TRANSPOWER

Whakamana i Te Mauri Hiko

Monitoring Report

March 2023

The Whakamana i Te Mauri Hiko Monitoring Report indicates how New Zealand is tracking against our energy futures

Our monitoring report series

In 2020 Transpower launched Whakamana i Te Mauri Hiko (WiTMH). This work took a scenario-based approach to consider what the future may look like in the year 2050 and the actions required to get us there.

The Monitoring Report is designed to identify, within the key drivers of Whakamana i Te Mauri Hiko, those factors that are consistent—or vary—from the expected course of our scenarios.

By publishing these six-monthly reports, we want to share with the rest of Aotearoa the trends we observe on our journey to decarbonise our economy. We aim for this to be a discussion and an industry resource, so we welcome feedback and suggestions on how to improve our monitoring. If you have comments please send them to: communications@transpower.co.nz

For all our reports in the Te Mauri Hiko series, visit https://www.transpower.co.nz/about-us/transmission-tomorrow

This edition

As we get a better understanding of the underlying electrification and decarbonisation trends, and have access to richer, more comprehensive data, we are continuously improving this report to bring readers newer, and more relevant insights.

What you might notice is that some of the data may not be refreshed every edition, and for some sources, the latest data refers to previous years. This is because some data sources are only published annually. However, the indicators we've chosen help tell New Zealand's story.

Since having published Whakamana i Te Mauri Hiko, we have seen other scenario work emerging across the industry. If they are looking at different aspects of the energy sector, they are broadly consistent with our findings: by 2050, demand for electricity will increase as we decarbonise Aotearoa's economy. However, the way to get there might differ, especially as technology, costs, and policy considerations continue to evolve.

In this edition, we are illustrating some of these changes, including new low-emissions options and alternative fuels.

We also want to highlight three domains in particular that we did not consider when we released our initial work:

- How sustainable aviation can become a significant demand driver for the electricity sector;
- A high-level impact of MBIE's published hydrogen scenarios on the electricity demand; and
- How grid scale solar generation is rapidly taking over its distributed alternative.

The associated studies remain at a high level, and as for all our Whakamana i Te Mauri Hiko work, they are intended to start a discussion. We welcome industry feedback on what you think the implications could be for the sector, and our collective responsibility to service Aotearoa's energy needs.

Our Whakamana i Te Mauri Hiko scenarios

The base case:
Accelerated Electrification

A realistic yet aspirational future, that anticipates large-scale transformation of energy in New Zealand

Tiwai Exit:
Electric Tiwai Exit

A variation of *Accelerated Electrification* where the Tiwai Aluminium smelter exits around 2025

Higher demand:
Mobilise to Decarbonise

Higher demand for electricity is driven by significant and rapid efforts to mitigate climate change after years of 'sitting on our hands'

Slower case:
Measured Action

A variation of *Accelerated Electrification* where transport electrification is slowed by factors such as policy or technology

Lower case:
Business as usual

Significant electrification fails to eventuate and other climate change mechanisms such as forestry abatement are prioritised

At a glance: New Zealand stays on course for the *Accelerated Electrification* scenario, supported by positive signs of electrification growth

Summary

In our last update, we reported that New Zealand is in the early phases of a new period of electrification growth. Since then, our key indicators continue to point towards growth in electrification of transport and process heat. We are observing enquiries starting to convert into committed projects on the supply side, and a corresponding response from the demand side through a strong pipeline of new customer connections. We expect this trend to continue as investors and developers invest in decarbonisation and we push to meet our energy and decarbonisation targets.

However, these tailwinds are dampened by challenges from peak demand, higher and more volatile energy prices, renewable energy project economics, as well as global energy and geopolitical instability. These issues prevail and remain as headwinds in our indicators.

There are emerging green shoots, including data centres, biomass, aviation fuels and hydrogen which could materially shift the future of energy in New Zealand. Our assumptions of the future decarbonisation pathways are being reset by the potential of these low carbon technologies, fuels and new demand sources. This includes the uptake of more mainstream technologies such as utility scale solar, hybrid passenger vehicles and more efficient residential heat pumps. These will create new challenges, but also opportunities, such as demand response and flexible storage and firming for renewable generation.

Together, these signs confirm that we are still in the stages of a push towards a more renewable electricity system and a new period of electrification growth. For this reason, New Zealand could remain on the base case *Accelerated Electrification* trajectory.

How our indicators are tracking against our forecasts

Renewable utility scale generation interest is large enough to meet 2050 forecasted demand from electrification. — ▲ Consistent

Emissions reduction continues to be a concern for New Zealand and the rest of the world, but policy needs to incentivise action. — ● Inconsistent

Electricity demand growth is slow due to industrial load reductions, but there are strong signs of potential new growth on the way. — ▲ Consistent

Drivers of base demand is slowly recovering from the COVID-19 pandemic, but future growth is uncertain. — ● Uncertain

Overall energy efficiency and energy intensity continues to improve. — ▼ Consistent

Industrial energy users are still relying on fossil fuels, rising costs are causing issues and new entrants are also on the way. — ● Uncertain

Process heat decarbonisation continues to increase supported by Government, driving growth in electricity and biomass. — ▲ Consistent

Electric vehicle numbers continue to push higher boosted by transport policy, but hybrids continue to dominate uptake. — ▲ Consistent

Electric passenger vehicle costs are aided by the Clean Car Discount and lower running costs, but policy sends mixed messages. — ▲ Consistent

Battery technology and flexible demand is showing it can provide solutions to help meet peak and energy demand. — ▲ Consistent

Distributed solar installations continue to increase with long term costs falling, but growth is slower than expected. — ● Uncertain

Capability to meet energy demand and peak demand is being challenged, as we transition to a more renewable system. — ● Uncertain

Electricity affordability needs to be maintained, as the transition to a highly renewable energy system to meet targets is underway. — ● Uncertain

Progress against the ten Whakamana i Te Mauri Hiko industry themes is ongoing and may shift with future energy policy. — ▲ Consistent

In the spotlight: Three major technology changes since we published WiTMH that will impact Aotearoa's decarbonisation journey

Aviation decarbonisation will be complex, and electricity is central

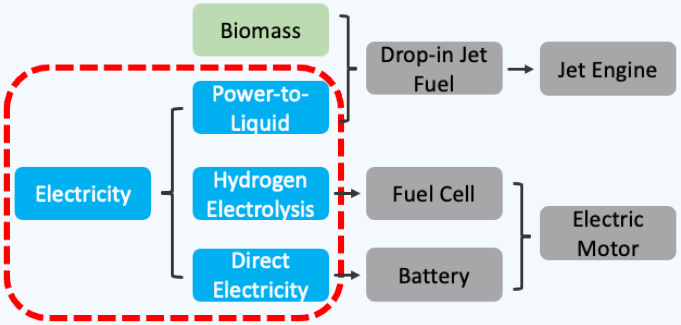
Aviation emitted 4.9 Mt CO_2 in 2019, equal to around 9% of NZ's net emissions. And, although air travel experienced a hiatus during COVID-19, it is already returning to pre-COVID levels with further expectations that global air travel will double by 2040. However, aviation is a challenging sector to decarbonise. NZ has poor alternative travel options given our geographical isolation. The physics of flight also present technical challenges to the use of batteries and hydrogen (H_2) gas.

However, the future is likely to see a mix of battery-powered, liquid H_2, and Sustainable Aviation Fuel (SAF) drop-in fuel replace traditional jet fuel. While some SAF can be made with biomass, competition for scarce land resources with other uses will limit its applicability as a feedstock.

Irrespective of the ultimate technology mix, the decarbonisation of aviation will significantly increase electricity demand. Many factors will determine the extent of the increase (e.g. economies of scale, technology readiness, network effects). Looking forward, aviation will be an important area to watch.

Pathways to net zero aviation

Almost all pathways involve increases in electricity demand



The potential demand growth from green hydrogen is enormous

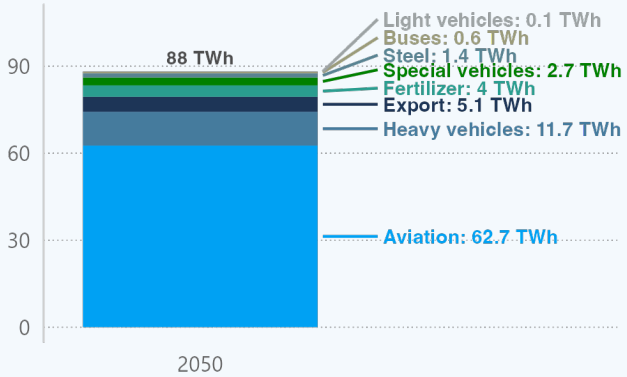
Our original WiTMH report in 2020 looked at electrification of the existing grid. Since then, the Government has started to focus on green hydrogen as one potential low carbon option to decarbonise our economy and export renewable energy.

MBIE recently published a report on hydrogen scenarios, which estimated the potential demand growth from key sectors in NZ. These estimates are subject to a wide range of uncertainty over factors such as technology splits in aviation and the price of both electricity and H_2 internationally and in NZ, and the technologies to store and transport H_2 at large scales.

The chart below illustrates the potential electricity demand that could result if all this H_2 was produced in NZ. In total, this amounts to over 88 TWh – for reference, the total national demand estimated in the *Accelerated Electrification* scenario was only ~70 TWh. The largest sector is aviation (71%), followed by heavy transport (13%) and fertilizer (4%). A further 6% could arise from export through initiatives like the Southern Green Hydrogen Project.

Potential green H_2 electricity demand

TWh, assuming 75% electrolysis efficiency



Source: MBIE Hydrogen Scenarios. Last updated June 2022.

Grid-connected solar is likely to vastly outgrow residential

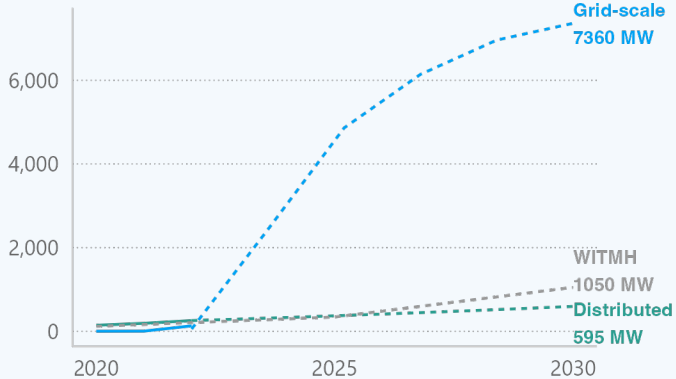
The original *Accelerated Electrification* scenario projected 6 GW of solar by 2050, with the majority (83%) of this coming through distributed (i.e. embedded) solar and only 1 GW of grid-scale solar. Since the publication of this work in 2020, new information is now leading us to revise these expectations.

The below chart shows the actual and projected growth of grid-scale and distributed solar out to 2030. By 2030, the original projection was for 1,050 MW of solar in total, all of which is distributed. However, while distributed solar continues to grow, the projections show that we estimate the uptake of grid-scale solar could exceed all expectations and outpace distributed solar, with a potential of 7,360 MW connected by 2030.

This estimate is based on enquiries lodged with Transpower that have a plausible chance of completion. While all of this solar might not be developed (or at least not before 2030), grid-scale solar has emerged as a central technology that we will need to consider carefully to maintain secure system operations.

Distributed vs grid-scale solar

MW capacity, with projected growth out to 2030



Source: Transpower grid enquiries and EMI. Last updated March 2023.

Capability to meet energy demand and peak demand is being challenged, as we transition to a more renewable system

Uncertain

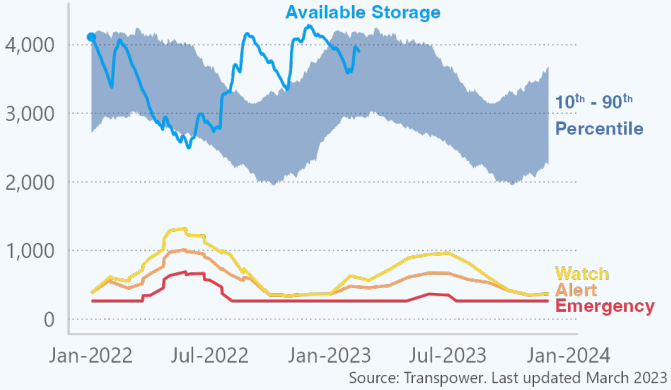
A year of two halves with a dry start and wet end to 2022

The industry needs to ensure there is enough electricity to meet energy demand, particularly during dry years when low rainfall impacts hydro generation. Transpower regularly assesses New Zealand's security of supply outlook to help the industry with decision making to avoid shortages.

The trend of La Niña climate conditions continue to impact New Zealand. This again resulted in below average rainfall in 2022 in the hydro catchments during summer and autumn, followed by above average inflows in the second half of the year during winter and spring. Current storage levels remain comfortably above the risk curve due to these higher inflows and increased gas production from Maui and Pohokura production facilities. Looking ahead, the 2023 Security of Supply Outlook is expecting La Niña conditions to extend into early 2023 and continued stable gas production. Following the first "triple-dip" La Niña since the 1970s, the climate is expected to shift towards ENSO-neutral (El Niño and the Southern Oscillation) during 2023. In the long term, large-scale storage and flexible demand could have a role to play in the future of security of supply.

Electricity risk status curve

Available storage, GWh



Source: Transpower. Last updated March 2023

Uncertain

Generation capacity exists to meet peaks but some growing concerns

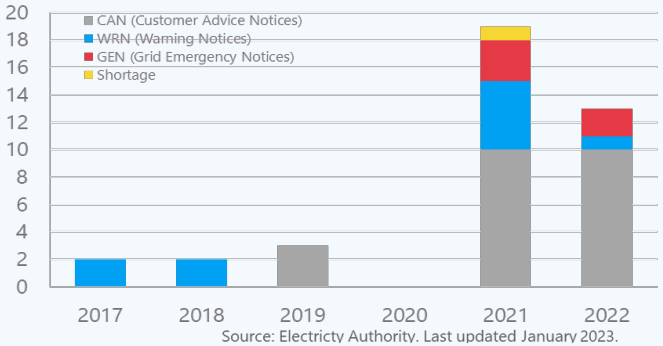
Half of New Zealand's thermal generation capacity is slow-start and not designed for peak capacity requirements. Compounding this is the total installed wind generation has increased more than 50% since 2019. This puts the power system at increased risk due to potential plant breakdown or material deviation from generation forecasts.

The System Operator has released a paper noting the winter peak capacity challenges over the next 3 years. It highlights the risk of capacity shortfalls without firm generation or demand response.

Further delays in build of new firm generation and demand side response increase the risk to meeting future peak demand. According to the EA's work on managing peak demand, there are signs that operational coordination issues are becoming more challenging. One indicator of capacity risk in the transition is the number of times the system had less than 200 MW of projected headroom in the supply stack. Notices indicating these situations and their frequency have increased significantly in the last few years. This is shown in the chart below.

Grid notices issued (generation shortfall)

Count by event, calendar year



Source: Electricty Authority. Last updated January 2023.

Uncertain

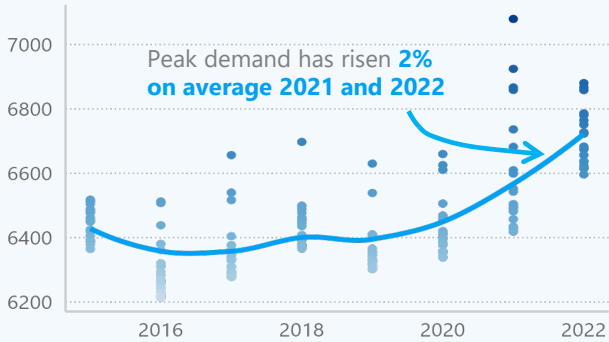
Firm capacity needed to meet peak demand growth and replace plant retirement

Recent peak electricity demand has raised concerns for potential capacity issues during peak demand periods. Analysis published by the Electricity Authority has confirmed that the removal of RCPD is associated with a 157 MW increase in daily peak demand – or about 2.2% of national demand. The top 10 largest peaks have all occurred in the past two winters; 6 out of those 10 occurred in 2022 – despite these winters being the warmest on record. Peak demand growth has risen 2% on average in both 2021 and 2022, being an increase of ~138 MW of demand per year. Several contributing factors include underlying demand growth (masked by warmer temperatures) and cold winter snaps.

New investment headwinds are starting to arise with the potential risk of new renewable projects being delayed and thermal generation retirements. For example, Contact Energy expects Taranaki Combined Cycle (TCC) will retire in 2024 after Tauhara geothermal power station commences operation. Peak demand is expected to grow as electrification of load ramps up. Looking forward, more flexible capacity will be needed, as well as non-network solutions like demand response.

20 Highest Daily Peaks Each Year

MW, 2015-2022



Source: Transpower. Last updated March 2023.

Renewable utility scale generation interest is large enough to meet 2050 forecasted energy demand from electrification

Consistent

Generation pipeline large enough to meet 2050 forecast energy demand

In the last two years, there has been a significant increase in the volume of announcements from potential developers of new generation. While not all of this pipeline will eventuate in built projects, the volume is a good indicator of developer appetite.

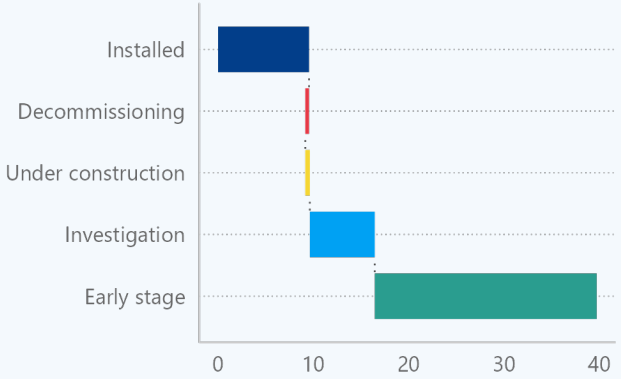
Transpower's view of the total potential capacity of generation in the pipeline has increased by 3 GW in the last six months to 30 GW. However, 23 GW of potential interest is still in the early stages of investigations. Overall, this signals strong and growing interest in renewables, large enough to meet the *Accelerated Electrification* demand forecast of 22 GW and 70 TWh by 2050.

Forsyth Barr expects 34 GWh (13 GW) of energy by 2050 from both listed generation companies and others who have announced renewable electricity generation projects.

However, as most of this is variable renewable energy from wind and solar, it may require firming to produce enough capacity at any one time to meet peak demand (MWp) needs of the system.

Forecast utility scale generation pipeline

GW, includes generation decommissioning by the end of 2023.



Source: Transpower. Last updated March 2023.

Consistent

Solar and wind dominate new generation enquiries by technology

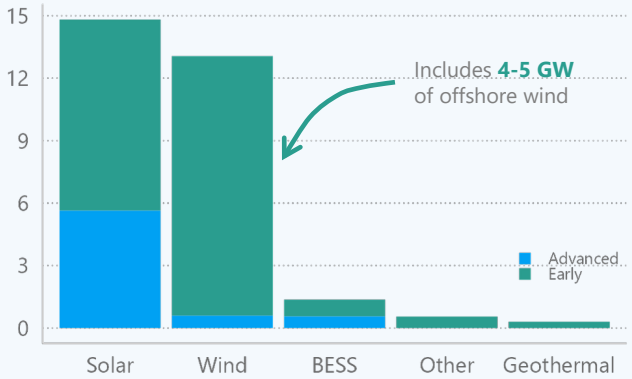
Of the new generation in the pipeline, approximately half of this interest is for grid scale solar with 14.8 GW (49%), followed by wind generation with 13 GW (43%). This interest exceeds our Accelerated Electrification scenario, which projected 6.5 GW of wind generation capacity by 2050.

One of the key drivers for the growth in wind enquiries is the recent and significant interest in offshore wind. Of generation enquiries for wind, around 4-5 GW of interest is for offshore wind projects. The government has committed to supporting the development of offshore wind. This includes developing a regulatory framework specifically for offshore renewable energy, in conjunction with work on a national energy strategy and a roadmap for development and use of hydrogen.

As at March 2023, there is approximately 8.5 GW of generation connection projects that Transpower has accepted application requests for new connections.

Breakdown of enquiries by generation type

GW. Excludes projects in delivery.



Source: Transpower. Last updated March 2023.

Uncertain

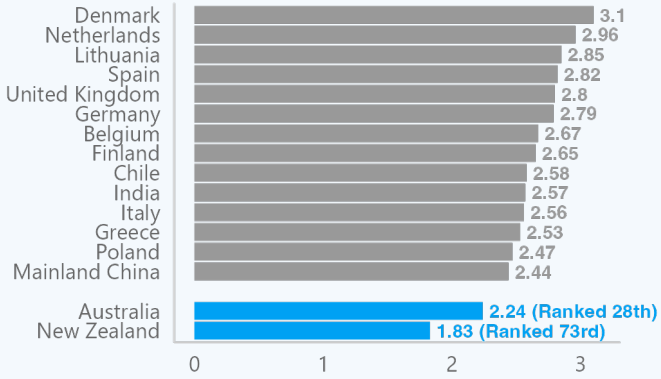
NZ does not score well compared to other countries to attract renewable energy project investment

According to Cimate Scope, New Zealand does not score well compared to other countries to attract renewable energy projects. It ranks 73rd out of 136 countries for the most attractive markets for renewable energy project investment. Globally, countries are competing for skills, labour, materials and investment to meet the challenge of electrification. Ensuring a strong clean-energy friendly policy environment will make countries more attractive for investment.

According to Westpac Bank, some New Zealand energy development projects are facing cost inflationary pressures from rising global inflation. We expect that the higher interest rates will make it harder to finance renewable electricity generation projects which are more sensitive to the cost of capital as they carry a much higher capital to operational expenditure ratio. In addition to generation investment, Boston Consulting Group expects $30 billion dollars of transmission and electricity distribution infrastructure is needed in the 2020s.

Attractiveness by country for RE projects

Ranking score by country



Source: 2022 ClimateScope BloombergNEF. Last updated Dec 2022.

Emissions reduction continues to be a concern for New Zealand and the rest of the world, but policy needs to incentivise action

Inconsistent

Global concern is high with emissions causing global warming

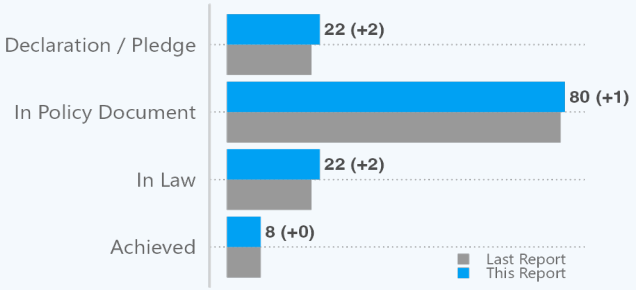
Countries and companies around the world are increasingly recognising the need for climate action, so that the globe avoids the catastrophic consequences of inaction.

In November 2022, the 27th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP27) took place in Egypt. COP27 resulted in countries delivering a package of decisions that acknowledged their commitment to limit global temperature rise to 1.5 degrees above pre-industrial levels. In March 2023, the Intergovernmental Panel on Climate Change (IPCC) released a Synthesis Report, which identified that emissions will need to be halved by 2030, if warming is to be limited to 1.5°C and escalating hazards such as weather extremes are to be reduced.

Since September 2022, an additional 5 countries have introduced net zero carbon targets. Currently, approximately 88% of the world's emissions are covered by net zero carbon targets. Despite this, however, global greenhouse gas (GHG) levels still reached their highest levels on record in 2021 and the IPCC has confirmed that 1.1°C of global warming has occurred from the burning of fossil fuels and unsustainable land use.

Countries with policies committed to net zero carbon by 2060 or earlier

Number of countries



Climate Action Tracker. Excludes countries with targets under discussion. Some European countries do not have a separate target from the EU.

Uncertain

New Zealand government stops short of making changes to ETS

New Zealand's emission reduction targets:

- **Domestic net zero target:** NZ legislation outlines a domestic target to reduce emissions to net zero by 2050 (other than biogenic methane). In addition to these targets there will be five-yearly interim targets in the form of emissions budgets.
- **International target:** Under the Paris Agreement NZ has a target of 50% of net emissions below our gross 2005 level by 2030. This target can be met through both domestic action and offshore mitigation.

Policy direction for the energy sector continues to be formed:

- In October 2022, the Government released a terms of reference for the **New Zealand Energy Strategy,** being developed by MBIE for 2024. The Government also released a terms of reference for the **Gas Transition Plan**. Gas Industry Co is working with MBIE to develop the plan by 2023.
- In December 2022, the Government did not adopt the advice of the Climate Change Commission to make new changes to unit limits (volumes) and price settings for the **Emissions Trading Scheme (**ETS). The changes would have put upward pressure on costs for carbon intensive fuels and accelerate the transition to lower carbon solutions. According to a Cabinet paper, it appears the Government needed to consider the trade-off between higher prices to achieve sufficient emissions reductions and the corresponding economic impacts on households and the economy. The CCC is due to provide its next advice on ETS settings in April 2023, on the back of the recent March 2023 NZ ETS auction which failed to clear any volume.
- In March 2023, the Ministry for Environment (MfE) released a consultation document that is reviewing the NZ ETS. It will assess whether additional changes are needed to incentivise gross emissions reductions to assist with the first emissions reduction plan (ERP), including the role of emissions pricing.

Sourced from various media updates. Last updated March 2023

Inconsistent

Greenhouse gas emissions have not yet begun to decline

Since 1990, New Zealand's net GHG emissions have grown an average of 0.8% per year, a total increase of 26% due to the underlying increase in gross emissions. In the latest Greenhouse Gas Inventory, total gross emissions decreased 3% between 2019 and 2020, and net emissions decreased by 5%.

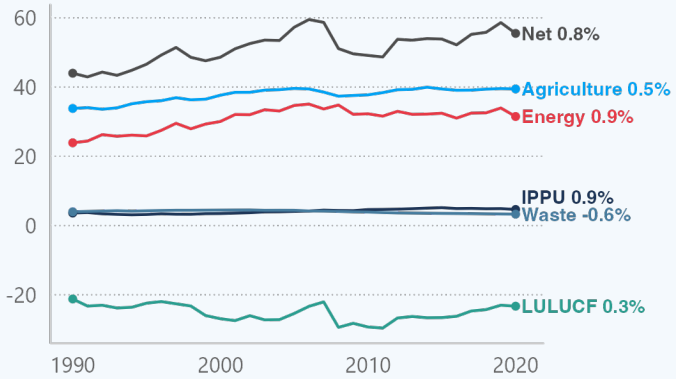
Emissions from the energy sector (including transport) in 2020 were 32% higher than in 1990.

Between 2019 and 2020, emissions from the energy sector decreased by 7%. However, this decrease was primarily due to impacts from COVID-19 which were felt across the sector. This saw decreases in emissions from road transport, domestic aviation and manufacturing.

Changes in emissions by sector will become evident in future data releases when the 2021 data is released from Government.

New Zealand emissions by sector

Mt CO_2e, annual, with 1990-2020 CAGRs



Source: Ministry for the Environment. Last updated March 2023.

*IPPU stands for Industrial Processes & Product Use
*LULUCF stands for Land Use, Land Use Changes, & Forestry

Electricity demand growth is slow due to industrial load reductions, but there are strong signs of potential new growth on the way

Consistent

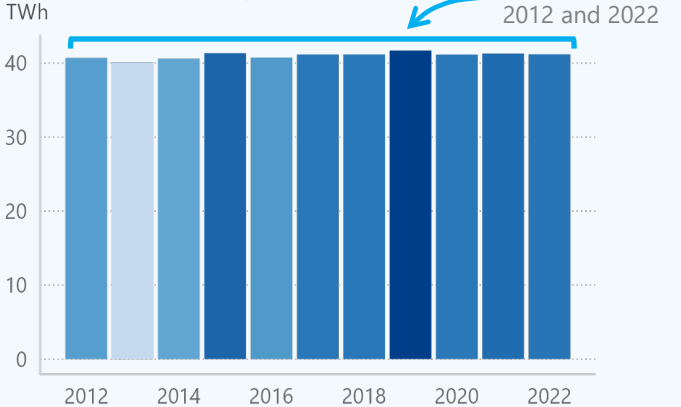
Electricity demand yet to materialise from potential green shoots

When we refer to demand we are referring to the volume of energy required to meet consumer and system requirements and ensure reliability. In the chart below, electricity demand is met from both generation that is grid connected and embedded, such as rooftop.

Electricity demand has been relatively stable in recent years, increasing at an average of 0.1% per annum from 2012 to 2022. Whakamana i Te Mauri Hiko estimates a 68% increase in electricity demand by 2050 in *the Accelerated Electrification* scenario. This demand is expected to come primarily through the electrification of private vehicles and process heat.

Although we're not seeing a ramp up in annual demand yet, other indicators suggest that it is imminent. However, as we explain in this report (see our coverage on peak demand in slide 5), the energy system's capability to meet energy demand and peak demand is being challenged, as peak demand continues to rise.

Annual electricity demand



Source: Electricity Authority. Last updated March 2023.

Consistent

Grid capacity expansions signal potential future expected growth

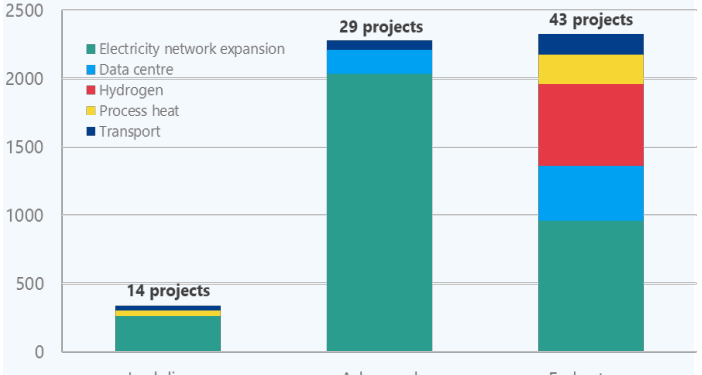
To meet forecast demand needs from anticipated increases in electrification of new and existing end uses, customers require expanded or new connections to increase grid capacity.

The chart below shows that there is almost 5,000 MW of total potential new grid capacity from active customer projects in the pipeline. 4,600 MW of this is at early and advanced stages of the connection process. It is expected that much of this will mature to delivery stage – requiring expansions or build of new connections to accommodate future step increases in demand.

This signals a speed of change in the electricity landscape, with greater electrification of industry and transport, new datacentres and major new residential developments. In total there are 86 active customer projects in the pipeline. Many of these are in the North Island where approximately 2/3 of projects are located. This confirms that EDBs are now beginning to forecast load increases as part of their network planning.

Breakdown of electricity grid load pipeline

MW, excludes propsective and commissioned projects



Source: Transpower. Last updated March 2023.

Uncertain

Industrial load reductions weighing on demand growth

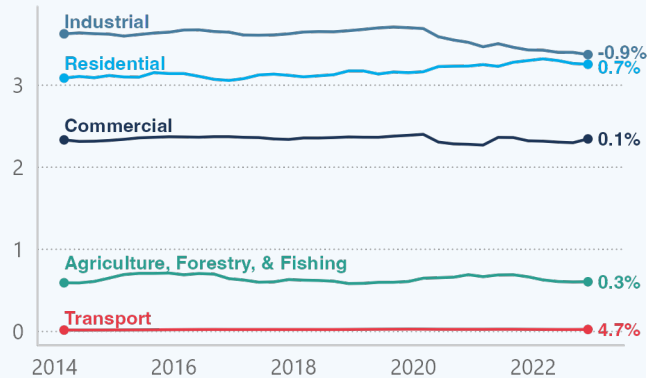
Electricity demand across the different sectors has been stable over the past ten years, in line with the country's total demand.

Electricity demand was soft across many of the key sectors in 2022, down 1.4% compared to 2021. The industrial sector continues to observe a decline in demand, largely due to closure of plant, curtailed operations due to higher electricity prices and the effect of COVID-19. However, there are indications of likely step changes in industrial load in the future from switching to electricity and/or dual fuel such as biomass.

Demand for the residential sector has been growing by around 2% per annum over the prior two years, due to a higher number of ICP connections from a boom in residential building consents and higher electricity consumption per ICP, partly due to increased working from home. However in 2022 total residential consumption decreased by -1.4% compared to 2021 compared to its long term average of 0.7% growth.

Electricity demand by sector

TWh quarterly, rolling 4 quarter average, CAGRs 2014-2022



Source: MBIE. Last updated December 2022.

Drivers of base demand is slowly recovering from the COVID-19 pandemic, but future growth is uncertain

Uncertain

Population rebounds in 2022, but is expected to remain slow

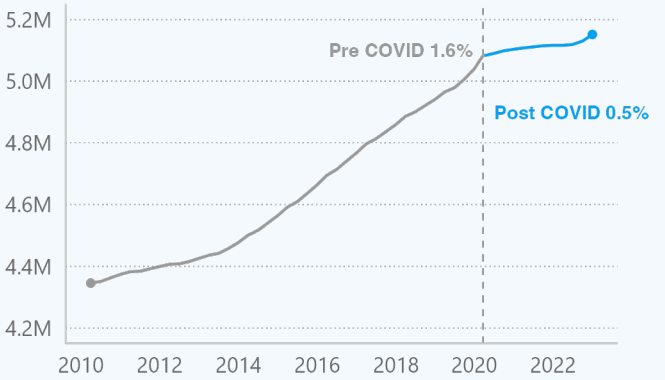
Because each New Zealander consumes electricity in their day-to-day life, population is an important driver of base demand. When excluding the impacts of increasing energy efficiency, we can expect base demand to increase with population growth.

Prior to COVID-19, the New Zealand population was growing at 1.6% per annum since 2010. Since COVID-19, our population has grown at just 0.5%. This was driven by a net migration gain from non-New Zealand citizens in the second half of 2022, and following the progressive relaxation of COVID-19-related border restrictions and coinciding with changes to immigration settings.

According to Stats NZ population projections, New Zealand's population growth is expected to slow in the long term, due to an aging population and a low birth rate. We expect North Island population growth to grow faster than the South Island with the population of Auckland reaching 2 million by 2040.

Estimated NZ resident population

Millions of people, annual (with CAGRs)



Source: Stats NZ. Last updated December 2022.

Inconsistent

The New Zealand economy is facing challenges in the near term

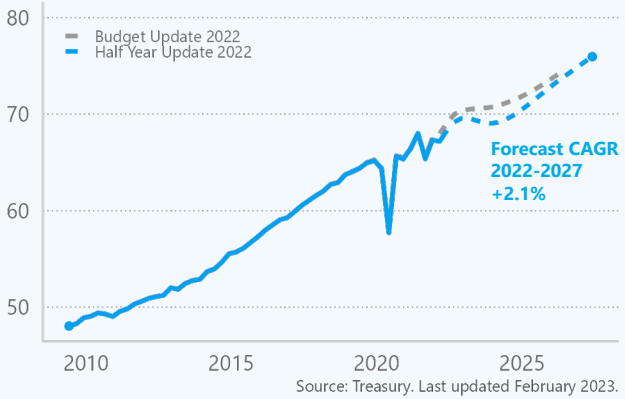
Economic activity is also a driver of base electricity demand as businesses use energy to deliver their goods and services.

We can expect base demand to increase with economic growth, although some of this is offset by increases in efficiency. The changing composition of the economy (e.g. increasing share of services) will also have an impact on base demand as some industries are more energy intense than others.

The below chart compares the previous Budget Update 2022 to the Half-Year Update 2022. New Zealand grew at a solid pace over 2022, continuing the recovery from the COVID-19 pandemic and COVID-19 related government spending. But the outlook has become more challenging. Stats NZ announced GDP growth was -0.6% for the quarter ending 2022. GDP growth is forecast to slow in 2023 with a likely recession, before a gradual recovery in 2024. The outlook is uncertain because of the range and scale of the challenges present, including persistent domestic and global inflation and sharply higher interest rates.

Historical and forecast real production GDP

NZD billions, 2009/10 prices, quarterly



Source: Treasury. Last updated February 2023.

Consistent

Growth in ICP volume steady in line with historic average

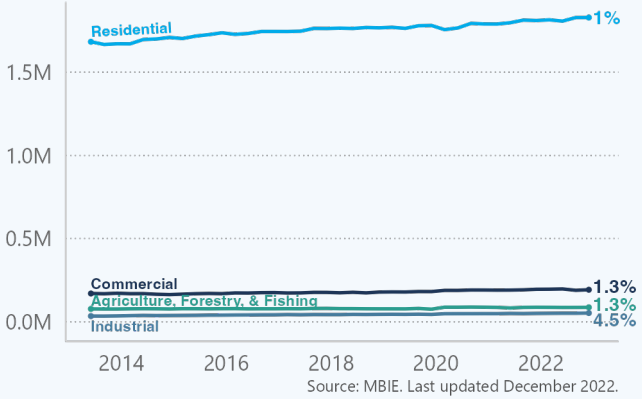
Installation Control Points (ICPs) are the physical points of connection on a local network. When new ICPs are added – for example when new houses are built – it is likely that there is an increase in electricity demand.

As with population and GDP growth, any growth in base demand will not be directly proportionate to ICP number growth due to energy efficiency and the specific consumer behaviours associated with those new ICPs.

In 2022, the total number of ICPs did not change significantly. The residential sector, the largest by ICP count, grew by 17,941 (+1.0%) compared to 2021, which is in line with the 10-year average. Decreases were observed in the agriculture, forestry and fishing sector by 509 (-0.6%) and in the commercial sector by 2,764 (-1.4%). The industrial sector increased by 2,170 (+4.3%).

Number of ICPs

Millions of ICPs, quarterly, 2014-2022 CAGRs



Source: MBIE. Last updated December 2022.

Overall energy efficiency and energy intensity continues to improve

Consistent

Energy intensity is decreasing at a national level

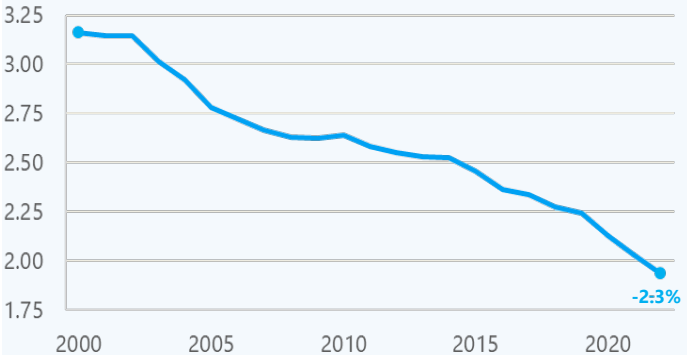
Energy intensity is a measure of the energy inefficiency of an economy. It is calculated as energy use divided by gross domestic product (GDP), and it tells us the amount of energy required to produce goods and services. High energy intensity means more energy is required per dollar of GDP.

According to Transpower analysis of MBIE's latest Energy in New Zealand data, we estimate that energy intensity improved in 2022, with the national average energy intensity indicator falling 4.5% in 2022. Up to 2022, the national average energy intensity had been improving (falling) on an average of 2.3% per annum since 2000.

This decrease has been driven by both efficiency improvements in the industrial sector and continued economic growth in the commercial sector which, being service based, is relatively less energy intensive than other parts of the economy.

Energy intensity across New Zealand

MJ/$ GDP in real 2009/2010 prices, annual. 2000-2021 CAGR



Source: MBIE and Transpower. Last updated March 2023.
Note: Renewables energy consumption is estimated for CY22 using 2021 data.

Uncertain

Residential electricity consumption per ICP declines

The average electricity consumed at a residential ICP can be an indicator for improvements in energy efficiency in New Zealand homes.

Between 2010 and 2017 average consumption fell by an average of 1.3% per year, reaching its lowest point at 7,055 kwh per ICP. This reversed during the period between 2017 and 2021 where it increased by an average of 1% per year. This may be explained by increased working from home due to COVID-19, however, the trend was apparent before the first lockdown, suggesting it is driven by changes in electricity consumption more broadly.

However in the year 2022, average residential consumption reversed and was 3% lower. Changes in consumption trends will become evident in future data releases. Energy efficiency remains an extremely important drive of household energy trends, however it's likely that residential consumption per ICP will continue to increase with electrification along with EV uptake and increasing electrification of space heating.

Average residential consumption per ICP

kWh, annual. 2000-2021 CAGR

Source: MBIE. Last updated December 2022.

Consistent

Increase in sales of heat pumps is improving energy efficiency

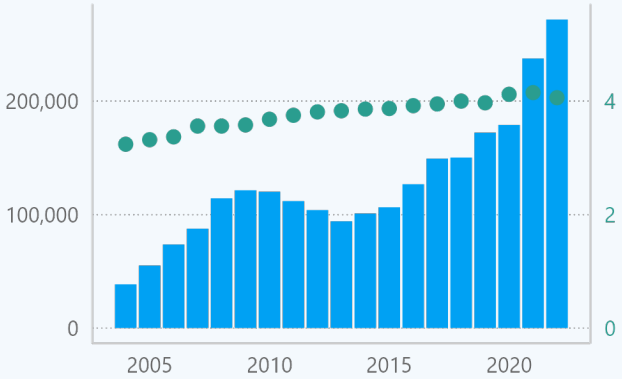
Heat pumps, powered by low-emissions electricity, are a central technology in the transition to sustainable heating. There has been a dramatic increase in the use of residential heat pumps over the last 10 years in New Zealand. According to data from the Energy Efficiency & Conservation Authority (EECA), sales of heat pumps reached 270,000 in the year ending March 2022, up 14% on 2021.

The sales weighted co-efficient of performance (CoP) expresses the efficiency of a heat pump, and has improved 25% since sales were first reported. It is now over 4 – meaning 1 kW of power input will achieve 4 kW of heat output. A recent study by MOTU found that houses with heat pumps see electricity use in winter fall by 16% relative to a house without a heat pump installed with the greatest electricity reductions occurring in the evening.

A report by the International Energy Agency identified heat pumps as a means of decarbonising space and water heating and can be used to provide flexible demand response, and are three-to-five times more energy efficient than natural gas boilers.

Heat pump sales

Number sold (left axis) vs COP (right axis), 2004-2022



Source: EECA. Last updated March 2023.

Industrial energy users are still relying on fossil fuels, rising costs are causing issues and new entrants are also on the way

Uncertain

Electricity becomes the largest industrial fuel, as overall demand drops from softer economic activity

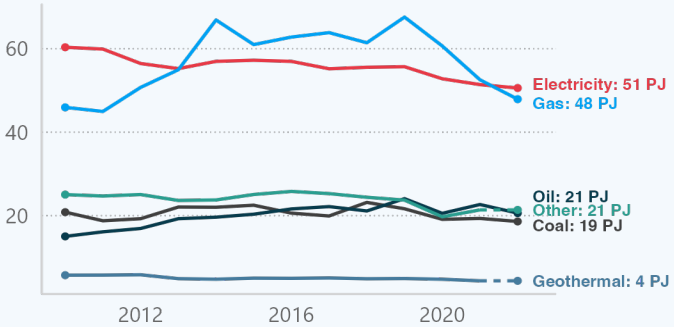
New Zealand's industrial sector relies on both fossil fuels and renewable energy sources. In the future, greater electrification should see some fossil fuel demand replaced by electricity.

Due to COVID-19 restrictions and supply issues, industrial sector energy consumption in 2021 was 13% lower than pre-COVID levels. In 2022, we continue to observe a decline in sector energy use due to lower economic activity, and we estimate industrial sector energy consumption will be 15% lower for 2022. This is led by a decline in natural gas consumption for industrial use which decreased by 9% compared to 2021, its lowest level since 2011. The wood, pulp, paper and printing and chemicals sectors were the largest contributors to the decrease, due to lower production from Methanex in 2022 and recent closures of mills. The food product manufacturing sector was lower, potentially driven by lower milk processing and meat production volumes.

Electricity also fell by 2% but has been growing by an average of 0.4% per annum since 1990. In 2022, electricity moved ahead of natural gas natural gas demand, the first time since 2013.

Industrial energy consumption

Petajoules



Source: MBIE (Transpower estimated data for missing points). Last updated December 2022.

Uncertain

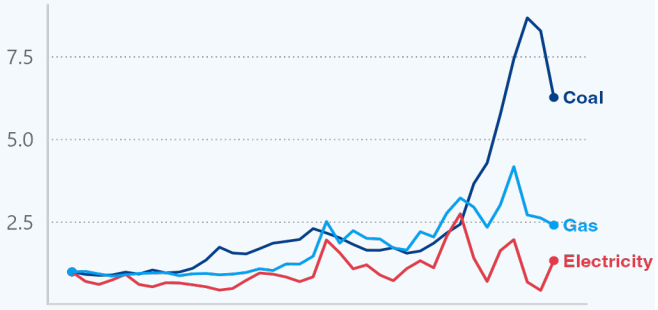
Increased levels of volatility and elevated prices for energy users

We are still observing higher fossil fuel prices and uncertainty around carbon prices, together these are one of several contributing factors to more volatile wholesale prices above long term averages.

- **Carbon:** The NZU spot price reached highs of $88 in November 2022, but has since retreated to $53 in March 2023. The cost of carbon impacts the input costs of gas and coal for electricity generation.
- **Coal:** Newcastle coal prices have more than halved from their September 2022 peak of $440/tonne USD, driven by a warmer than expected winter in the Northern hemisphere and the reduced risk of gas shortages in Europe.
- **Gas:** Tight supply drove higher NZ gas spot prices in 2022 but production at Maui and Pohokura has since improved. The industry expects supply to be tight in 2023 and recent quarterly contracted prices for commercial and industrial customers has increased.
- **Electricity**: During the end of 2022, prices were lower, linked to high hydro storage inflows. However, prices lifted in early 2023 and forward futures prices remain elevated.

Change in fuel prices

Average price indexed against 2014, quarterly (incl. carbon)



Source: Electricity Authority, emstradepoint, theecanmole, & investing.com. Last updated March 2023.

Uncertain

Large energy users continue to adapt to higher energy prices

Large energy user reviews

- **Tiwai Aluminium smelter –** The NZ Aluminium Smelter (NZAS) consumes about 12% of the country's electricity per annum**.** Rio Tinto has signalled that the planned closure date in 2024, when its current electricity contracts ends, is not final. They have entered negotiations to cover their energy needs. In February 2023, NZAS announced an agreement to sell low carbon high purity aluminium to a Japanese motorcycle manufacturer. The smelter might enter into a long-term contract and could play a role in dry-year cover, or alternative demand sources for the electricity could emerge such as green hydrogen or data centres.
- **Fonterra –** The company has plans to convert three of the nine remaining sites that still use coal to low carbon energy by the end of 2023. The majority of coal is expected to be transitioned by 2030 but high prices and capital costs are a barrier. Fonterra is improving its energy efficiency and fuel switching to biomass, including Te Awamutu, Stirling and Waitoa. It has recently entered into a strategic partnership with MAN Energy Solutions to trial high temp heat pump technology and is working with Genesis Energy on exploring biomass.
- **Oji Fibre Solutions** – Entered into a partnership with the NZ government to explore opportunities to develop the Kinleith Mill to commercially produce wood products such as biofuels.

Potential large energy user entrants

- A number of new data centres are progressing, including Infratil (CDC Data Centres) who opened two data centres in Silverdale and Hobsonville in Auckland in November 2022. Together the centres consume approximately 28 MW of electricity. Infratil is planning to expand with further data centres to have a combined demand capacity of 110 MW. Others include DataGrid, DCI Data Centre, NextDC, Akamai Technologies, Microsoft and Amazon WS who have announced investment options for data centres in NZ.
- Meridian Energy have selected Woodside Energy as its preferred partner for the development stage targeting 500,000 tonnes of ammonia from renewable electricity per year. Final investment decisions could be made as early as 2024.

Sourced from various media updates. Last updated March 2023.

Process heat decarbonisation continues to increase supported by Government, driving growth in electricity and biomass

Consistent

Electrification of process heat is supercharged by GIDI and RETA

Decarbonising process heat is a large opportunity for New Zealand as it contributes 10% of gross emissions and 27% of energy-related emissions. Approximately 60% of process heat is supplied by fossil fuels.

The Energy Efficiency and Conservation Authority (EECA) are developing several Regional Energy Transition Accelerators (RETA) to identify opportunities for process heat decarbonisation. The aim is to develop a coordinated approach for regional decarbonisation. EECA published a report for the first RETA programme in the Southland region. It has involved extensive collaboration with key energy users and suppliers – including Transpower. The main focus of the Southland report – the culmination of phase one of the RETA programme – is the fuel switching decision. Both biomass and electricity are considered as potential fuel sources.

RETA will drive more process heat decarbonisation projects, which can be supported through the Government Investment in Decarbonising Industry (GIDI) fund. This is administered by EECA, to accelerate emission reductions from industrial process heat. In the first three rounds the fund has invested $185 million in total Government and applicant funding across 53 approved projects. Collectively, this represents a reduction in lifetime emissions of 7.5 million tonnes at an average marginal abatement cost of $44 per tonne of CO_2e. Of this, 29 electricity projects are expected to deliver 2.9m tCO_2e in emissions reductions. Announcement of round 4 projects are expected by May 2023.

GIDI round	# of electricity projects	GIDI co-funding for electricity	Lifetime emissions reductions (tCO2-e)
1	7	$11,907,075	945,480
2	12	$15,321,382	1,433,927
3	10	$6,566,644	533,606
Total	**29**	**$33,795,101**	**2,919,013**

Sourced from various media updates. Last updated March 2023.

Consistent

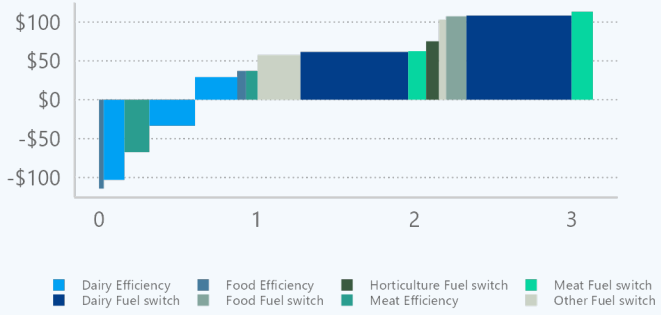
Technology shifts for process heat making electrification attractive

Electrification technology for process heat is changing fast and understanding the options available as part of the fuel switching step is key. As a result of their high efficiency, opportunities to use high temperature heat pumps (HTHPs) where heat requirements are lower than 100°C are highly likely to be economic. While not yet available on the market, high temperature steam heat pumps (currently being trialled by Fonterra), can produce up to 150°C of heat and also have the potential to decarbonise much of New Zealand's industry, within the 15-year timeframe contemplated by EECA's RETA decarbonisation pathways for Southland.

The Southland report assessed the application of demand reduction and HTHPs, which found that of the 19 projects assessed for this technology, two thirds are viable under $150/t and one third of projects under $75/t. The chart shows the marginal abatement cost (MAC) for low and medium temperature food processing heat use which is part of the total process heat emissions of approximately 7.7 million tonnes of CO2e emissions from process heat identified in Transpower's Electrification Roadmap. At a carbon price of $75/t his could achieve up to 1.8 million tonnes of CO2e abatement.

Marginal abatement costs for process heat

Cost per tonne CO_2e vs million tonnes of abatement potential



Source: Transpower. Last updated March 2023.

Uncertain

Biomass will complement electricity to decarbonise process heat

Alternative fuels outside of electricity are playing a role in decarbonising process heat, including, biogas, energy efficiency, biomass and geothermal. Biomass has the potential to play a key role, but markets are currently immature to meet process heat users' needs.

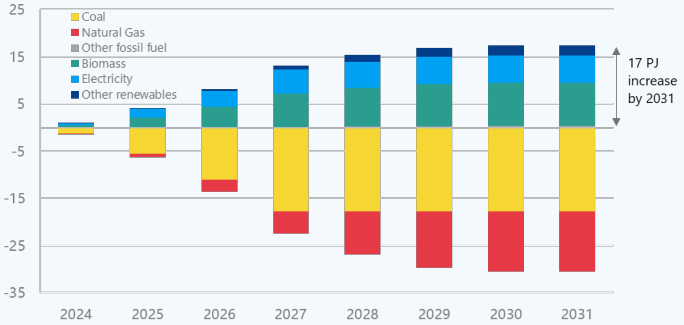
EECA has launched a ROI for a 'Biomass Supply Chain Investment Fund' that is exploring potential biomass supply chain projects in the South Island. In addition, the Government is working to strengthen the biomass market as part of its Forestry and Wood Processing Industry Transformation Plan. It aims to increase the use of woody biomass to substitute coal and diesel use. The plan targets a 25% increase in processing volume by 2035.

In March 2023, Beca was appointed as the lead consultant for Genesis Energy and Fonterra to look for ways to accelerate replacement of coal with biomass. Fonterra has converted its Stirling and Brightwater plants to take wood waste, commissioned a wood pellet conversion at its Te Awamutu site and has plans for a 30 MW biomass boiler to replace coal at Waitoa.

The chart below shows the potential forecast of biomass and electricity fuel switching, under the expanded GIDI 2.0 funding.

Forecast GIDI fuel switching, by type

PJ, annual consumption change per annum (modelled)



Source: First Emissions Reduciton Plan for GIDI 2.0. Last updated July 2022

Electric vehicle numbers continue to push higher boosted by transport policy, but hybrids continue to dominate uptake

Consistent

Light EV uptake continues to climb, but hybrids still lead

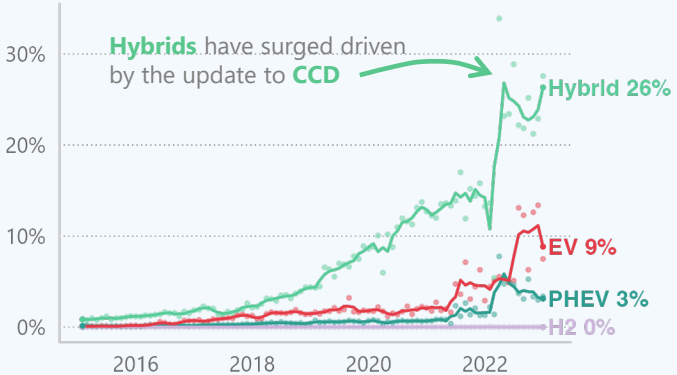
There are currently around 69,000 electric plug-in BEV and PHEV vehicles in NZ, or 1.6% of the total light vehicle (LV) fleet. On a percentage basis, 12% of all light vehicles entering the fleet each month are plug-ins reflecting approximately 3,500 plug-in vehicles.

This growth in EVs has been supported by the Clean Car Discount (CCD), through which new zero and low emissions vehicles are eligible for a rebate proportionate to their emissions (to a maximum of $8,625), while highly emitting vehicles in contrast are charged a fee. The CCD has driven a surge in hybrid uptake as a low emissions alternative to a BEV.

Increasing consumer concern about climate change and government-led incentives for zero and low emission vehicles has led to a significant increase in their uptake. As of February 2023, 37.2% of vehicles entering the fleet have a battery of some kind (including hybrids). This compares to only 6.2% in 2019.

Light low emission vehicle registrations

Percentage of registrations, rolling 3 month average



Source: NZTA. Last updated February 2023.

Consistent

Small but consistent increase in numbers of heavy electric vehicles

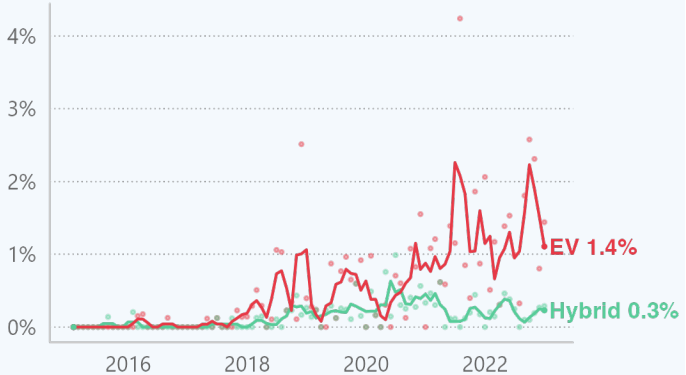
Heavy vehicles are also continuing to electrify, but at a much slower pace than light passenger vehicles, due to the technology being in earlier stages.

In the past 12 months, there have been 150 heavy electric trucks added to the fleet, or 1.3% of all trucks. Unlike light vehicles, the number of battery-electric vehicles eclipses hybrids – of which there were only 24. The number of new electric heavy trucks has increased significantly in the last two years. It now averages 12 trucks per month (compared with only 5 from 2018 – 2020). Hydrogen fuel cell technology is also expected to be a potential competitor to battery electric trucks, however hydrogen has not emerged in NZ as yet. According to the Ministry of Transport (MoT), there are also 278 BEV buses in the fleet.

Both heavy and light EVs will require significant investment in EV charging infrastructure to support uptake. In March 2023, the MoT released the 'Charging Our Future' strategy for consultation. It sets out the Government's long-term strategic vision for the national EV charging infrastructure system.

Heavy low emission vehicle registrations

Percentage of registrations, rolling 3 month average



Source: NZTA. Last updated February 2023.

Uncertain

Most small cars are hybrid or EV, but larger vehicles lag behind

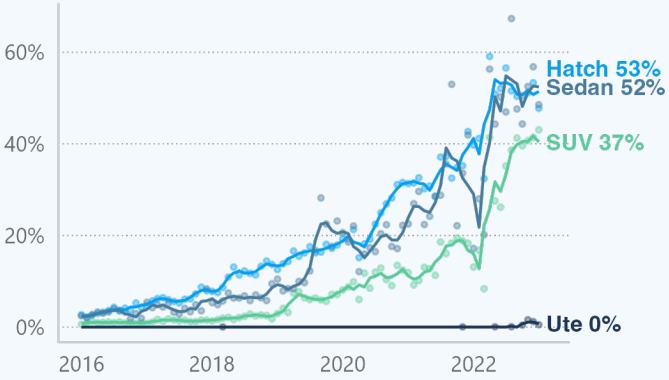
In NZ, SUVs make up 40.3% of monthly registrations. This is up from a share of 33.2% 10 years ago. At that time, the SUV share was slightly less than a small hatchback at 36.5%; however, small cars now amount to only 35% of new registrations, having lost ground both to SUVs and to NZ's third favourite vehicle type: the tray utility vehicle or ute, with 13.3% of registrations.

As the below graph shows, over half of all smaller vehicles (hatches and sedans) entering the fleet are now either a hybrid or EV. In the case of SUVs, however, this falls to 37% – though the rate of low emissions technology uptake in SUVs has been strongly increasing recently. NZ continues to see new manufactures and models entering the markets, such as MG and BYD, driving increased diversity of options for consumers.

However, very few utes entering the fleet are currently low emissions. There are currently only 13 hybrid utes registered in NZ and no full EVs. But with the arrival of LDV's new fully electric ute and others expected to enter the market in the next 12-24 months, this will likely change soon.

Low Emissions Vehicle Combined Share

Monthly registrations, rolling 3 month average by body type



Source: NZTA. Last updated February 2023.

Electric passenger vehicle costs are aided by the Clean Car Discount and lower running costs, but policy sends mixed messages

Consistent

EV purchase price parity still higher than ICE but has narrowed

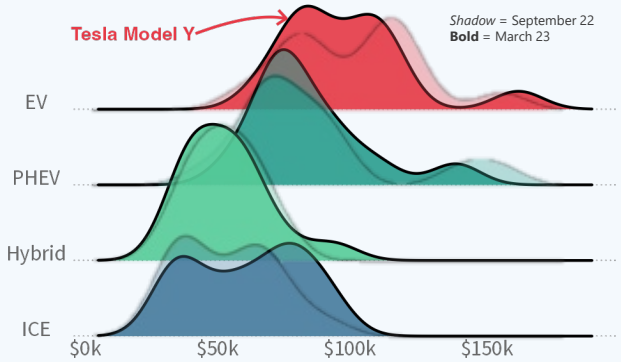
Upfront purchase price is a key barrier to adoption of electric vehicles. EV purchases will start to grow significantly once the purchase price of EVs is on par with internal combustion engine (ICE) vehicles. Research by Bloomberg suggests global price parity with petrol and diesel equivalents between 2026-2030.

The upfront cost of an EV has decreased since the September 2022 report and increased for the ICE equivalent, as shown by the last report's graph imposed behind the present graph. EVs have been shifting slightly cheaper in the past six months, while other tech stayed constant. Hybrids are broadly similar in price to ICE vehicles, helping drive their uptake.

The all-time most popular EV in NZ is the Nissan Leaf with 18,351 currently registered. However, in the past 12 months, the Tesla Model Y has overtaken the Leaf as the current best seller, with 4,446 registered in the past 12 months. But at $65,275 (incl. rebate) this model is still considerably more expensive than an average ICE vehicle. The cheapest EV is still the MG ZS at $41,365.

Distribution of vehicle prices

Top selling vehicle prices, including rebates



Source: NZTA for vehicle registrations. Genless, Turners, & Toyota for price data. Last updated March 2023.

Consistent

Total cost of ownership is lower for EV than ICE equivalent

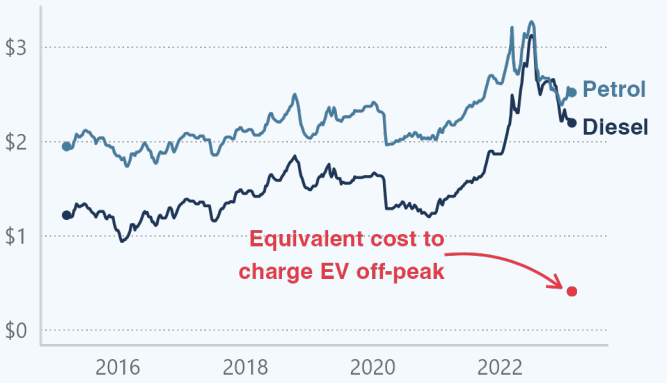
The total cost of ownership (TCO) is a more accurate cost comparison, and factors in both purchase price and operating expense over the lifetime. EECA has recently reported that even when the higher purchase price is accounted for, EVs now have a lower TCO than their petrol and diesel equivalents, due to lower running costs, lower maintenance, and higher resale values.

Fuel is a large component of a vehicle's running costs. Petrol prices fell as the pandemic hit in 2020, but have now risen higher than pre-COVID-19 levels. Fuel prices have continued to increase during 2022 from a weaker NZD-USD exchange rate, higher import costs, and supply chain issues due to COVID-19. They continue to rise amid volatility from higher oil prices and geopolitical instability from the Russia-Ukraine war.

Higher petrol costs make charging an EV more attractive and the gap is widening with petrol 6 times more expensive than (off-peak) electricity on a per litre equivalent basis.

Vehicle fuel prices

Dollars per litre (nominal). Petrol refers to regular.



Source: MBIE. Last updated March 2023.

Inconsistent

Mixed messages mute price signals for transport

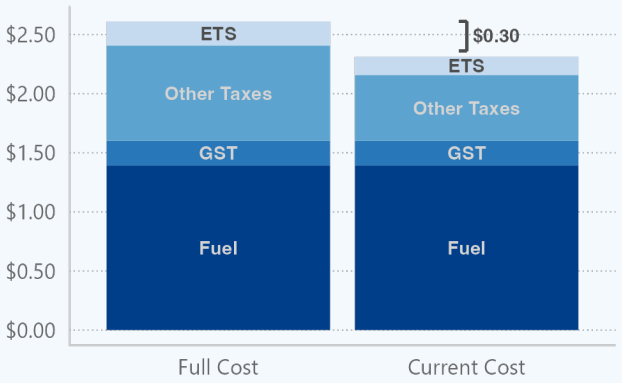
In March 2022, the government announced a 25c per litre reduction on fuel excise duty. Diesel users are not charged a duty at the pump but rather are taxed through road user charges, which were similarly reduced by 36%. Originally, these reductions were meant to last for three months, but they are now expected to be reintroduced in June 2023.

In December 2022, the government also rejected a recommendation by the Climate Change Commission to tighten up the supply of carbon credits in the emissions trading scheme. Consequently, the price of carbon in NZ has fallen by around $20/tonne since its peak last year of $88. This has resulted in a further discount of 5c at the pump for petrol.

The difference amounts to $0.30/litre or $15 per 50L fill. Assuming an average 7.3L/100km for a modern ICE vehicle, fossil-powered driving costs are reduced by $2.19/100km (or ~$240 for an average 11,000 kms per year). Whilst this helps with the cost of living, it also sends mixed messages and mutes the price signals meant to drive higher EV and hybrid adoption.

Breakdown of Costs for Regular Petrol

Dollars per litre, current vs hypothetical full cost scenario



Source: MBIE. Last updated March 2023.

Battery technology and flexible demand is showing it can provide solutions to help meet peak and energy demand

Consistent

Grid-scale battery projects are underway and being constructed

Recent announcements across New Zealand's electricity industry shows both micro-grid and large grid-scale batteries are now playing an active role in NZ's power system.

- **SolarZero** entered the reserves market in late 2022 with a staged enrolment of its 40 MW of virtual power plant load from 10,000 household battery systems. It is also collaborating with Powerco on a 1 MW distributed battery system for network support in Coromandel.
- **WEL Networks** through Infratec are building a 35 MW / 33 MWh battery energy storage system in Waikato. It will provide electricity reserves into the market and is expected to be commissioned in 2023. Recent declines in lithium prices are helping to lower the cost of battery storage.
- **Meridian Energy** has awarded the construction contract for the battery component of its renewable energy park near Marsden Point. It includes Stage 1 construction of 100 MWp (200 MWh) capacity grid-connected battery to be built by 2024, with future construction of a 130 MW solar farm.
- **Several electricity distribution businesses** issued requests for non-network alternatives (e.g. batteries), including Network Tasman GXP in Brightwater (Feb-23), Aurora in Upper Clutha Area and Orion in Lincoln (Dec-22). Non-wires alternatives include solutions such as distributed generation, energy storage, demand-side management and demand response.

These are not the only battery projects in New Zealand and it is expected that further large-scale projects will occur by 2030. The Government recently announced an update to the NZ Battery Project. Phase 1 investigations show a pumped hydro scheme at Lake Onslow would take approximately seven to nine years to build, with an estimated building cost of $15.7 billion.

Sourced from various media updates. Last updated March 2023.

Uncertain

Flexible demand needed to support energy security

Flexible demand (such as demand response) provides another layer in supporting energy security as it allows for electricity consumption to flex (either up or down) in line with available supply. This dynamic potential is particularly useful at times when energy supply is tight. Flexible demand can be deployed to help avoid outages in the electricity system by preventing demand from exceeding supply line limits.

However, as noted in the SO Winter Review paper, this is dependent on sufficient market signals. For example, the removal of price signals such as Regional Coincident Peak Demand (RCPD) has created disincentives for existing forms of flexible demand in New Zealand's electricity system, specifically hot water ripple control.

Demand response progress in NZ is quietly continuing but more action needs to occur. Recent developments include:

- **Electricity Authority** released an issues paper in December 2022 seeking input on updating the regulatory settings for distribution networks, including flexibility services.
- **FlexForum** released a Flexibility Plan 1.0 to outline the initial steps how a co-ordinated and collaborative approach can unlock the value of DER and flexibility resources.
- **Influx hot water management** – Influx, a cloud-based energy data solution provider has launched a service that makes hot water demand management available to retailers.
- **Ara Ake** announced finalists of an Electricity Distribution Business Decarbonisation Challenge, opening the possibility of partnerships with ANSA, Future Grid and Gridsight on network analytics, consumer behaviour and impacts of DER growth on the low voltage network. In March 2023, Ara Ake released a report on Stationary Battery Energy Storage Systems Analysis.
- **NZAS demand response agreement with Meridian**, which can be triggered to assist with managing low hydro periods.

Sourced from various media updates. Last updated March 2023.

Consistent

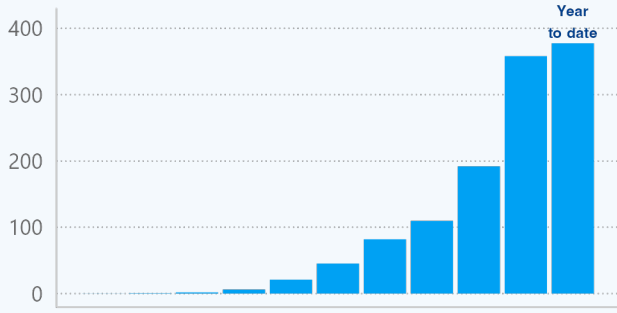
Electric vehicles present a rapidly growing potential resource

Distributed energy resources (DER) are growing in large volumes globally as consumers seek to benefit from their own controllable systems, and networks take advantage of wider energy system benefits. One potentially very significant source of DER is electric vehicles (EVs). EVs can be used to provide flexible demand response through smart charging. In the future, EVs may also provide energy back into the grid through technology known as Vehicle-to-grid (V2G). V2G trials are already underway in California.

The average EV battery size in NZ has been steadily increasing. Over the past decade it has risen from 32 kWh to 57 kWh (weighted by vehicle sales) – an average growth rate of 5.3% per year. Taken together, this results in at least 2,450 MWh of combined EV battery storage in NZ as of February 2023. However, EV energy available for demand response or V2G is limited by AC charging constraints. Yet this capacity is increasing too, having doubled from a volume-weighted average of 4.2 kW in 2012 to 8.6 kW in 2023. Evnex recently shared a report on insights about how NZ consumers use their electric vehicles.

Potential distributed energy in EVs

MW, Cumulative NZ EV battery power capacity, noting AC charging constraints. (Excl. heavy vehicles & buses).



Source: NZTA for registrations. evdb.nz and ev-database.org.uk for battery facts. Last updated February 2023.

Distributed solar installations continue to increase with long-term costs falling, but growth is slower than expected

Consistent

Residential solar installations set new record in 2022

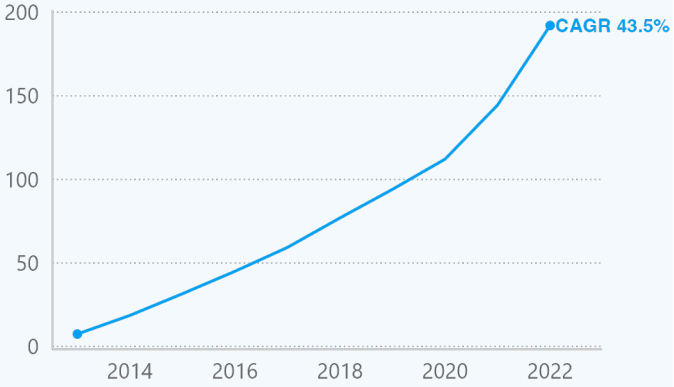
More New Zealand households are installing solar photovoltaic (PV) systems on their rooftops to take advantage of lower electricity costs.

Over the past decade, the total number of solar installations have grown by an average of 40% per year to reach 42,793 ICPs by the end of 2022 – this equates to approximately 2.3% of households. Almost all of these installations are below 10 kW, however the average size of a new installation has been increasing, from 3.5 kW to 5.7 kW.

A record 48 MW of residential solar was installed in 2022, up 47% on the prior 12 month period. Rooftop solar installations have slowed in recent months and have had a soft start to 2023, with 2.7 MW installed in January, the lowest figure since September 2021. Despite this, at the current total installed capacity of 170 MW, we are well on track against the *Accelerated Electrification* projections to have 300 MW by 2025.

Residential Solar in New Zealand

MW, total installed distributed capacity



Source: Electricity Authority. Last updated January 2023.

Consistent

Commercial solar installations continue strong growth

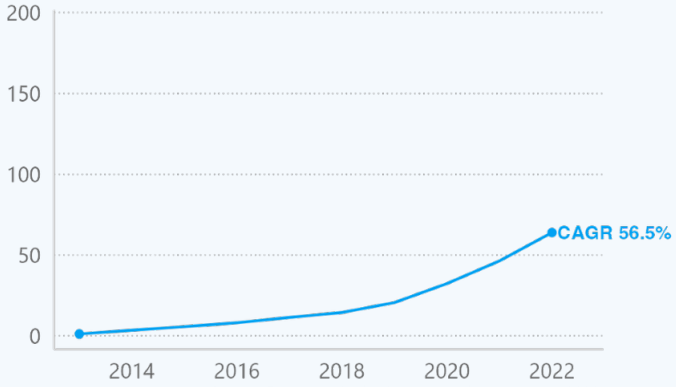
As with residential sites, commercial and industrial solar installations have also been increasing. These installations are embedded and do not include any grid-connected solar installations.

Over the past decade, the total number of solar installations have grown by an average of 38% per year to reach 3,049 ICPs by the end of 2022. The majority of installations are still under 10 kW, but the proportion of large installations has been steadily increasing: from 11% in 2013 to 34% in 2022. The average capacity for new installations is approximately 32 kW in 2022.

In 2022 approximately 18 MW were added to commercial solar, the largest annual increase so far. Although commercial solar lags behind residential, it is rapidly catching up, with an average annual growth rate of 56.5% (compared to 43.5% for residential).

Commercial Solar in New Zealand

MW, total installed distributed capacity



Source: Electricity Authority. Last updated January 2023.

Consistent

Distributed solar costs forecast to continue on sharp decline

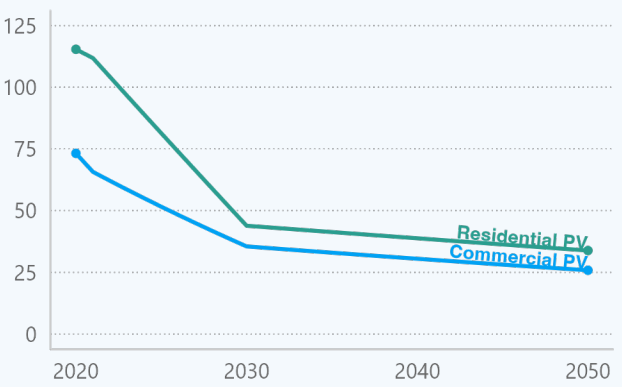
The National Renewable Energy Laboratory (NREL) releases industry updates on forecast solar PV levelised cost of energy (LCOE). Between now and 2030, the cost of solar is expected to fall by 58% and 43% for residential and commercial respectively.

Recent movements in global PV module prices have started to stabilise, after rising significantly in the prior year. Recent cost pressures were driven by the higher cost of polysilicon, a key feedstock to most PV modules, supply chain disruptions caused by the global pandemic, and inflation. Overall the installed price of a 3 kW system in New Zealand is about $10,000 in 2022 which has increased from $8,000 in 2021. In Australia, an installed 6 kW system is 31% cheaper than a 3 kW system installed in New Zealand.

As a result of supply chain shortages and component price pressures, price increases in PV systems were seen for the first time. Despite this, analysts expect that the pace of installations will continue to increase, buoyed in part by the United States Inflation Reduction Act which analysts expect will more than double annual US solar installations between 2022 and 2025.

Levelised cost of energy for distributed solar

$/MWh (USD)



Source: NREL. Last updated September 2022.

Electricity affordability needs to be maintained, as the transition to a highly renewable energy system to meet targets is underway

Uncertain

Average household electricity bills fall, but consumers are concerned

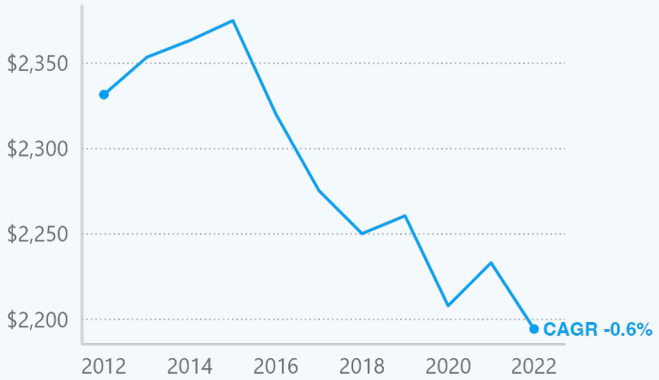
Energy affordability is a core pillar of the energy trilemma. Electrification is only likely to occur if electricity is affordable and competitive against other forms of energy.

At a household level, the average price per kWh slightly decreased from $0.31 in 2012 to $0.30 in 2022. Over the same period, the average household consumption per ICP has fallen 6.0%. In 2022, the average household used 7,146 kWh per year, down from 7,602 in 2012. Consequently, the real average household bill has decreased and is now $2,194 per year – a average annual reduction of 0.6% since 2012.

However, a recent survey commissioned by the Consumer Advocacy Council found that 58% of residential and small business consumers were concerned about the cost of electricity. Over two-thirds are concerned that electricity will become unaffordable over the next 10 years. This comes as the sector is grappling with rising wholesale prices which we expect will filter through in future data releases to the prices householders pay.

Average annual residential household cost

NZD (real)



Source: MBIE. Last updated December 2022.

Consistent

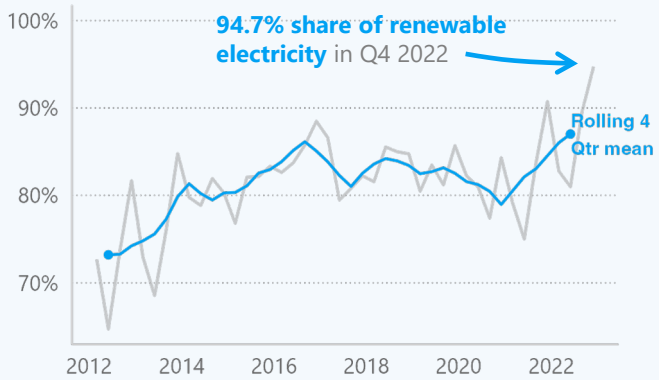
Renewable electricity generation reaches new record

For the majority of the past decade, New Zealand's electricity system had an average of 82% renewable generation. The past couple of years have set new records. In the quarter ended December 2022, a rise in hydro inflows and increased wind generation saw renewability of the electricity system increase to 94.7%, the highest quarterly renewable share since 1980. This resulted in a decreased reliance on coal and gas for electricity generation. The abundance of hydro storage during the second half of the year has led to the system operating on 99% renewables for prolonged periods of time. This differs from the June quarter of 2021, where renewability fell to 74.9%. This was due to dry hydro conditions and the need for coal generation to maintain security of supply.

These recent swings in renewability highlight some of the challenges with our current generation mix. As the NZ electricity system is highly dependent on hydro (57% on average in the past 10 years), dry conditions impact the proportion of higher carbon fossil fuels in the mix. Adding more diverse renewables such as wind and solar will improve the renewables share.

Renewable share of electricity generation

Average percent, quarterly



Source: MBIE. Last updated March 2023.

Uncertain

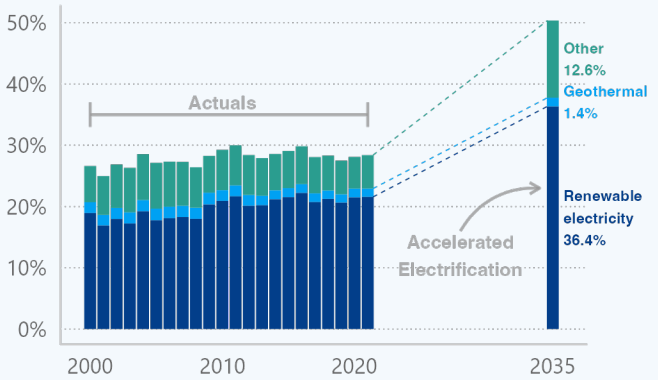
Renewable energy consumption is still a long way short of the target

Overall, renewable energy consumption has consistently averaged around 28%. 20% of this comes from renewable electricity. The remaining 8% was made up of around 2% Geothermal and 6% from other renewables, such as biomass. These proportions have remained remarkably stable for the past few decades. The next few decades, however, will look very different.

The government has posed an ambitious target of 50% renewable final energy consumption by 2035 to deliver on its decarbonisation goals. This target is in line with WiTMH's *Accelerated electrification* scenario. To achieve it, renewable electricity will need to increase from 20% total consumption to 36%. The remaining 14% will come through other fuel switching possibilities such as gas to hydrogen, and the use of biomass/ biofuel. As discussed in earlier slides, the draft Industry Transformation Plan outlines goals to produce more biomass and biofuel, and MBIE is expected to release its Energy Strategy in 2024 that addresses this gap.

Renewable share of energy consumption

Annual, total final consumption vs Accelerated Electrification



Source: MBIE. Last updated September 2022.

Progress against the ten Whakamana i Te Mauri Hiko industry themes is ongoing and may shift further with future energy policy

1 Streamlining our connections process

- We implemented our Connection Management Framework for generation connections and pipeline sequencing of project applications.
- We have published an online connection enquiry dashboard of our forward pipeline of works.
- We have implemented our fast-track process for very simple grid connections (e.g., indoor feeder connection).

2 Integrated system planning

- Transpower submitted its first Major Capital proposal to the Commerce Commission as part of its Net Zero Grid Pathways (NZGP) project, which aims to ensure New Zealand can take an integrated view of future investment needs. It includes investment to strengthen the grid backbone in the Central N.I, Wairakei and the HVDC.
- ENA 'heat map' providing a visual demonstration of the investment drivers for EDBs over coming decades.

3 Getting the incentives right for electrification and renewables

- The Government is currently reviewing the ETS to ensure the NZ ETS and aligned ERP actions prioritise gross emissions reductions.
- EECA-managed funding and support available to transport (LETF) and process heat (GIDI) electrification.
- Introduction of new policy, e.g. new coal boiler ban, Clean Car Discount, Clean Car Standard.
- Development of the NZ Energy Strategy due in 2024.

4 Removing barriers to low carbon infrastructure

- National and Built Environment Act (NBA) and Spatial Planning Act (SPA) have been introduced to parliament as part of the Resource Management Act Reform.
- EECA's GIDI fund expansion to include funding for electricity transmission and distribution infrastructure upgrades to support fuel-switching.
- Government announced national direction for industrial GHG emissions in late 2022 under the proposed NBA.

5 Demand-side management of peaks

- EECA /EEA's FlexTalk project to investigate for flexibility services for smart devices and use of Open ADR.
- MoT have published a draft EV Charging Strategy for NZ.
- FlexForum release a Flexibility Plan 1.0.
- Distribution businesses conducting various projects:. WEL Networks' innovative transformation to a Distribution System Operator (DSO) model and Ara Ake EDB decarbonisation challenge partnering with EDBs.

6 Ensuring generation meets peaks

- Grid-scale generation and flexible BESS projects are being built.
- SO releases information highlighting issues with winter peak challenges and Electricity Authority releases paper on peak demand impacts from removal of RPCD.
- MDAG's options paper on wholesale market settings under a 100% renewable electricity supply.

7 Managing dry year risk

- Genesis Energy ROI for Market Security Options.
- MBIE's NZ Battery Project moves to next phase with alternative options identified (biomass, flexible geothermal energy and hydrogen).
- Genesis Energy successfully trials Huntly biomass burn.
- Flexible demand projects are being investigated to assist with dry-year management, e.g.: Southern Green Hydrogen project, Tiwai and Methanex flexibility.

8 Protecting system stability

- Transpower continues to monitor risks to system stability.
- Transpower published its latest system security forecast (SSF) in December 2022.
- Transpower is working with the Electricity Authority on understanding the future security and resilience of the electricity system. An issue paper on Part 8 of the Code relating to common quality is due to be released in April.

9 Access to skilled workforce

- As an Accredited Employer Transpower continues to recruit and build our talent pipeline of migrant employees.
- We have developed a compelling 'employment value proposition' to attract and recruit talent.
- Our commitment to the Wonder Project – Power Challenge has deepened with Transpower staff teaching STEM.
- Transpower Graduate and Internship Programme continue at 16 and 30 placements in 2024 respectively.
- Transpower Head of Sector Workforce Development role has been created to develop the workforce of the future.

10 Collaboration

- Boston Consulting Group (BCG) released a 'Future is Electric' report to which Transpower provided data.
- Transpower is currently working with EECA and EDBs on collecting data on process heat end use and the Regional Energy Transition Accelerator (RETA).
- Transpower is investigating the concept of Renewable Energy Zones in New Zealand.
- Transpower is supporting MBIE on the regulatory settings for offshore wind energy.