abundant.

Why is it important?

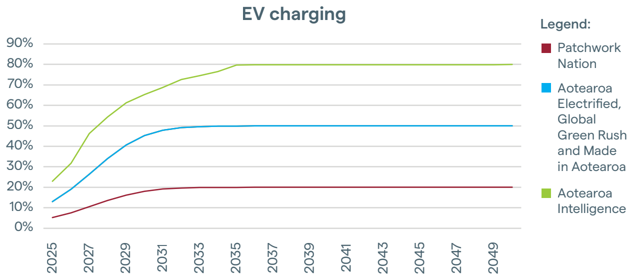
Smart vehicle charging helps shift demand away from peak periods and reduces strain and congestion on the grid. It can also coordinate large numbers of EVs so they collectively support system balancing, improve utilisation of renewable generation, and minimise the need for network upgrades.

Our assumptions

Figure 30 shows how smart charging varies across the scenarios. Scenarios Aotearoa Electrified, Global Green Rush, and Made in Aotearoa have identical smart charging assumptions, reaching 50% of all charging by the mid-2030s. Patchwork Nation reaches 20% and Aotearoa Intelligence reaches 80%.

Our assumptions are based on information drawn from MBIE's consultation **Supporting the uptake of Smart Electric Vehicle charging in New Zealand**; EECA's publication **Electric Vehicle Charging Technology - A New Zealand Residential Perspective** and internal Transpower analysis.

Figure 30: Percentage of EV charging that occurs off-peak



Demand response and deficit

What is this?

Demand response is the ability of consumers or devices to actively reduce their electricity use in response to price signals, system needs, or grid constraints. It provides load that can be turned down to help balance the system without requiring additional generation or network upgrades.

Deficit describes periods where available load flexibility or generation is insufficient to fully meet demand, even after all demand response options have been activated. It represents 'unmet demand' that the system must record as an energy shortfall.

Why is it important?

Both factors reveal how costly it is for the power system to come under such stress that load reduction occurs.

Our assumptions

Demand response

Table 1 shows our assumptions which are applied after all CER and flex services are exhausted. When demand response occurs, the load is removed, not shifted. Up to 15% of demand can be reduced economically.

Deficit

Deficit is assumed to occur when the system needs to shed more than 15% of demand. The cost of deficit is assumed to be $20,000 per MWh in all scenarios. Demand response and deficit assumptions are based on Transpower analysis and the Electricity Industry Participation Code.

Table 1: Demand response tranches according to scenario

Proportion of instantaneous demand	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
First 5% of demand	$3,000 per MWh	$5,000 per MWh	$5,000 per MWh	$3,000 per MWh	$1,000 per MWh
Between 5%-10% of demand	$4,000 per MWh	$7,000 per MWh	$7,000 per MWh	$4,000 per MWh	$2,000 per MWh
Between 10%-15% of demand	$6,000 per MWh	$10,000 per MWh	$10,000 per MWh	$6,000 per MWh	$3,000 per MWh

Generation resource adequacy

What is this?

The power system's ability to reliably meet demand, at all times, using the mix of generation available across normal conditions, peak periods, dry years, and low renewable events without relying excessively on emergency measures.

In our modelling, resource adequacy is tested by examining whether expansion plans can cover annual energy needs, meet peak demand, and maintain reliability even when renewable output is low or hydrology is stressed.

Why is it important?

Generation resource adequacy provides a clear test of whether scenarios can reliably meet demand across all conditions. Without checking adequacy, a generation mix might appear economically optimal but still fail to supply consumers during stressed conditions. It highlights where capacity shortages, energy shortages, or intermittency issues may emerge once detailed dispatch modelling is applied and ensures that scenarios include enough firm, flexible, and renewable balanced capacity to deliver the reliability standards expected.

Our assumptions

Capacity adequacy

Generation resource adequacy estimates are based on internal Transpower analysis of market data for generation availability.

Capacity adequacy refers to the system's ability to balance *short term variability* in supply and demand. We use a firm capacity constraint to ensure the model builds adequate supply. The firm capacity constraint works by summing the firm capacity in the system and ensuring it meets a certain minimum requirement. The firm capacity factors applied to different technologies are shown in Table 2, and these are applied to all scenarios. The thermal capacity factor should be considered in connection with the thermal fuel availability assumptions discussed in the next section.

Table 2: Firm capacity factors applied by technology

Plant technology	Firm capacity factor (p.u)
Hydro plant	0.8
Thermal plant	0.9
Wind[10] and Solar	0.07
Battery	1

10 Assumed coincident generation output on a still night at peak demand

The firm capacity requirement is set by defining it as a fraction of peak island demand. We vary the firm capacity requirement across scenarios, as shown in Table 3.

Table 3: Firm capacity requirements as a fraction of peak (island) demand

	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Firm Capacity requirement	Low	High	High	Medium	Low
North Island	0.7	0.85	0.85	0.75	0.7
South Island	0.8	0.95	0.95	0.85	0.8

Energy adequacy

This refers to the system's ability to manage *long term* supply challenges, such as during dry years or extended periods of low renewable output. Table 4 outlines the different solutions across the five scenarios.

Table 4: Energy reserve capacity for dry years and extended renewable droughts

	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Energy reserve solution	Coal, gas, LNG, and diesel.	Coal, biomass, gas, LNG, and minor overbuild of renewables.	Biomass and significant renewable overbuild.	Biomass and LNG until 2040. Pumped hydro beyond 2040.	LNG, industrial and commercial demand response, and minor overbuild of renewables.

Thermal fuel availability and cost

What is this?

This refers to how much fuel, such as natural gas, coal, diesel, biomass or biogas, is accessible to run thermal power stations at any given time, and how much it costs. It encompasses supply chain factors such as existing stockpiles, production rates, gas storage levels, delivery constraints, outages on gas production or transmission systems, and seasonal patterns in supply.

In practice, thermal fuel availability determines how much thermal generation can be counted on to support security of supply, especially during periods of peak demand, low renewable output, and dry years.

Why is it important?

Incorporating realistic assumptions about fuel availability ensures that the grid blueprint reflects actual operational limits, avoids overestimating firm capacity, and supports robust planning decisions for both near and longterm system resilience.

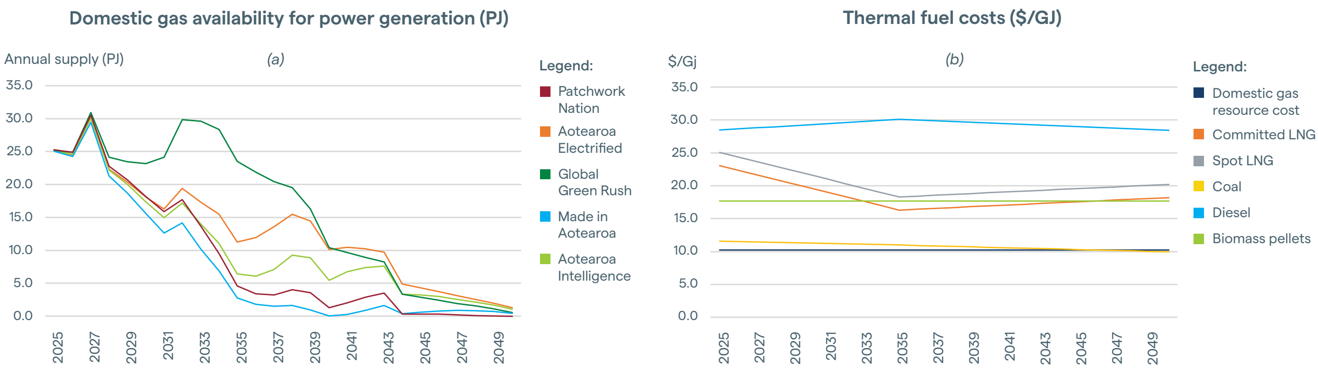
Our assumptions

Our assumptions around the availability of domestic gas, LNG, biomass, diesel and coal are outlined in Table 5. Figure 31 shows (a) the domestic gas available for power generation, which varies by scenario, and (b) the thermal fuel costs, which do not vary by scenario. Our assumptions are drawn from emsTradepoint data, the **Gas Industry Co Supply and Demand study 2024** and our own **Industrial Electrification Survey** data.

Table 5: Thermal fuel availability and cost across the five scenarios

	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Domestic gas availability for power generation	18 PJ in 2030 decreasing to 0 PJ in 2050	18 PJ in 2030 decreasing to 2 PJ in 2050	23 PJ in 2030 decreasing to 1 PJ in 2050	16 PJ in 2030 decreasing to 1 PJ in 2050	17 PJ in 2030 decreasing to 2 PJ in 2050
LNG availability	Available in 2030	Available in 2029	None	Available in 2028	Available in 2028
Biomass pellets availability	No biomass	Unconstrained supply for Huntly Unit 2	Unconstrained supply for Huntly Unit 1 and 2	Unconstrained supply for Huntly Unit 2	No biomass
Diesel availability	Unconstrained supply	Unconstrained supply	Unconstrained supply	Unconstrained supply	Unconstrained supply
Coal availability	Unconstrained supply	Unconstrained supply	Unconstrained supply	Unconstrained supply	Unconstrained supply

Figure 31: Domestic gas availability for power generation (a) and Thermal fuel costs (b)



Carbon and New Zealand Units price

What is it?

The expected future prices of New Zealand Units (NZUs) under the ETS. These assumptions represent how costly it will be to emit greenhouse gases over time, influencing the relative economics of carbon emitting generation versus renewable alternatives.

Why is it important?

Carbon costs shape both long-term generation investment and short-term dispatch decisions. They influence both the economics of future generation and the overall pathway of the country's energy transition.

Because carbon costs shape dispatch outcomes, investment timing, electricity prices, and longterm system configuration, consistent NZU price assumptions are essential for building credible scenarios and ensuring the grid blueprint reflects realistic futures for emissions policy and market behaviour.

Our assumptions

Our Carbon and NZU price assumptions are sourced from emsTradepoint while our NZU futures prices are sourced from ASX and New Zealand Treasury's values found here. We have a low, medium and high forecast; all shown in Figure 32. Our scenario assumptions are shown in Table 6.

Figure 32: Carbon price assumptions

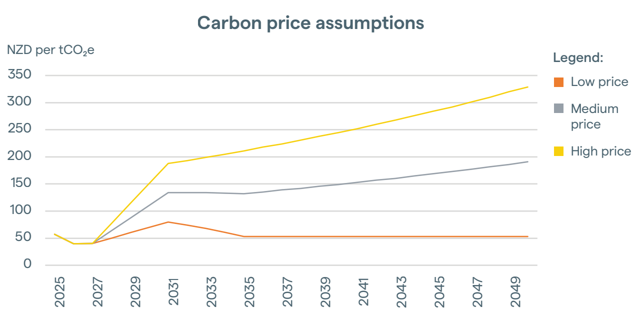


Table 6: Scenario assumptions for carbon prices

Scenario	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Carbon Price	Low	Medium	High	Medium	Medium

Thermal plant retirements

What is this?

The expected closure of thermal generation units when they reach their end of life. Retirements can occur because equipment has aged beyond its viable operating life, midlife refurbishment is not pursued, or because evolving market conditions make continued operation uneconomic.

Determining a retirement date is complex: factors such as refurbishment decisions, fuel availability, emissions costs, and policy or regulatory settings all influence whether a plant continues operating or exits earlier than expected.

Why is it important?

Retirements determine when key sources of firm, dispatchable generation will leave the system, directly affecting future reliability and generation adequacy. Incorporating realistic retirement assumptions ensures the grid blueprint accurately identifies when replacement capacity, transmission upgrades, or new flexible resources will be needed.

Our assumptions

Table 7 outlines the dates for thermal retirements assumed in our scenarios. These are based on life expectancy of different plants and have been adjusted to align with the internal scenario narrative. Our assumptions are drawn from information contained in MBIE's **2020 Thermal Generation Stack Update Report**.

Table 7: Thermal retirement dates across scenarios

Scenario		Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Type	**Plant**					
Coal	Huntly Unit 1	Beyond 2050	2035	2035	2035	2035
	Huntly Unit 2	2035	2040	2035	2040	2035
	Huntly Unit 4	2035	2035	2035	2035	2035
Peakers	Huntly Unit 6 (P40)	Beyond 2050	2044	2044	2040	2044
	Whirinaki	2029	2029	2029	2029	2029
	Stratford Peakers	Beyond 2050	2035	2035	2040	2035
	Junction Road	Beyond 2050	2045	2045	2040	2045
	McKee	Beyond 2050	2038	2038	2038	2038
	Bream Bay Peaker	2035	2035	2035	2035	2035
Other gas	Huntly Unit 5 (e3P)	2037	2037	2037	2037	2037
	Taranaki Combined Cycle (TCC)	2026	2026	2026	2026	2026
Cogeneration	Kapuni	2040	2040	2040	2040	2040
	Hawera	2026	2026	2026	2026	2026
	Edgecumbe	2026	2026	2026	2026	2026
	Glenbrook	2035	2035	2035	2035	2035

Generation expansion restrictions

What is this?

The limits on how much, or how quickly, new generation capacity can be added within a planning model or future scenario. Constraints are used to keep modelled build-outs realistic by recognising that projects cannot be deployed instantaneously due to real world barriers such as consenting, construction time, and workforce availability. Restrictions prevent the optimisation from assuming implausibly rapid transitions to the least-cost mix.

Why is it important?

These ensure the modelling reflects the real world pace at which new generation can practically be built. By incorporating realistic build limits, the grid blueprint can better identify when transmission upgrades will be needed to unlock timely investment and maintain reliability as the system transitions.

Our assumptions

The earliest build dates for new generation depends on technology and project stage. These are outlined in our technical approach. To reflect supply chain and workforce constraints, a maximum of 1GW capacity added per year for solar and wind is applied from 2025-2029. This constraint is relaxed after 2029.

Table 8 outlines the thermal build restrictions that have been applied to align with the scenario narratives. Assumptions are based on information shared during engagement with industry and internal Transpower analysis.

Table 8: Restrictions on thermal plant capacity build

Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
No new thermal build. Forced retention of Huntly and Taranaki peakers.	Allow gas generation to be built if economic. Rankines last until 2035 on coal. 1 Rankine runs partially on biomass from 2030.	No new thermal build. Force retirement of coal at 2035. Biomass assumed to run on two Rankines.	Allow gas generation to be built if economic. Biomass available.	Limited gas generation can be built if economic. Battery preference created via cost. Rankines run until 2035 on coal.

Forced generation expansion decisions

What is this?

Instances where specific generation projects are manually included, or "forced" into the model, rather than left for the optimisation to choose. This occurs when certain builds are either 1) known to be happening or 2) represent such uncertainty to Transpower, that it is considered too risky to remain blind to the potential consequence.

Examples of 1) include committed projects once they reach a final investment decision or explicitly specifying replacement thermal capacity following a retirement. Examples of 2) include large binary build decisions such as offshore wind or giant pumped hydro projects.

Why is it important?

Forced builds ensure that the expansion plan aligns with real world commitments, policy expectations, and operational reliability needs, even when pure least-cost optimisation would produce a different, less practical outcome.

Applying forced decisions to large binary builds such as offshore wind and giant pumped hydro projects is important for two reasons.

Firstly, the project would have a significant impact on the transmission grid. By forcing the decision in some scenarios, we maintain visibility of what would be required, thereby improving our visibility of risk, without committing to a course of action.

Secondly, some projects may provide greater value to Aotearoa than what can be gleaned from a pure electricity market model. This is relevant in the case of both offshore wind and pumped hydro storage which could arguably provide additional economic and resiliency benefits which occur outside the electricity market.

Our assumptions

Table 9 outlines our forced generation build decisions as they apply to each scenario. The large demand for electricity in the Made in Aotearoa and Global Green Rush scenarios trigger big build decisions for offshore wind and pumped hydro. Assumptions are based on information shared during engagement with industry.

Table 9: Forced generation expansion build decisions

	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Offshore wind	None	None	1.5 GW Taranaki 1 GW Southland staged from 2034	1 GW Taranaki staged from 2038 1 GW Southland and 0.5 GW Taranaki staged from 2045	None
Pumped hydro	None	None	None	1 GW South Island from 2035	None

Regional wind and solar resource profiles

What is this?

These profiles describe how the availability and quality of renewable energy resources vary across geographic areas. They are essential for planning where renewable generation should be built, how it will complement other resources, and how much firm capacity or storage is needed to ensure reliability across the wider system.

Why is it important?

These are essential inputs because they reveal how renewable generation potential varies across the country and how those differences shape system design. By identifying which regions offer the most reliable or highest yield renewable resources, they inform decisions on how transmission should be reinforced to move energy from high resource areas to load centres.

Without these profiles, a grid blueprint would risk misallocating investment, over- or under-building storage, and missing opportunities to leverage natural geographic diversity to improve reliability and reduce system costs.

Our assumptions

These profiles capture hourly or seasonal patterns in wind speeds and solar irradiation, typically derived from datasets such as global reanalysis models or local measurement campaigns.

We use our best estimate for regional wind and solar resource profiles using the most up-to-date information we have, which is shown in Table 10. For this reason, the resource profiles do not vary by scenario. Our assumptions are based on **MBIE's publication Wind Generation Stack update**.

Table 10: Regional resource (wind and solar) annual capacity factors according to region

Region	Wind capacity factor (%)	Utility solar capacity factor (%)	Distributed solar capacity factor (%)
Far North	43	24.5	-
Northland	41	24.8	22.3
Auckland	41	24.4	22.2
Waikato	40.2	24	21.7
Bay of Plenty - Taupō	38	23.9	22
Eastland	42	23.7	21.5
Central Plateau	40	22.1	20.5
Hawke's Bay	41	24.2	21.8
Taranaki	43	23.8	21.3
Manawatu	38	23.3	21.2
Wairarapa	47	23.7	-
Wellington	47	-	21.9

Region	Wind capacity factor (%)	Utility solar capacity factor (%)	Distributed solar capacity factor (%)
Marlborough	43	24.5	21.8
West Coast	29	17.7	-
North Canterbury	43	23.5	20.7
South Canterbury	43	24.1	21.1
Otago	40	22.1	20.2
Southland	43	15.7	18.1
Offshore - Waikato	39.9	-	-
Offshore - Taranaki	53.4	-	-
Offshore - Southland	54.3	-	-

Generation capex costs

What is this?

Generation capex costs refer to the upfront capital expenditure required to build new electricity generation projects, covering all components needed to bring a plant into service.

Why is it important?

These capex costs are used to compare technologies, assess future build options, and project long-term investment pathways.

Our assumptions

Our generation costs assumptions are based on the **2025 Generation Stack Report**. The cost trajectories are varied across scenarios according to Table 11.

Table 11: Generation capex costs assumptions by scenario

Feature	Patchwork Nation	Aotearoa Electrified	Global Green Rush	Made in Aotearoa	Aotearoa Intelligence
Generation Costs	High.	High for new thermal generation and Medium for other technologies.	Low.	Low for new geothermal generation and Medium for other technologies.	Medium for new thermal generation and low for other technologies.
Reasoning	Weak currency and economy raises import costs.	Standard technology learning curves.	Global manufacturing boom drives rapid CAPEX reduction.	Economy of scale in deployment reduces unit costs.	Standard technology learning curves.

Large industry demand step changes

What is it?

Large industry step changes are sudden, significant increases (or decreases) in electricity demand caused by major expansions (or closures) of existing facilities.

Why is it important?

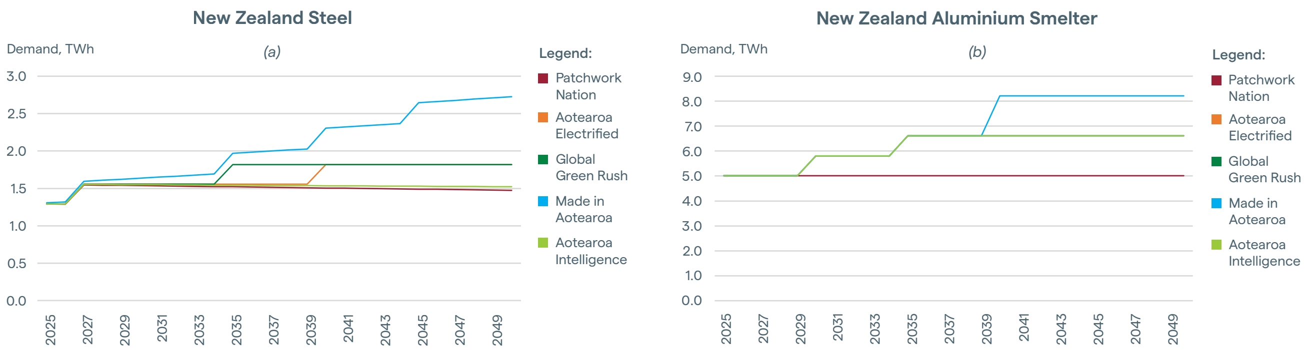
These jumps must be explicitly modelled to ensure the grid can support large industrial developments without compromising reliability or delaying electrification ambitions.

Our assumptions

We assume varying levels of step changes in demand at the New Zealand Aluminium Smelter and New Zealand Steel. These are shown Figure 33 (a) and (b), respectively. Assumptions are based on information shared during engagement with industry.

Ballance and Methanex closures are assumed to occur in 2025 and 2027, respectively.

Figure 33: Large industry demand step changes (a) New Zealand Steel and (b) New Zealand Aluminium Smelter (NZAS)



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