TRANSPOWER

Monitoring Report

March 2021

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

This report

In 2018 Transpower launched Te Mauri Hiko to start a discussion on New Zealand's Energy Future. Taking a scenario-based approach we considered what the future may look like, in the year 2050, as a mechanism to understand the opportunities and discussions stakeholders need to focus on.

Since the first Te Mauri Hiko, we have further refined our understanding and released Whakamana i Te Mauri Hiko (WiTMH) in 2020, and the Electrification Roadmap in 2021.

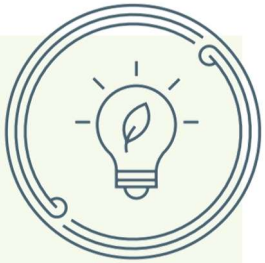
We also have more refined scenarios. Nearly two years have passed since the original Te Mauri Hiko and the pace of social, political, scientific and environmental concern around climate change has continued to accelerate. At the same time, the rate of development and price reductions across a range of renewable energy technologies has continued to increase.

It is critical we continue to monitor the signs and drivers that underpin our scenarios. This active intelligence gathering will provide insight to help us identify both likely to be realised future scenarios, as well as new and divergent alternative scenarios.

This report is designed to identify, within key drivers of Te Mauri Hiko, those factors that are consistent—or vary—from the expected course of our scenarios. We aim for this to be a discussion and an industry resource like Te Mauri Hiko, 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



Refreshed!

You will notice that this Monitoring Report looks and feels a lot different to those we first started releasing in 2018.

A lot has happened since the original Te Mauri Hiko, so we've reinvigorated the monitoring report, revising the indicators we monitor and aligning to our latest Whakamana i Te Mauri Hiko scenarios.

We have also changed the frequency of our reporting to twice a year, rather than quarterly because not all indicators will undergo material change within three months, and six months gives us a wider window to evaluate trends.

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 Point Aluminium smelter exits in 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: Following a recovery from the impacts of COVID-19, New Zealand is tracking towards *Electric Tiwai Exit* scenario

Summary

New Zealand is trending towards the 'Electric Tiwai Exit' scenario.

Drivers of electricity demand, such as economic growth and electrification are continuing to grow, despite the setback in early 2020 due to COVID-19.

Uncertainty remains from if and when the New Zealand Aluminium Smelter at Tiwai exits the system, if and when replacement smelter demand (e.g. data centres, hydrogen) materialises and the long term implications of the COVID-19 pandemic.

Base case scenario

Accelerated Electrification

Emerging scenario

Electric Tiwai Exit

How our indicators are tracking against our forecasts

Tiwai Point and COVID-19 are two uncertainties that could materially shift the future of energy in New Zealand	▼	Uncertain
Climate change continues to be a growing concern for New Zealand and the rest of the world, but carbon emissions remain constant	—	Inconsistent
Electricity demand has remained constant over the past decade, with COVID-19 causing a minor anomaly	—	Consistent
Drivers of base demand have been growing despite setbacks caused by the COVID-19 pandemic	▲	Consistent
Energy efficiency and energy intensity continues to improve across the country	▼	Consistent
Industrial energy users are still relying on fossil fuels, but costs are rising; reviews underway and potential new entrants in hydrogen and data centres	—	Uncertain
Process heat decarbonisation building momentum through both electricity and biomass	▲	Consistent
Electric vehicle numbers are rising and expected to accelerate due to domestic and international developments	▲	Consistent
Electric passenger vehicles have significantly higher up front costs, a barrier even with lower running costs	▲	Consistent
Battery technology and demand response providing solutions to meet peak demand and support system reliability	▲	Consistent
Distributed solar installations continue to grow in number and capacity, driven by falling generation costs	▲	Consistent
Utility scale generation continues to develop to increase renewability and in anticipation of growing electrification demand	▲	Consistent
Capability to meet energy demand and peak demand is still sufficient but low rainfall and gas supply may affect security of supply	—	Consistent
Electricity affordability, renewability and contribution to wider energy system stable with no growth	—	Consistent
Progress against the ten Whakamana i Te Mauri Hiko industry themes is ongoing, and may shift based on outcome of Climate Change Commission's advice	▲	Consistent

Tiwai Point and COVID-19 are two uncertainties that could materially shift the future of energy in New Zealand

Tiwai Point to run until end of 2024, after which future of smelter is uncertain

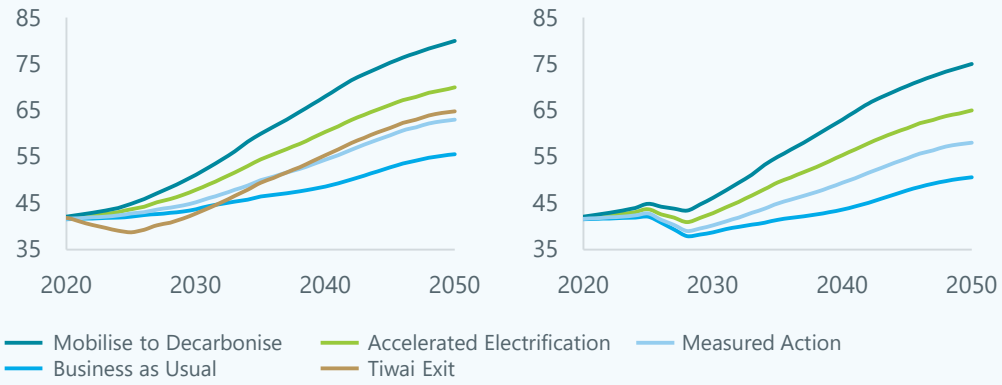
In late 2019, the Tiwai Point aluminium smelter, which uses 12% of New Zealand's electrical energy, announced it was considering exiting New Zealand, and in WiTMH we included the 'Electric Tiwai Exit' scenario to model an exit from 2021-2025.

At the time of writing, it is likely that the smelter will not cease operation before 31 December 2024, the end date for a recently signed deal with Meridian Energy, but it has not confirmed whether it would continue running after that date.

Regardless of the exit date, Transpower is continuing on the Clutha-Upper Waitaki transmission work to improve electricity supply to Southland during dry periods, and to allow additional generation to be exported north from Southland.

Other parties are also investigating new demand loads in Southland, such as electrifying process heat, hydrogen production and data centres.

Electricity demand by scenario



1 Based on Meridian's 14 January 2021 announcement. Source: Whakamana i Te Mauri Hiko analysis.

COVID-19 outbreak creating disruption across the globe with full impact yet to be seen

The emergence of COVID-19 in early 2020 heavily disrupted the New Zealand and global economies. As a result, energy systems have also been disrupted.

The **lockdown period** had an interesting effect on the electricity market as:

- Demand from non-essential commercial and industrial loads decreased
- The need for public to stay home changed household consumption

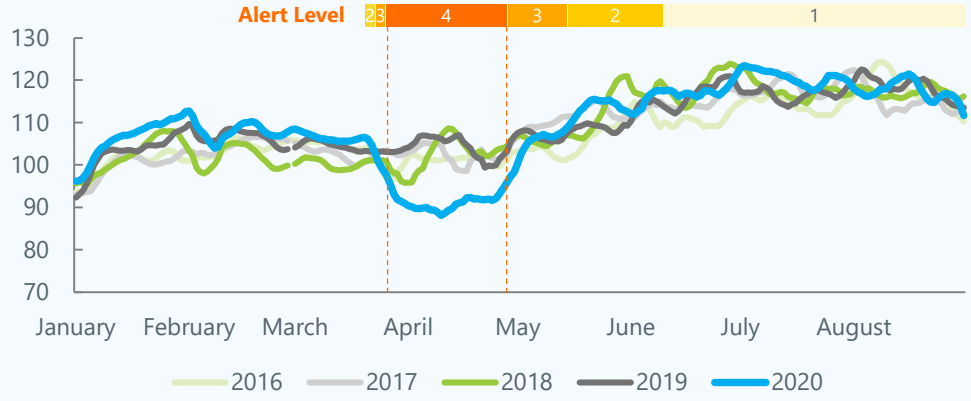
What resulted was overall lower electricity demand, and a dampening of typical weekday peaks (in the morning before work and once people return from work). The lower demand contributed to lower electricity prices and price volatility.

Despite demand levels returning to normal through levels 3, 2 and 1, there are some emerging long trends that could impact the electricity system:

- Economic stimulus focused on climate change could accelerate electrification
- Increased working from home and other behaviours could change demand profile

Electricity grid demand

GWh, 7-day rolling average



Source: Electricity Authority. Last updated September 2020.

Climate change continues to be a growing concern for New Zealand and the rest of the world, but carbon emissions remain constant

Consistent

Global concern remains high and COVID-19 driving a green recovery

Countries around the world are becoming increasingly concerned with climate change and recognise the need for action now, so that we avoid the catastrophic consequences of inaction.

Over 45 countries have or are in the process of committing to a net zero target by 2050 or earlier.

In 2020, China announced it would reach net zero carbon by 2060, Japan by 2050, South Korea by 2050, Europe by 2050, and the USA has recently proposed by 2050. Collectively, these economies represent around 60% of global emissions.

Countries with policies committed to net zero carbon by 2050 or earlier

Number of countries

Source: Climate Action Tracker. Excludes countries with targets under discussion. Some European countries will be rolled up in EU target and not have a separate country target. Last updated March 2021.

According to the Climate Action Tracker, with current policies around the world, the earth is on track for a 2.9^{o}C increase in temperature by 2100, and 2.6^{o}C if current pledges and targets are successful, both higher than the 1.5^{o}C Paris Agreement goal.

Consistent

New Zealand government pushing for stronger action

In December 2020, the Government declared a climate emergency and pledged for the public sector to be carbon neutral by 2025, a signal for strong national action.

Two key emissions targets

- **Paris Agreement:** 30% below 2005 levels by 2030
- **Zero Carbon:** net zero emissions of all greenhouse gases other than biogenic methane by 2050

Policy continues to be strengthened

- Climate Change Commission released first package of advice for consultation in February 2021, with final advice going to government in May 2021
- A number of reforms have been or will be made to the NZ ETS to provide more certainty for businesses, make the scheme more accessible and improve its administration
- New Zealand is the first country to require financial market participants to assess and report climate-related financial risks, by 2023 at the earliest
- Several transport policies announced January 2021

Several new enabling tools have been introduced

- **Government Investment in Decarbonising Industry (GIDI) fund**: $69m of co-funding for decarbonisation of private sector industrial process heat
- **New Zealand Green Investment Finance Ltd (NZGIF):** fund with a mandate to invest in projects that reduce New Zealand's greenhouse gas emissions
- **State Sector Decarbonisation Programme:** $200m to cut public sector emissions from fossil fuel power
- **Support for Energy Education in Communities (SEEC):** $7.9m to tackle energy hardship

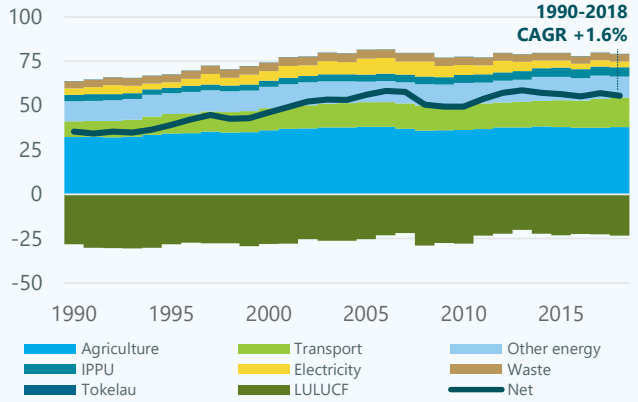
Inconsistent

Greenhouse gas emissions have remained constant

Since 1990, New Zealand's net greenhouse gas emissions have grown an average of 1.6% per year, and since the 2000s, gross emissions have grown 0.8% per year.

New Zealand's greenhouse gas inventory

Mt CO_2-e, annual



Source: Ministry for the Environment. Last updated September 2020.

Globally, carbon dioxide emissions have continued to increase – the concentration in the atmosphere is now the highest for at least the past 3 million years.

Although New Zealand contributes only a small proportion of total emissions, in 2018 New Zealand was the fifth highest emitter on a per capita basis amongst OECD peers.

According to the Climate Action Tracker, if the world to adopt the same level of climate action as New Zealand, earth warming would reach between 2-3^{o}C by year 2100.

Electricity demand has remained constant over the past decade, with COVID-19 causing a minor anomaly

Consistent

Stable annual electricity demand over past five years

When we refer to demand we are referring to the volume of energy required to meet consumer and system requirements and ensure reliability.

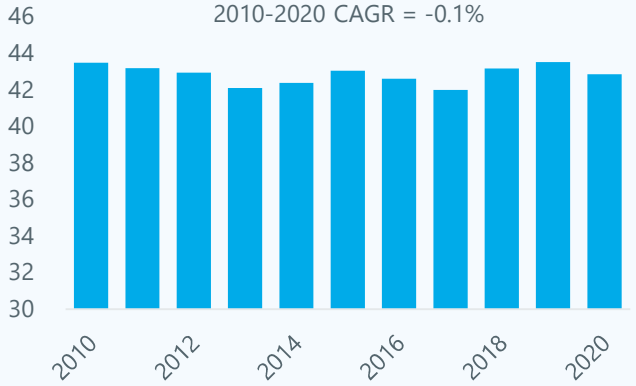
In the chart below, electricity demand is met from both generation that is grid connected and embedded, such as rooftop.

Electricity demand has been relatively stable in recent years, decreasing at an average of 0.1% per annum from 2010 to 2020.

Whakamana i Te Mauri Hiko estimates a 55% increase in electricity demand by 2050 in the Electric Tiwai Exit scenario.

Annual electricity demand

TWh, annual



Source: MBIE. Last updated March 2021.

Consistent

COVID-19 effect evident in monthly electricity demand

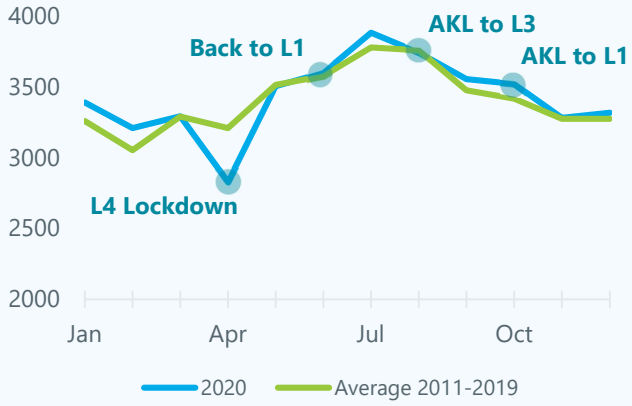
Electricity demand typically follows a seasonal pattern, with consumption being higher in the winter period, as New Zealanders use more power to light and heat their homes.

In 2020, total monthly demand began the year trending slightly above average, with consumption in January and February approximately 1% higher than in previous years.

However, demand fell to 12% below average during he March/April Level 4 lockdown, as most of the economy shut down. Demand very quickly returned to normal levels as the country eased restrictions, and at times trended above average. Demand didn't substantially fall when Auckland returned to Level 3, likely due to many businesses being able to partially operate unlike in Level 4.

Monthly electricity demand

GWh, monthly



Source: Electricity Authority. Last updated March 2021.

Consistent

No material growth in electricity demand across different sectors

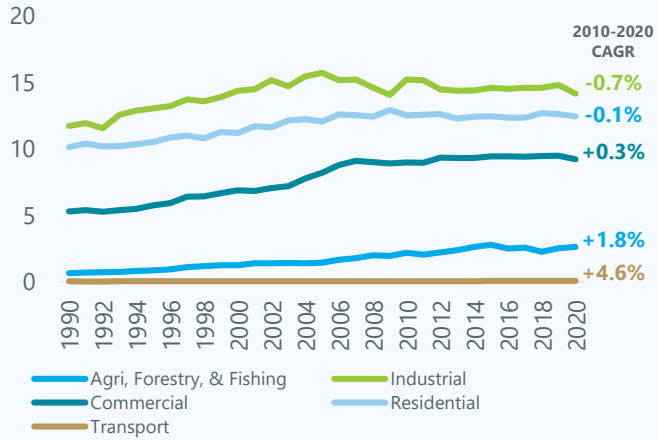
Electricity demand across the different sectors hasn't grown materially over the past ten years, in line with the country's total demand.

In the near term, electricity demand could shift significantly due to operating decisions made by existing large electricity users (such as Tiwai), and potential new entrants such as data centres.

In the long term, as sectors respond to the push for electrification, we should expect to see some growth in electricity demand, especially from the industrial and transport sectors. This growth will be partly off set by continuing energy efficiencies.

Electricity demand by sector

GWh, annual



Source: MBIE. Last updated March 2021.

Drivers of base demand have been growing despite setbacks caused by the COVID-19 pandemic

Consistent

Population continues to grow at a slower rate due to COVID-19

As each New Zealander consumes electricity in their day to day lives, population is an important driver of base demand.

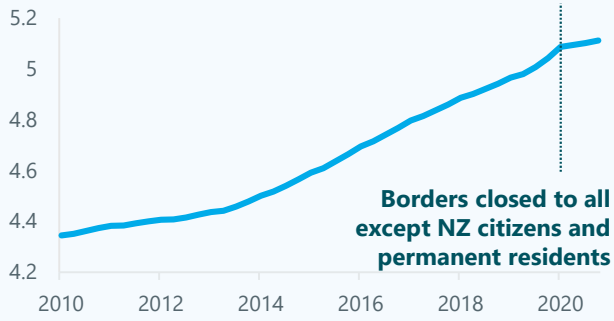
When excluding the impacts of increasing energy efficiency, we can expect base demand to increase with population growth.

Prior to COVID-19, the New Zealand population was growing at 1.6% per annum since 2010. After the border was closed in March 2020, growth slowed to 0.5%, or about 2500 people a month. In the final quarter, this rose to around 3600 a month as capacity in managed isolation facilities increased.

Future population growth will be dependent on how and when the government opens the borders to foreigners.

Estimated resident population of New Zealand

Millions of people, quarterly



Source: Stats NZ. Last updated February 2021.

Consistent

Economy set to recover and resume growth in coming years

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

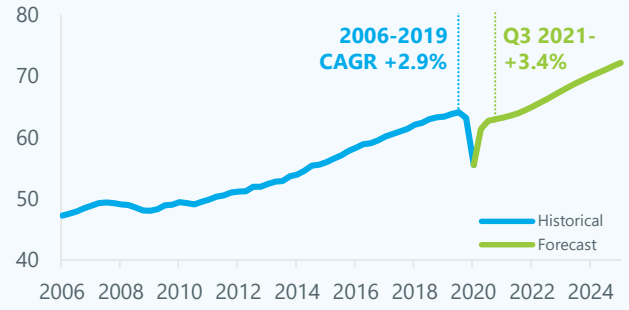
When excluding the impacts of increasing energy efficiency we can expect base demand to increase with economic growth. The changing composition of the economy (e.g. increasing share of services) will also have an impact on base demand as some industries are more energy intense than others (covered later in this report).

At the highest level, gross domestic product (GDP) is used as a measure for the size of the economy.

Prior to COVID-19, GDP had been growing at an average of 2.9% per annum. Treasury's December 2020 forecast suggests that GDP will grow at 3.4% per annum following the recovery from the initial shock in 2020.

Historical and forecast real production GDP

NZD billions, 2009/10 prices, quarterly



Source: Treasury. Last updated December 2020.

Consistent

ICP growth accelerated after COVID-19 lockdown

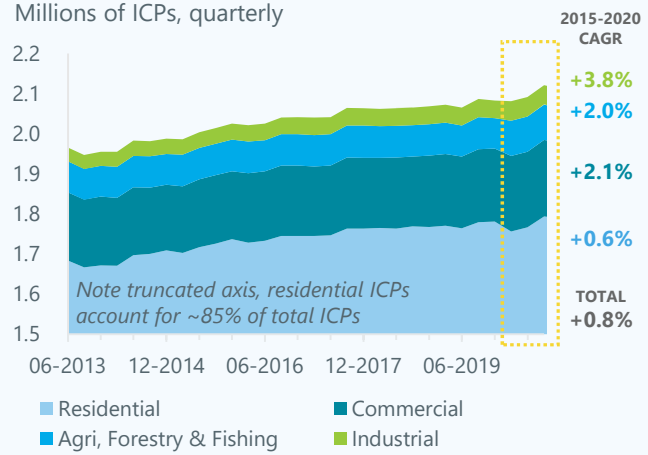
Installation Control Points (ICPs) are the physical points of connections on a local network. When new ICPs are added, for example when new houses are built, it is likely that there is an increase in electricity demand.

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.

There was a notable drop in ICPs in early 2020 due to COVID-19. However, over the past year, growth in ICPs has been robust at 1.4% overall, driven by COVID-19 recovery and new housing developments.

Number of ICPs

Millions of ICPs, quarterly



Source: MBIE. Last updated March 2021.

Energy efficiency and energy intensity continues to improve across the country

Consistent

Energy intensity declining an average of 1.4% per annum

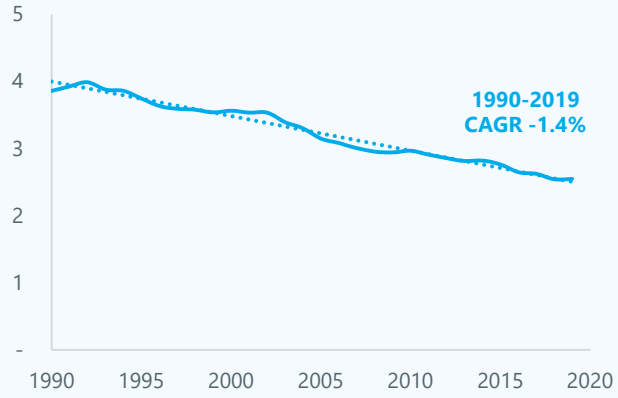
Energy intensity is a measure of the energy inefficiency of an economy. It is calculated as energy use divided by gross domestic product (GDP), and tells us the amount of energy required to produce each dollar of GDP. High energy intensity means more energy is required per dollar of GDP.

Overall as a country, New Zealand's energy intensity has been decreasing, at an average of 1.4% over the past 30 years, indicating an overall improvement in energy efficiency.

This has been driven by 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



Source: MBIE. Last updated August 2020.

Consistent

Industrial sector continues to have highest intensity but improving

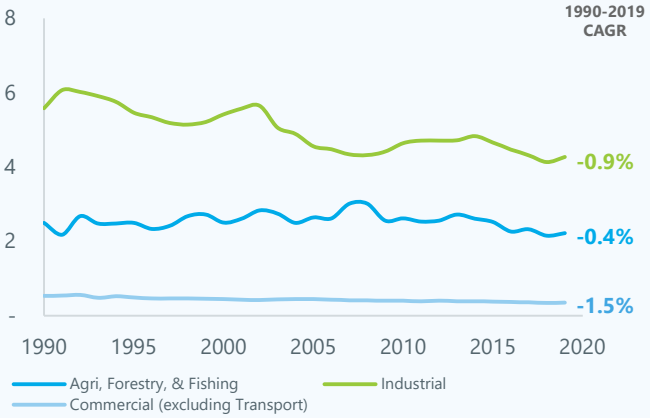
Energy intensity differs across sectors, and tends to be higher in capital intensive industries and lower for more service based industries.

Therefore, the industrial sector has consistently had a higher energy intensity since 1990, but has been falling at a rate of 0.4% per annum. Technology enabling even more efficient conversion of electricity to energy will only increase over the next 30 years, and we should see the industrial energy intensity decline further.

Agriculture, forestry and fishing follows next, with little change over the past thirty years. The commercial sector, being largely service-based, has the lowest energy intensity and has been declining at an average rate of 1.5% per year.

Energy intensity by sector

MJ/$ GDP in real 2009/2010 prices, annual



Source: MBIE. Last updated August 2020.

Consistent

Residential electricity consumption per ICP also declining

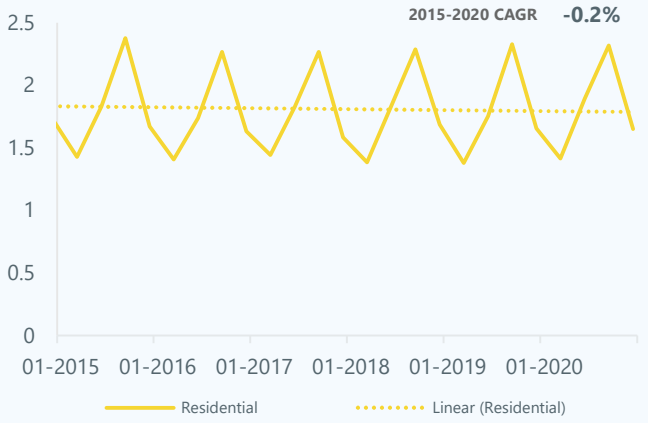
The average electricity consumed at a residential ICP can be an indicator for improvements in energy efficiency in New Zealand homes. From 2015-2020, the average consumption fell by an average of 0.2% per year.

A lot of this decrease can be attributed to increasing energy efficiency in the home. For example, people are buying more energy efficient appliances, which is partly driven by EECA's E3 programme.

Houses are also becoming better insulated, reducing the need for heating. This has been supported by the Government's Warmer Kiwi Homes programme.

Average residential consumption per ICP

kWh, quarterly



Source: MBIE. Last updated March 2021.

Industrial energy users are still relying on fossil fuels, but costs are rising; reviews underway and potential new entrants

Consistent

Fossil fuels continue to power industrial sector

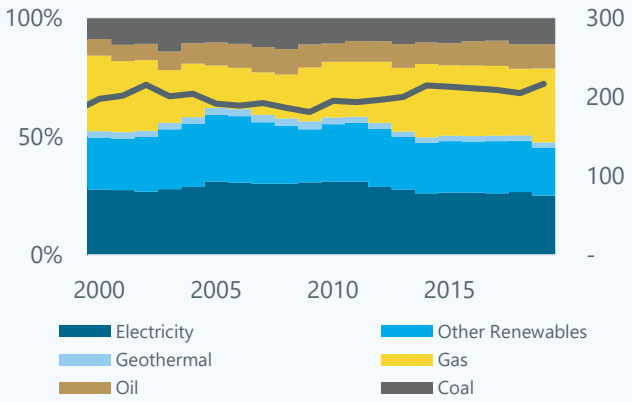
New Zealand's industrial sector relies on both fossil fuels and renewable energy sources. Over the past ten years overall industrial energy consumption increased at an average rate of 2% per annum.

Over that same period gas contribution grew from 23% to 31%, electricity decreased from 31% to 25%, and other renewables decreased from 23% to 20%. The other energy sources have remained relatively constant.

In the coming years, the push for electrification should see some fossil fuel demand displaced by electricity. Not all industrial processes are able to be electrified technically or economically and therefore alternative renewable fuels such as biofuels or hydrogen will have a role to play.

Industrial energy consumption by fuel

Proportion by fuel — **Annual gross PJ**



Source: MBIE. Last updated August 2020.

Uncertain

Cost of fuels are rising and the past year has been volatile

The cost of fuels have increased, which when coupled with the market pressures of a global recession, have led to the strategic reviews of a number of large energy users.

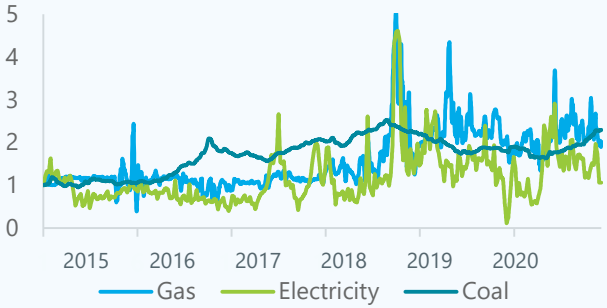
Increased coal prices, primarily driven by rising carbon prices. International price has fluctuated, most recently because of COVID-19 shutdowns in supply and demand.

Increased gas prices since the unplanned outages in 2018 at Pohokura, partly driven be carbon prices. Long term uncertainty remains as the largest gas fields have indicated declining gas production.

Increased wholesale electricity prices, partly linked to constrained gas supply, dry years and limited renewable generation. High electricity prices will be a disincentive to electrification of process heat.

Change in fuel prices, carbon inclusive

Indexed to Jan-2015



Source: Coal – Trading Economics; Gas – emsTradepoint; NZUs - Wikipedia. Last updated March 2021.

Uncertain

A number of large energy users are undergoing review

Large energy user reviews

Tiwai Point smelter
5TWh annually from grid, 12% of NZ's electricity demand
Running to at least end of 2024, future uncertain

Refining NZ – Marsden Point
341GWh annually from grid, 1% of NZ's electricity demand
Making progress on converting oil refinery to an import terminal. Also scoping other potential uses for its assets

NZ Steel – Glenbrook Steel mill
440GWh annually from grid, 1% of NZ's electricity demand
Has exited pipe and hollows production and will cease producing cold-rolled annealed products in April

Norske Skog – Tasman pulp and paper at Kawerau
470GWh annually from grid, 1% of NZ's electricity demand
Review is expected to be completed in the early 2021.

Methanex
Undertaking an organisational review caused by low gas production in New Zealand. The CCC noted that Methanex uses 40% of local gas production. Reduction in its gas use could have flow-on cost and supply implications for other gas users, including electricity generation.

Potential large energy user entrants

Other large energy users could potentially enter the market, such as data centres, hydrogen production and process heat conversions. Some of these projects are likely to come from the push to build South Island electricity demand to replace Tiwai Point's load.

Sourced from various media updates. Last updated March 2021.

Process heat decarbonisation building momentum through both electricity and biomass

Consistent

Policy and market conditions are enabling p. heat decarbonisation

Decarbonising process heat is a large opportunity for New Zealand as it contributes 10% of gross emissions and 17% of those covered under the Net Zero Carbon target.

In February 2021, we released our Electrification Roadmap, which sets out pathways for decarbonising process heat, outlining barriers businesses face, such as complexity and costs, and mechanisms that could help overcome these.

There are already a number of mechanisms in place:

- In November 2020, the Government launched a $69 million ***Government Investment in Decarbonising Industry*** **fund** to help businesses switch from coal and gas to electricity and process heat. The first $15 million round closed for proposals on December 14 2020
- To build up electricity demand following a Tiwai exit, **Meridian has developed an electrification package** for South Island process heat users that offers cheap, long-term supply contracts and a capital contribution
- The **New Zealand Green Investment Fund** was established in 2019 to invest in commercial opportunities to reduce greenhouse gas emissions
- EECA launched its **Energy Transition Accelerator (ETA)** which co-funds 40% of the cost of an expert assessment of opportunities and initiatives for businesses to reduce their emissions
- EECA has commissioned Standards New Zealand to develop **best practice guidelines** for new technologies such as very high temperature heat pumps and biomass boilers

Sourced from various media updates. Last updated March 2021.

Consistent

Electrification of process heat is already happening

A number of large process heat users have already made or are in the process of making the switch to electricity:

- **Open Country Dairy's** Awarua site near Invercargill will use New Zealand's first electrode boiler used to generate steam for milk drying. The boiler produces 4,650 metric tonnes less annual CO_2 emissions than a coal boiler and will be powered by renewable sources with no associated third-party emissions.
- **McCain Foods'** Timaru plant is reducing its environmental impact. The business has slashed coal consumption used in potato processing by installing 'Pulsed Electric Field Technology', a New Zealand first.
- **Meridian** has announced the first three projects of its process heat electrification programme, targeting an initial 15,000 tonnes of annual emissions in total. Two have been disclosed: **ANZCO Foods** and **Meadow Mushrooms**. The other undisclosed project is with a South Island coal user. Meridian has also signed a memorandum of understanding with **Meadow Fresh**.

Check out our Electrification Roadmap for more detailed case studies on:

- **Alliance Group's** commercial heat pump at its Nelson meat processing plant
- **Synlait's** electrode boiler at its Dunsandel site
- **Electricity Ashburton, Transpower** and **EECA**'s collaboration to collect information on fossil-fuelled heat boilers, which is extending to all South Island electricity distribution businesses

Sourced from various media updates. Last updated March 2021.

Consistent

Other fuels are also playing a part in decarbonising process heat

DB Breweries' Timaru plant is transitioning to biomass, which in February this year met 60% of the brewery's steam requirements and will increase to 100% by October. Switching to biomass, and away from coal, will decrease DB's total carbon footprint by 28%.

Fonterra is moving away from coal at its Te Awamutu milk processing plant, substituting the fuel with Nature's Flame biomass, and reducing its national coal consumption by 10%. Fonterra plans to have net zero emissions at its manufacturing sites by 2050.

Danone Nutricia NZ's new biomass boiler plant in South Otago is expected to be commissioned later this year. In 2019, the French food giant announced a $40 million investment in its spray drying plant at Clydevale as it looked towards achieving carbon neutrality by 2021. The new biomass boiler would reduce the plant's CO_2 emissions by 20,000 tonnes per year.

Oji Fibre, over the past three years, has been upgrading its Kawerau Tasman pump and paper mill to eliminate coal and reduce fossil fuels. Part of the solution involved decommissioning the fossil-fuelled boiler and using geothermal steam instead.

Beca, EECA, Firstgas Group and Fonterra are backing a study to assess the potential of raw biogas by treating it so it becomes a possible substitute for natural gas, which would enable gas users to decarbonise without having to change out boilers or appliances.

Sourced from various media updates. Last updated March 2021.

Electric vehicle numbers are rising and expected to accelerate due to domestic and international developments

Consistent

Passenger EV growth slowed but long term trend still uncertain

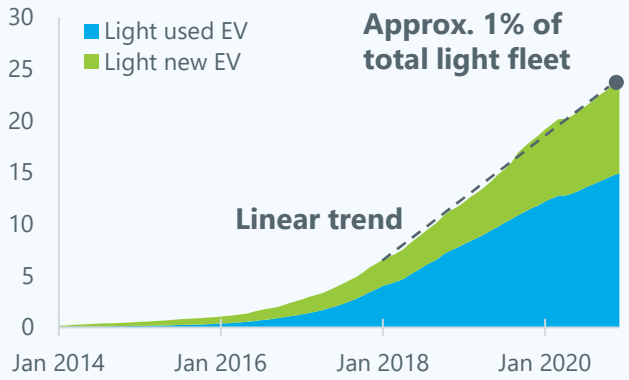
The electrification of the passenger fleet is a big decarbonisation opportunity, as cars and two-wheelers combined contribute to 58% of transport emissions.

Since 2018, the growth of EVs appears to be linear, with approximately 500 EVs being added to the fleet every month. If this trend continues, then total fleet conversion would take 565 years.

In 2021, the Government announced that it would require it's fleet of 16,000 to be electric by 2025. It also announced the introduction of a fuels emissions standard. These two policies, alongside any that arise from the CCC advice, will likely accelerate electric vehicle uptake.

Electric passenger vehicles in New Zealand

Thousands of vehicles



Source: Ministry of Transport. Last updated March 2021.

Consistent

Small but rising numbers in electric trucks

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

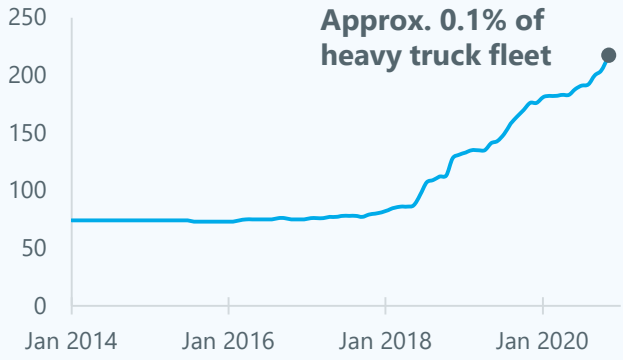
From January 2018 to December 2020, the electric truck fleet was growing by approximately 4per month. From March to June 2020, there was a slow down in uptake due to COVID-19, followed by a quick recovery.

Hydrogen and biofuels may play a larger role in decarbonising the heavy fleet because they are denser energy vectors. Hiringa is developing a network of hydrogen fuelling stations that will service vehicles developed by HYZON motors.

The Ministry of Transport's Green Freight Project discusses the decarbonisation opportunities for heavy transport.

Electric trucks in New Zealand

Number of vehicles



Source: Ministry of Transport. Last updated March 2021.

Consistent

Other transport is decarbonising, supported by Government

Public transport

The Government announced that from 2025, only zero-emission buses can be purchased for public transport, and from 2035, the whole fleet will be decarbonised. They have also committed $50 million in funding to help councils meet those goals.

Recent public transport developments include:

- **Auckland Transport** will be trialling New Zealand's first fuel cell buses built by Christchurch based Global Bus Ventures, on its Howick-Britomart route
- **Greater Wellington Regional Council** purchased 98 new electric buses in 2020, provided by NZ Bus and Tranzit
- In Auckland, **KiwiRail** is currently extending by 19 kilometres the electric commuter service from Papakura to Pukekohe. It is also on a programme to upgrade 15 electric trains the company has used on freight services between Palmerston North and Hamilton since 1988
- **East by West** ferries are part-way through building the country's first electric ferry in Wellington

Other developments

- In January, the Government announced that it would be mandating a lower-emitting **biofuel blend** for vehicles
- In February, EECA announced the latest round of 22 projects that will be co-funded by the **Low Emissions Vehicle Contestable Fund,** which include projects such as demonstration electric and hydrogen trucks, public charging expansion and community car share schemes

Electric passenger vehicles have significantly higher up front costs, a barrier even with lower running costs

Consistent

EV purchase price almost double petrol and diesel equivalent

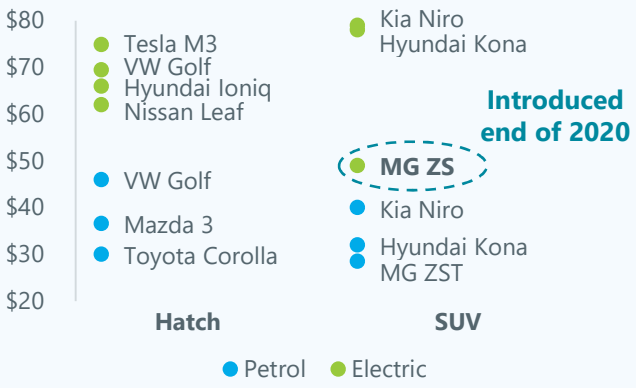
Electric vehicle purchases will start to grow significantly once the purchase price of EVs is on par with petrol / diesel vehicles. Currently, EVs are up to 50% more expensive and based on current trends and forecasts, purchase price parity is expected to be reached in 2030.

More car manufacturers are transitioning to EV production only (e.g. GM by 2035, Volvo by 2030, Ford by 2030 in Europe). The MG ZS was introduced in late 2020 and is currently the cheapest on the market.

Electric vehicles are already starting to meet 'total cost of ownership' parity due to the significantly lower running costs. Falling up front costs will further make electric TCOs attractive, which is a driver for government and commercial fleets.

Sticker price of petrol and electric models

Thousands of dollars, including GST



Source: EECA and Optifleet TCO tool. Last updated March 2021.

Consistent

EV running costs significantly lower than petrol and diesel equivalents

Electric vehicles are already becoming more attractive than their petrol and diesel equivalents due to lower running costs, and therefore in some cases, lower total cost of ownership.

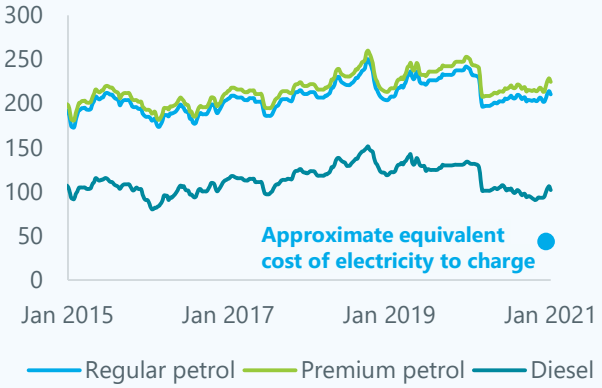
Fuel is a large component of a vehicle's running costs. Before the COVID-19 pandemic, consumers were facing rising petrol costs with the price at the pump increasing by approximately 5% annually from 2015 to early 2020.

Following the global crisis from COVID-19, petrol prices saw a considerable drop in 2020 and are yet to see a recovery.

Even with the recent drop in petrol prices, the equivalent cost to fill an electric vehicle is on average, only 20% of an petrol equivalent.

Vehicle fuel prices

Cents per litre



Source: MBIE. Last updated March 2021.

Consistent

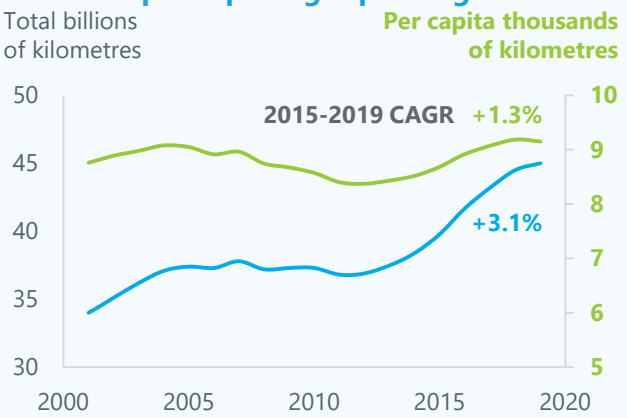
Over past five years, total and per capita travel was rising

Despite the push to lower our carbon emissions, New Zealanders' reliance on cars have grown, with total vehicle kilometres travelled (VKTs) growing at a rate of 3.1% annually from 2015-2019, and 1.3% on a per capita basis.

COVID-19 is expected to have some positive impact on VKTs during 2020, as people were forced to restrict their movements for periods at a time, but as we are seeing with electricity demand, it is likely that vehicle use has bounced back close to pre-pandemic levels.

The strong reliance on private vehicles highlights how important a role electrification will have in reducing our transport emissions, as well as the need for more attractive travel alternatives, such as walking, cycling, micro mobility, public transport and reducing the need for travel.

Total and per capita light passenger travel



Source: Ministry of Transport. Last updated December 2020.

Battery technology and demand response providing solutions to meet peak demand and support system reliability

Consistent

Total global battery capacity at the start of major growth curve

Globally, large batteries are expected to grow significantly in number and capacity as battery costs fall and their multiple value streams are realised:

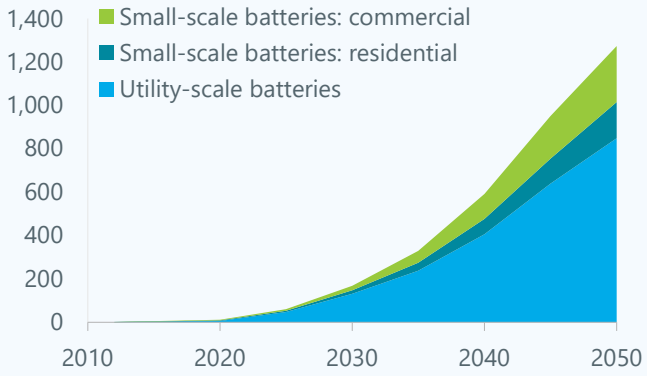
Batteries store excess energy produced by wind and solar, saving it for when generation levels are low. Battery storage can also ensure resource adequacy at a larger scale, for example during dry years.

Batteries can relieve congestion on the electricity system, enabling the deferral of distribution and transmission network investments.

Batteries can support the electricity system's stability and resilience by providing services like voltage support and frequency regulation.

Global cumulative installed battery forecast

GW



Sources: Bloomberg New Energy Finance. Last updated March 2021.

Uncertain

Total capacity of batteries in New Zealand a big unknown

Batteries are a significant opportunity for meeting New Zealand's energy storage challenge and contributing to daily peak demand periods.

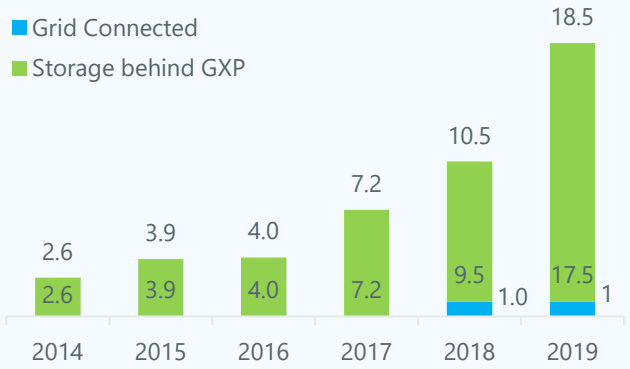
Recent large scale projects include:

- **Counties Power** are repurposing EV batteries to store over 120kWh of energy for network support
- **PowerCo** has a 2MW/2MWh battery installed in Whangamata to provide power during outages

The volume of embedded batteries are not recorded in a central platform, therefore it is difficult to determine the total capacity currently on New Zealand's network. The chart below reflects data collected in a Commerce Commission study in 2019. It is expected that today this number will be much higher.

Battery storage on power system

Estimated MW, annual



Source: Commerce Commission. Last updated December 2019.

Consistent

Consistent demand response and ripple control contribution to peak

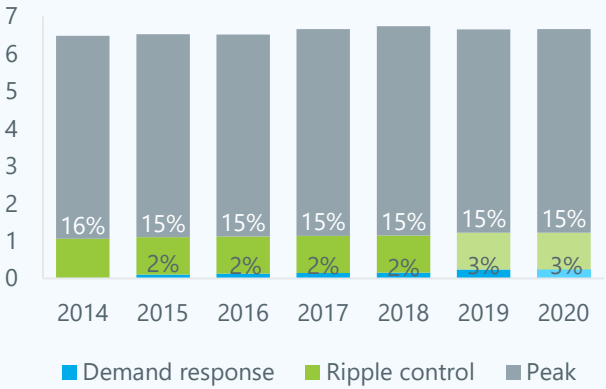
Ripple control and demand response are two other tools that are used to managed peak demand.

Ripple control has been in place since the 1950s and allows distribution businesses to turn off consumer's hot water systems at times of peak demand. Over the recent years, ripple control load is equivalent to around 15% of peak demand.

Demand response allows consumers to respond to reduce their electricity demand for a period of time in exchange for a payment. Transpower's demand response programme has grown from an equivalent of 1% of peak demand in 2014 to 3% in 2020.

Demand response and ripple control as proportion of peak demand

GW



Source: Transpower DR Programme and EECA's Ripple Control Of Hot Water in New Zealand - Sept 2020. Light shading denotes an estimate as data is not readily available. Last updated March 2021.

Distributed solar installations continue to grow in number and capacity, driven by falling generation costs

Consistent

Residential solar installations continue to grow

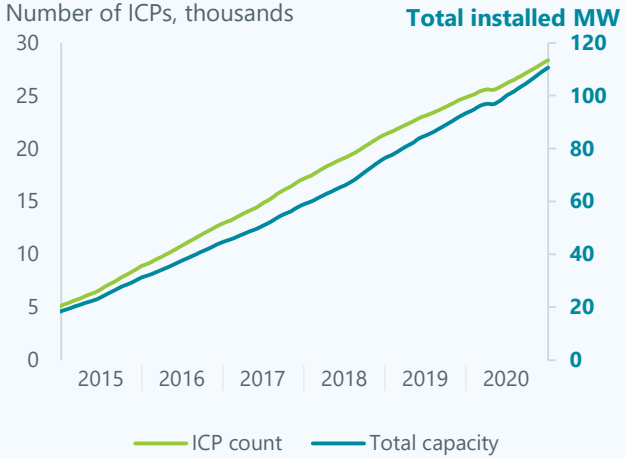
More New Zealand households are installing solar PV systems on their rooftops to take advantage of lower electricity prices.

Since the beginning of 2015, the total number of solar installations have grown by an average of 33% per year, from ~5000 ICPS to ~28,000 ICPs in 2020.

COVID-19 had a minor impact, with installations stalling during March and April 2020, after which the rate of installations regained momentum.

The average capacity of new installations grew from 3.5 kW at the beginning 2015 to 4.7 kW at the end of 2020.

Residential solar installations



Source: Electricity Authority. Last updated March 2021.

Consistent

Commercial solar installations continue to grow

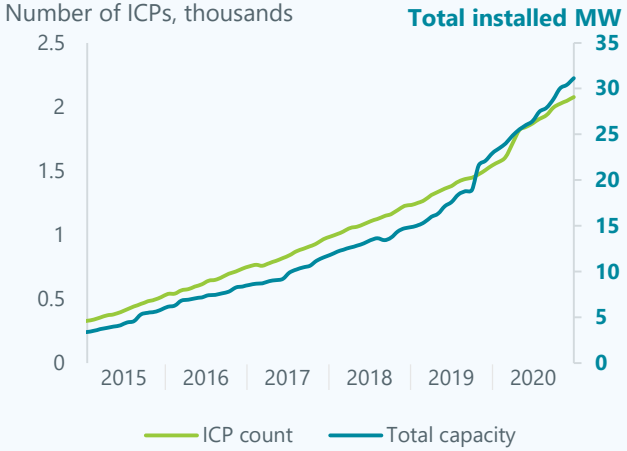
As with residential sites, commercial solar installations have also been increasing. These installations are embedded and do not include any grid connected solar plants.

Since the beginning of 2015, the total number of solar installations have grown by an average of 36% per year, from 330 ICPS to 2100 ICPs in 2020.

COVID-19 did not slow down commercial installations in the first half of 2020. Commercial installations actually increased at a faster rate during this period.

The average capacity per installation grew from 4.0 kW at the beginning 2015 to 5.9 kW at the end of 2020. In October 2019, average installation capacity jumped to 10.9 kW.

Commercial solar installations



Source: Electricity Authority. Last updated March 2021.

Consistent

Distributed solar costs forecast to continue on sharp decline

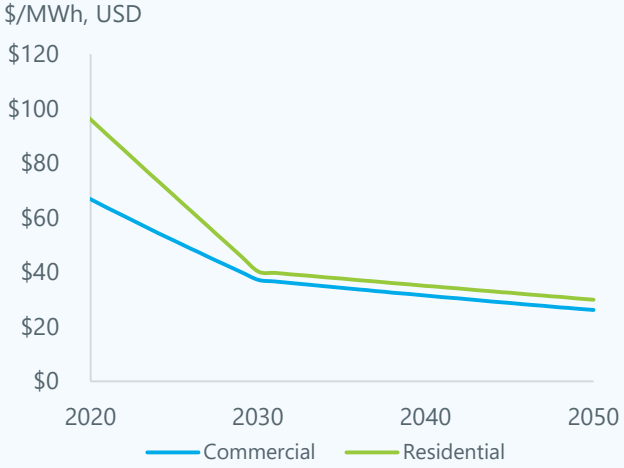
Distributed solar uptake is expected to be driven by the continued falling cost of solar panels.

Current forecasts estimate that residential solar costs could fall by 44% from 2020 to 2030 and commercial solar costs could fall by 58% over that same period. More gradual decreases are expected out to 2050.

As New Zealand's demand peak is in the evening, distributed solar is less economically attractive to consumers unless deployed alongside battery storage, which would incur an additional cost.

There is currently limited data available on the volume of solar plus battery installations in New Zealand.

Levelised cost of energy for distributed solar



Source: NREL. Last updated December 2020.

Utility scale generation continues to develop to increase renewability and in anticipation of growing electrification demand

Consistent

New grid connected generation being announced

New renewable generation will need to be built over time to meet the growth in electricity demand and to increase the renewability of electricity.

A number of new generation projects have been announced and are in various stages of development.

Who	What	Type	Capacity
Commissioned in 2020			
Todd Generation	Junction Road	Gas	100 MW
Top Energy	Ngawha OEC4	Geo	31.5 MW
Scheduled for 2021 completion			
Mercury	Turitea	Wind	222 MW
Tilt Renewables	Waipipi (complete)	Wind	133 MW
In various stages of development			
Mercury	Puketoi	Wind	200 MW
Meridian	Harapaki	Wind	176 MW
Contact	Tauhara expansion	Geo	152 MW
Tilt Renewables	Tararua 1 repowering	Wind	140 MW
Mainpower	Mt Cass	Wind	93 MW

Sourced from various media updates. Last updated March 2021.

Consistent

Power purchase agreements emerging in New Zealand

Power purchase agreements (PPAs) are used where one party agrees to purchase electricity from a generator for a set price for a set period of time, defining the revenue and credit quality for that generation project.

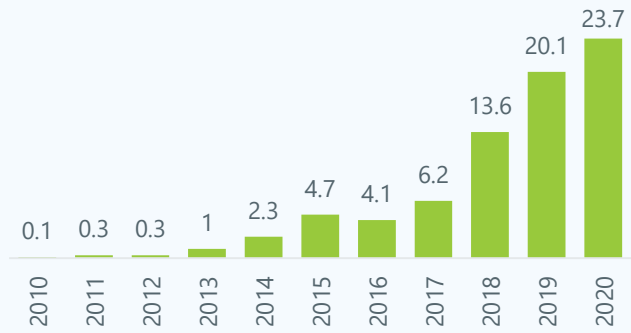
PPAs are gaining traction internationally. In 2020, corporations purchased a 23.7 GW of clean energy, up from 20.1 GW in 2019, despite a global recession.

In New Zealand, the PPA market is still emerging:

- In 2019, Tilt Renewables entered into a PPA with utility Genesis Energy for the output of its 130MW Waverley Wind Farm.
- In 2020, the Major Electricity Users Group (MEUG) went to market seeking proposals to supply major electricity users with renewable electricity

Global corporate PPA volumes

GW



Source: BloombergNEF. Last updated March 2021.

Consistent

Cost of utility scaled renewable generation forecast to fall

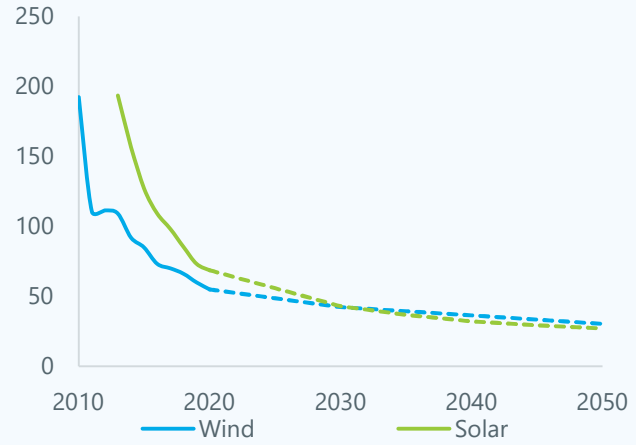
For new renewable generation to be built, the costs of renewable generation need to be cost competitive with existing thermal generation.

Over the past ten years, wind and solar generation costs have rapidly fallen – by 75% in the instance of wind – and are projected to fall further.

Because wind and solar are 'intermittent' generation sources due to their output being dependent on the weather, more expensive 'firming' capacity will be required in the form of hydro, batteries or other technology.

Levelised cost of energy of new renewable electricity generation

NZ$/MWh



Source: NREL. Last updated December 2020.

Capability to meet energy demand and peak demand is still sufficient but low rainfall and gas supply may affect security of supply

Uncertain

Low rainfall and limited gas may create risk for security of supply

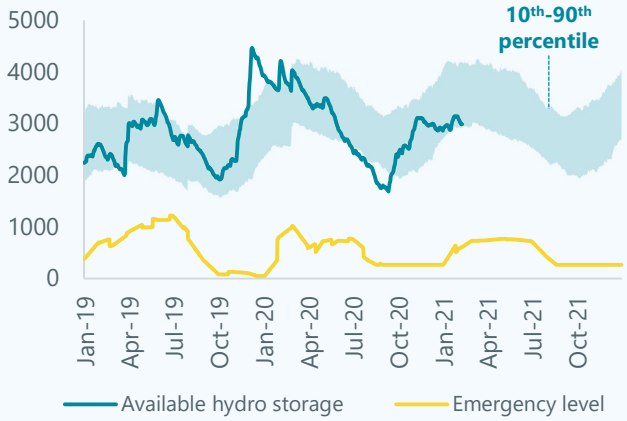
The industry needs to ensure there is enough electricity generation to meet energy demand, particularly during dry years when low rainfall impacts hydro generation. Transpower regularly assesses New Zealand's security of supply to help the industry with decision making to avoid shortages.

Over the past year, low rainfall has resulted in more thermal generation contributing to supply than typical. Coal is also being increasingly used as gas supply is constrained. Our team held a webinar last month to explain the details.

The outcome of MBIE's NZ Battery project could have a big effect on what security of supply will look like in the future, as the project aims to solve the 'dry year' problem.

Electricity risk status curve

Available storage, GWh



Source: Transpower's Security of Supply. Last updated March 2021.

Consistent

Thermal baseload being phased out and replaced with peakers

To move towards a low carbon economy, traditional baseload thermal power stations, which have backed up our hydro-dominated system, are progressively being phased out and replaced with peaking capacity.

Plant, comm. date and capacity	Announced developments
Huntly Rankines (U1,2,& 4) 1982, 750 MW Coal/Gas	• Commitment to no coal after 2025 in normal year or at all from 2030 • Unit 2 made available for coal generation for security of supply
Huntly U5 2007, 403 MW Gas	• No announced plans
Huntly U6 2004, 51 MW Gas	• No announced plans
Taranaki Combined Cycle 1998, 385 MW Gas	• Contact undertaking strategic review of its thermal plants
Stratford Peaker 2011, 200 MW Gas	• Contact undertaking strategic review of its thermal plants
Whirinaki Peaker 2004, 155MW Diesel	• Contact undertaking strategic review of its thermal plants
McKee Peaker 2013, 100MW Gas	• No announced plans
Junction Rd Peaker 2020, 100MW Gas	• No announced plans • Commissioned May 2020

Sourced from various media updates. Last updated March 2021.

Consistent

Peak demand largely unchanged but with some COVID-19 anomalies

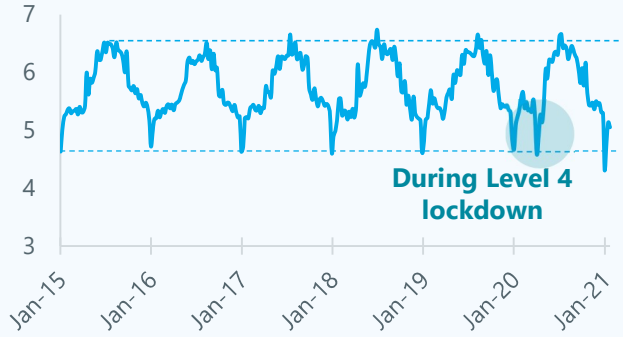
The power system is built to ensure the highest demand at any one point in time can be met. As with overall demand, peak demand follows a seasonal pattern, with higher levels during winter, specifically in the mornings and evenings as people light and warm their homes.

Peak demand has seen little variation over the past five years. During Level 4 in March peak demand dropped to levels similar to the New Years period. In both periods, most people are home and do not require as much light or heating because of the season.

Peak demand is expected to grow as electrification takes off. Historically, new investment in infrastructure has catered for peak demand growth, but emerging technology, such as batteries and smart charging, have the potential to limit peak growth by 'smoothing the peaks' and spreading demand on the network across the day.

Weekly peak demand

GW



Source: Electricity Authority. Last updated March 2021.

Electricity affordability, renewability and contribution to wider energy system stable with no growth

Consistent

Residential electricity bill declining due to falling consumption

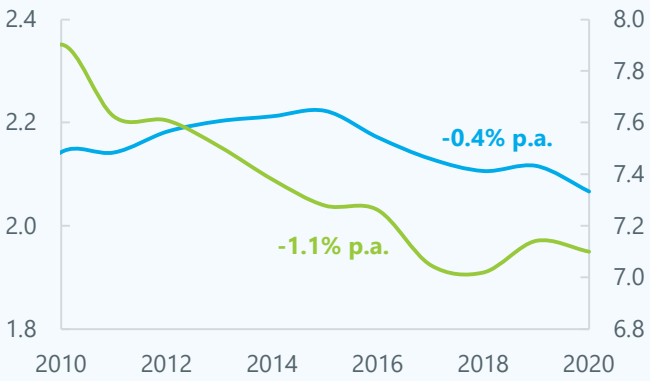
Energy affordability is a core pillar of the energy trilemma. Electrification is only likely to occur if electricity is affordable and competitive against other forms of energy.

At a household level, the average cost of electricity hasn't changed much, at 29-30 cents per kWh over the past five years.

The total household bill however has fallen by an average of 0.4% annually over the same period. Much of that is driven by a reduction in electricity consumption from improving energy efficiency, partly driven by Government programmes such as Warmer Kiwi Homes and energy efficiency standards.

Average annual residential consumption

(● $000s) (● MWh)



Source: MBIE, Quarterly Survey of Domestic Electricity Prices. Last updated December 2020.

Consistent

Renewable electricity hovering around 80% of electricity demand

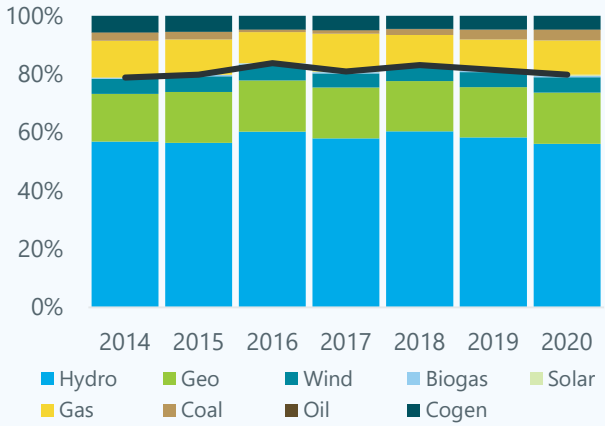
Over the past decade, New Zealand's electricity system has consistently been around 80% renewable. In 2020, approximately 56% of generation came from hydro, the lowest since 2015, 18% from geothermal and 5% from wind, both similar levels to previous years. Solar (including embedded) and biogas together made up around 1%.

Years of lower renewability generally coincides with low hydro levels, 2020 included. During the 2020/21 summer period, the thermal share of generation reached up to 20%, double what had been seen in the previous four summers.

In our base case in WiTMH, we estimate that electricity supply could reach 95% renewable by 2035 through low cost generation and the phase out of coal.

Renewability of electricity generation

Percentage



Source: MBIE. Last updated March 2021.

Consistent

Electricity consistently contributes a quarter of energy needs

Although New Zealand's electricity system is largely renewable, New Zealand's energy system is not.

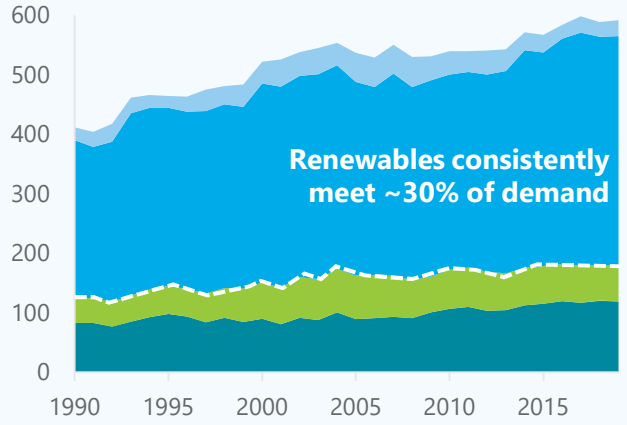
Electricity has consistently contributed around 25% of New Zealand's energy needs over the past ten years. The remaining 75% is made up of 13% renewables, such as geothermal and biomass, and 87% fossil fuels.

Through electrification and efficiency improvements, we estimated in WiTMH that electricity's contribution to New Zealand's energy demand would grow to 58% by 2050.

Other fuel switching possibilities such as coal to gas, gas to hydrogen, and the use of biomass/ biofuel will also have a role to play in the displacement of fossil fuels out to 2050.

Energy consumption by supply source

Annual, petajoules



Source: MBIE. Last updated August 2020.

Progress against the ten Whakamana i Te Mauri Hiko industry themes is ongoing, and may shift based on outcome of CCC's advice

1 Streamlining our connections process	• Transpower is continuing on its programme to streamline its connections process • A 'Getting you connected' section has been added to our website to improve information available to those wanting to connect to the grid
2 Integrated system planning	• Transpower has begun its 'Net Zero Grid Pathways' project, which aims to ensure New Zealand can take an integrated view of future investment needs • Phase One of NZGP underway, starting with the build of Clutha Upper Waitaki Lines Project
3 Getting the incentives right for electrification and renewables	• EECA-managed funding and support available to transport and process heat electrification • Mandate for a carbon neutral state sector • Outcome of Climate Change Commission advice likely to have an effect
4 Removing barriers to low carbon infrastructure	• Announcement of Resource Management Act reforms • Transmission Pricing Methodology reform currently underway • Outcome of Climate Change Commission advice likely to have an effect
5 Demand-side management of peaks	• Transpower's demand response programme ongoing • Other parties such as Vector exploring demand response opportunities • Outcome of Climate Change Commission advice may have an effect
6 Ensuring generation meets peaks	• New generation has been announced • Some generation projects deferred due to possibility of Tiwai Point exiting • Outcome of Climate Change Commission advice likely to have an effect
7 Managing dry year risk	• MBIE's NZ Battery project is underway; Phase 1: Investigation into solutions due to finish April/May 2022 • Outcome of Climate Change Commission advice likely to have an effect
8 Protecting system stability	• Transpower continues to monitor risks to system stability • Transpower is commencing work on the Waikato Upper-North Island Voltage Management project which is needed to manage potential changes in demand and generation in the region
9 Access to skilled workforce	• No major developments • Near term uncertainty due to ongoing immigration constraints and recent vocational training reform, resulting in the amalgamation of training institutes into a single New Zealand Institute of Skills and Technology
10 Collaboration	• Continuously exploring opportunities to collaborate • Transpower is currently working with EECA and South Island distribution businesses to explore process heat electrification opportunities