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Waikato Regional Energy Inventory

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Executive Summary

Energy is integral to society and economy; its use has fundamentally supported the development of human civilisation into current times. The pressing need for climate action has led to a global shift towards sustainable low and no carbon, renewable energy sources. Renewable energy technologies offer promising solutions to reduce carbon emissions and support mitigating the impacts of climate change.

The need for, and use of energy is ubiquitous, and no single agency has responsibility or control for all facets of access and use, therefore this inventory covers the breadth of entities involved.

Waikato Regional Council (the council) is involved through direct policy levers which mostly concern the supply side of the energy equation. Where others have direct policy levers such as pricing, markets and demand management, the opportunities for the council's indirect influence are noted.

The purpose of this inventory is twofold:

- to create an updated evidence-base for a review of the Waikato Regional Energy Strategy so as to contribute to the transition to a low-emissions regional economy; and
- to allow the regional council and the Waikato communities to engage with central government energy initiatives.

This inventory draws together what is known about energy, and what we understand climate futures to be. It shows this information through maps, tables, and appendices. It also identifies the known unknowns and presents these as gaps to be addressed as work that will need to be commissioned for the Regional Energy Strategy.

In addition to describing societal dependence on energy and in particularly the way fossil fuels have created a legacy of high energy use, the inventory recognises the climate impacts and the need to transition from these sources of energy. It explores what we understand to be alternative sources of renewable energy. In doing so, the relationship between energy and energy carriers is explained as these are often conflated.

The inventory itemises the known spatial extent of existing and potential energy resources in the region and briefly describes the technology used to access them. It recognises the current reliance of electricity as a just in time energy carrier and the opportunities to expand its role in the transition from fossil fuels. It also identifies opportunities to produce other energy carriers from renewable electricity either for industry, export, storage, or alternative fuels in hard to electrify uses.

The inventory includes the regional regulatory context to inform the review of the Regional Energy Strategy and future central government engagement and advocacy on energy matters.

The inventory also addresses the current understanding of demand management, including opportunities for transition to a low emissions economy with electrification and substitution of portable transport fuels.

Electrification of economic sectors will be a key policy response, and this is a focus of the inventory on both supply and demand and transmission. It is also much greater than any one region can control, but knowledge from the inventory will allow engagement at a national level on policy response. While it is not possible to separate out the Waikato region's contribution to grid access enquiries as Transpower's planning regions do not exactly fit the region's administrative boundaries, the Waikato's contribution is significant and is likely to total at least 25 percent of the anticipated future connection activity. The enquiries focus on new supply in the Waikato and Central North Island, particularly with solar and wind, and for new load in Auckland with specific reference to data centres and transport infrastructure.

The inventory highlights the existing regional dominance of hydro, thermal and geothermal electricity generation with an existing installed capacity of 3,837 megawatts. This is over one third of the national electricity generation. Future generation interest, including a transition of current fossil fuelled generation with biomass, is dominated by wind (offshore and onshore) and grid connected or distributed roof top solar estimated at 9,898 megawatts. This places the Waikato region at the forefront of the nation's energy transition.

The new generation and additional transmission infrastructure are currently land use decisions regulated in district plans on the environmental effects of the technology used to access them. The regional council has a role of strategic integration of infrastructure with land use. This is a key element of the Regional Policy Statement.

In addition to the facts on resource availability and the current national policy and regulatory environment, the inventory also summarises the electricity market with the conclusion that it is currently set up to provide returns to shareholders, rather than transitioning to a low carbon economy to meet government emissions reduction commitments.

Finally, the expectations of regional partners and stakeholders for the review of the Waikato Regional Energy Strategy are itemised, providing direction for the next phase of this work.

1. Introduction

The fundamental drivers that prompted the 2008 Waikato Regional Energy Strategy have not changed, however, there is an increased requirement to decarbonise the economy.

The expectations from communities, businesses, and successive governments on the local government sector to facilitate and deliver low-emissions and resilient communities have increased. The relationships between the Waikato Regional Council, iwi partners and local councils have also matured. The economic environment has also changed in that more options are now available to decarbonise the economy through technology advances allowing cheaper generation and demand-side efficiencies, particularly in transport.

The challenge remains to decarbonise the economy within an envelope of maintaining energy security and supply. The Waikato Regional Council has the powers and functions to interface between the economy and the natural environment through its role in support of citizens and businesses and its delegated role to implement central government's resource allocation responsibilities.

Central government, through the Ministry of Business, Innovation and Employment (MBIE) is developing a New Zealand Energy Strategy, which is planned for completion by the end of 2024. For the strategy to operate effectively in the Waikato region, it must be complemented by a regional understanding (inventory) of the local energy supply opportunities and constraints and inter-regional demand issues, as well as solutions specific to the needs and capacity of the Waikato region.

The objective of this regional energy inventory is to inform Waikato Regional Council's input to the national energy strategy and inform a future review of the Waikato Regional Energy Strategy. This inventory establishes the evidence base. It provides an understanding of what is, and not what could be. It will allow the regional council to respond in a coherent and robust manner to central government's energy related initiatives. It will also raise awareness of the regional potential in the transition to low emissions economy.

2. Background

2.1 History of the human use of energy

All ecological systems involve the transfer of energy through trophic levels[1], and human biological systems are no different. Human civilizations have evolved and developed through use of energy over generations. Our species' history is tied to our use of energy.

Human cultural evolution and civilization development has centred around the use of energy and the ability to turn energy into heat, light, and motion (the three energy services). Access to these services have been a driving force behind cultural and economic progress over the past 10,000 years and can be grouped into a series of distinct stages characterised either by the fuel source (energy carrier) or dominant use.

Initially humans were subject to the same constraints applied to all ecosystem elements as human ecology was linked to the transfer of energy from one trophic level to the next. The energy transfer medium (carrier) was organic molecules called food.

Human dependence on energy was enabled by conversion of solar energy through photosynthesis into plant biomass that powered muscles that provided motion (either human or from domesticated animals) with heating and lighting from burning wood biomass. The fuel in both cases was carried in the chemical bonds of organic molecules and originated from the sun. In preindustrial times, the fuels were biologically sourced from plant biomass and animal oils, connecting ecology to the human economy.

Only the very wealthy could command labour in the form of animal ownership and in extreme cases human slavery. This advantaged empires and kingdoms rather than individuals. Access to biomass allowed civilizations to cook food and create technologies that produced pottery and tiles, smelted metals (bronze and iron) to develop sharper and lighter tools and use flowing waters and wind to mill flour and pump water into aqueducts.

The next step change in the use of energy came from using fossil fuels and was started by the invention of the steam engine. This is known as the industrial revolution which itself evolved in a series of steps with ever more efficient use of fossil fuels. Fossil fuels are the geologically sequestered, decayed and transformed remains of plants and animals from previous geological eras.

The consequence of digging up and using fossil fuels (biomass from Palaeozoic summers) was that this use of energy created an unforeseen consequence – that of increasing the insulating capacity of the atmosphere – shifting the balance between incident solar radiation and reflected heat. This is because fossils fuels are primarily made up of molecules of carbon and hydrogen which when burned (combined with oxygen) release water and carbon dioxide. Carbon dioxide is a long lived (millennia) molecule that prevents reflected solar energy from exiting into space, trapping heat in the lower atmosphere as a greenhouse would. It and other gases, all with greater impact, but often shorter lives are known as 'greenhouse gases'.

Over the course of the last 250 years, human use and dependence on fossil fuels went through a series of distinct phases. The first between 1760 – 1840, saw the use of coal to fuel more and more machines for motive power; steam engines for trains, pumps and looms and ultimately for electricity generation initially to supply heating and lighting services.

A resurgence of the industrial revolution between 1860 and 1914 created a rapid growth in transportation technology and inventions in the way energy (oil and latterly natural gas) was used. This also increased the use of electricity in industrial processes, petroleum from oil for transport

[1] The levels on the food web consisting of primary producers, herbivores and predators.

and enabled the production of steel. Natural gas was also used in some countries for industrial and public street lighting creating the conditions for productivity, wealth and population increase.

In the early 20th century and following the change to oil as a fuel that gave the British Royal Navy a strategic advantage during the First World War, the steam engine was overtaken by the internal combustion engine. This was particularly the case for transport including commercial aviation (motive power) as well as providing feed stock for plastics and asphalt. This tied individual, social and economic progress to oil.

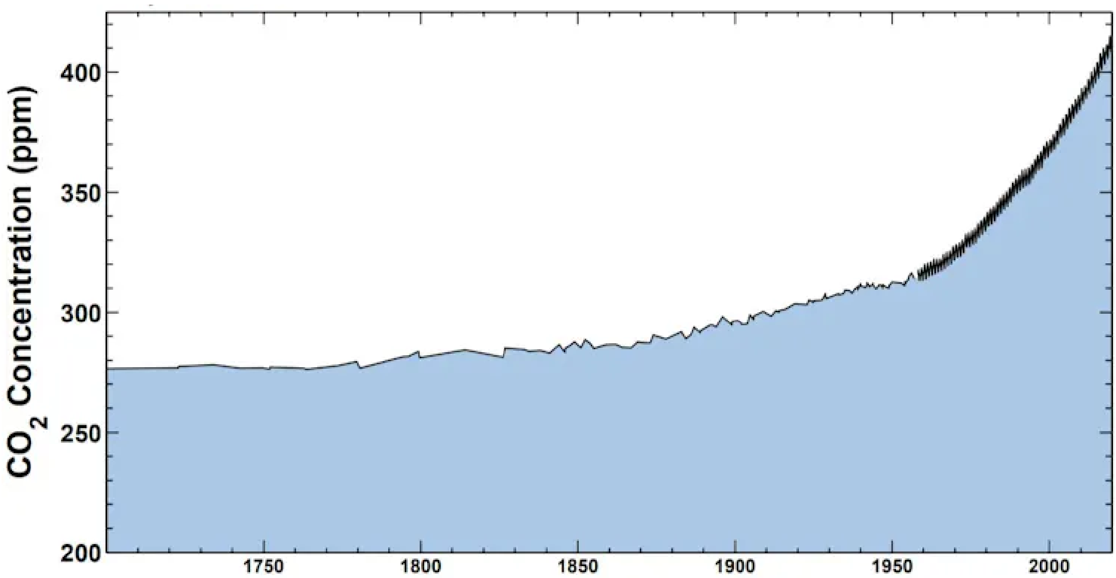
If the First World War created the shift between fossil fuel types, it was the Second World War twenty-two years later that pioneered a totally new energy source: the energy found within atomic structures (nuclear) rather than between them (molecules).

Atomic energy can be used as a non-greenhouse gas emission alternative to fossil fuels as a source of heat converted to steam that can power generators for grid supply electricity generation or in limited naval situations for motive power. In this way, it is a return to the technology that started the industrial revolution - a newer version of the steam engine – the steam turbine. Groundwater heated from deep within the earth can also be used either directly or to generate electricity using the same technology.

The increased manufacturing capacity created during World War II was repurposed and used to further democratise energy services in the form of automobiles and domestic appliances, and the booming population created suburbs that were automobile-centric. This has created a legacy issue of reliance on individual fossil-fuelled automobiles and the transportation of produce.

The effect of releasing emissions from combusting fossil fuels and atmospheric concentrations of CO_2 has been measured from 1958. The following figure shows the amount of CO_2 emissions that are stored in the atmosphere. This tracks the industrialisation since the 18th century. The concentration that is stored in the atmosphere is just 70 per cent of the CO_2 emitted from burning fossil fuels and land use change. The remaining 30 per cent has been absorbed into the oceans and contributes to ocean acidification.

The following graphic shows atmospheric carbon dioxide concentrations since pre-industrial times:[2]



[2] The Keeling Curve, from 1700 to the present: The early data was derived from ice cores and the data since 1958 was collected at Mauna Loa Observatory. Credit: University of California San Diego, Scripps Institution of Oceanography, 2020 The Keeling Curve (ucsd.edu)

The result of trapping heat (energising) in the atmosphere has changed the way energy (heat) is distributed around the planet with consequent impact on weather systems and outcomes, with some weather events becoming more violent and droughts becoming more extreme. That is, the very fuels we have used to develop our cultures and civilisation are no longer fit for purpose: their use has now changed the chemistry of the atmosphere so much so that we are losing resilience to the weather.

The present day brings us to a back-to-the-future situation where we are using technologies developed as a result of fossil fuels to create new opportunities to supply energy services using renewable energy that we can now harvest.

2.2 Out of scope

Fossil fuels and nuclear energy are out of scope of this inventory. Nuclear energy and the reasons why it is not in scope are described in Section 4.2.2. Fossil fuels are addressed in Section 4.3.

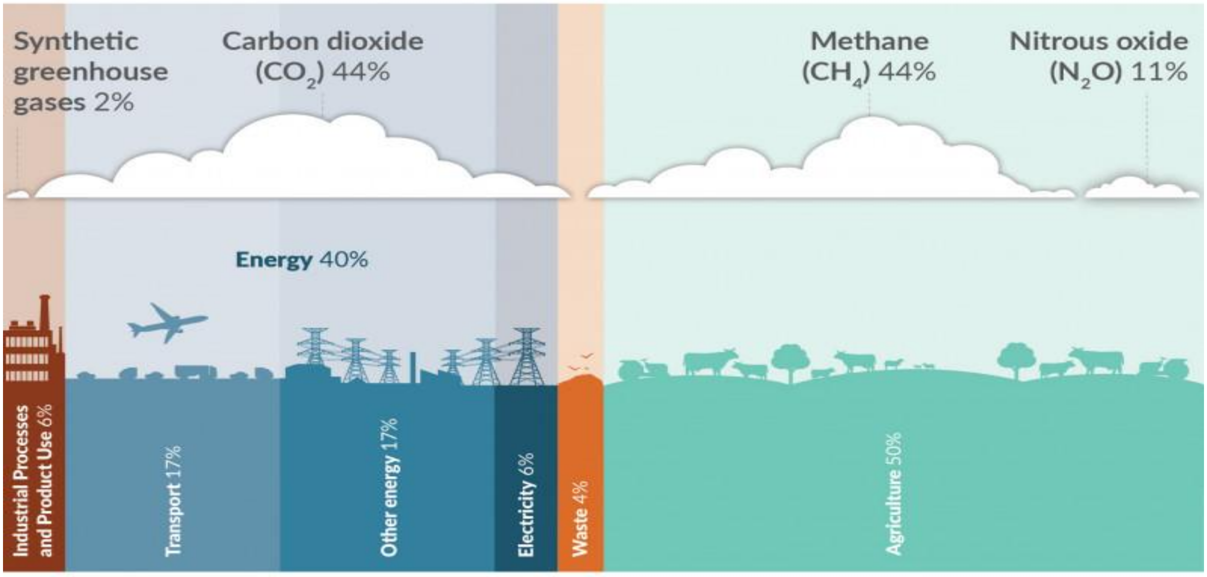
3. Context – operating environment

In October 2016, New Zealand signed up to the 2015 Paris Agreement which entered into force in November 2016. The primary purpose of the agreement is to keep the global average temperature well below 2°C above pre-industrial levels, while pursuing efforts to limit the temperature increase to 1.5°C. In 2016, New Zealand submitted its nationally determined contribution to move to a net zero emissions economy by 2050, and by 2030 to reduce net greenhouse gas contributions to 30 per cent below gross 2005 levels. This was updated in 2021 to reduce net greenhouse gas emissions to 50 per cent below gross 2005 levels by 2030.[3]

At the recent United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP28, December 2023), the incoming coalition government recommitted to achieving a net zero greenhouse gas emissions economy by 2050 by doubling the country's renewable electricity generation. It also signed up to the official list of countries to globally triple renewable energy use and double energy efficiency by 2030.

To meet this target, it is necessary to understand which economic sector the nation's greenhouse gas emissions come from. From returns submitted to the UNFCCC, New Zealand's gross emissions were 78.8 million tonnes of carbon dioxide equivalent (Mt CO_{2e}). This was partially offset by land use, land use change and forestry sequestration giving 55.5 Mt CO_{2e}. At 31.5 Mt CO_{2e}, the energy sector was the second highest contributor making up 40 per cent of gross emissions, as shown in the following figure.

Figure 1: Breakdown of New Zealand's gross greenhouse gas emissions by sector and gas type in 2020[4]



3.1 Energy policies of the coalition government

Both coalition agreements of the current government recognise the independence of the parties as having differing manifestos. There are mutual recognition statements in both documents recognising that the agreed policies may overlap. The energy specific policies of coalition parties are found in Appendix 1.

[3] Nationally Determined Contributions Registry | UNFCCC and New Zealand NDC November 2021.pdf (unfccc.int)
[4] New Zealand's Greenhouse Gas Inventory 1990-2020 snapshot | Ministry for the Environment

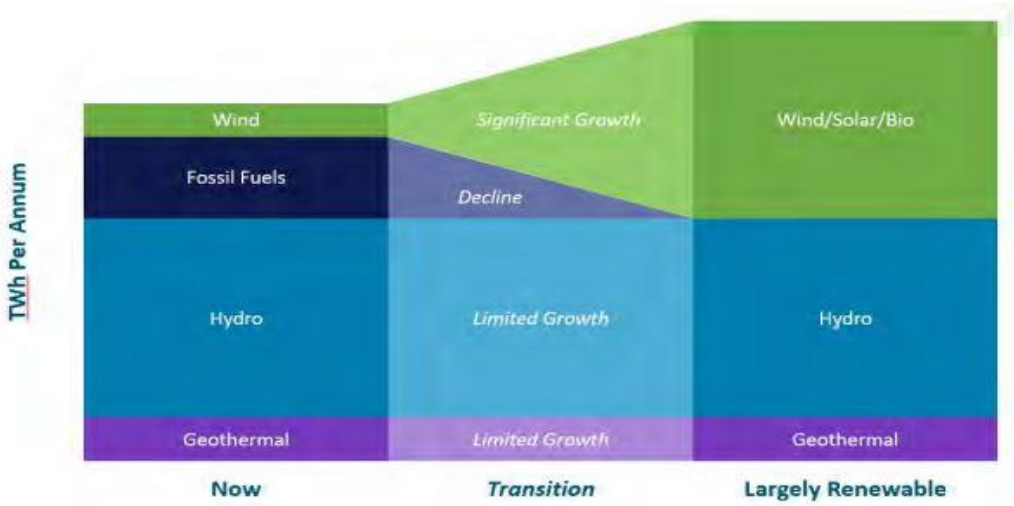
The renewable energy commitments were further reinforced by the Hon Chris Bishop, Minister for Resource Management Act Reform during the parliamentary process to repeal the Natural and Built Environment Act2023 and the Spatial Planning Act 2023:

"W*hen it comes to renewable energy, we need to go further and faster, which is why this Government's committed to updating a national policy statement on renewable electricity generation. I acknowledge the work of the prior labour government, who had done some initial work on that. We intend to use that and have our own national policy statement on renewable electricity generation."*[5]

Clearly, facilitating renewable energy, increasing transmission capacity and the role of oil and gas in the transition will be a focus of the government.[6] The government is also progressing with a targeted review of national direction for renewable electricity generation and transmission. This will update the current national policy statements for renewable electricity generation and transmission and the national standard for transmission while at the same time introduce a national standard for renewable electricity generation.

At the time of writing, the relationship between the new fast-track legislation and the revised national direction for energy infrastructure is unclear.

The transition to a decarbonised or low carbon energy system is underway, and this has been advancing with the electrification of industrial process heat and transportation. This will create greater demands on the electricity supply system itself in coming years. The Ministry of Business, Innovation and Employment (MBIE) indicated where (the type of renewable energy resources) the increased generation will come from in its briefing to the incoming Minister of Energy, the Hon. Simeon Brown.[7] The briefing document contains the following graphic summarising the current electricity generation fuels, a transition and the anticipated mix of fuels for a 'largely renewable' future generation portfolio.



It is expected that generation capacity will grow as the rest of the economy decarbonises and transitions into using electricity. The briefing document also makes the following assumptions:

[5] Hansard Committee (part 1)

[6] Dentons in New Zealand - Policy shifts in the energy sector - what to expect. See also the Fast-track Approvals Bill - Fast-track Approvals Bill 31-1 (2024), Government Bill Contents – New Zealand Legislation

[7] 27 November 2023 Briefing for the incoming Minister for Energy (mbie.govt.nz)

- That electricity generation from both hydro and geothermal resources are mature industries and there will be only limited growth in these sectors. This can be expected to occur through increasing technological improvements for those resources already being used. An example is the increased generation outputs from hydro dams each time the respective power houses are refurbished, and turbine/generators are replaced. Another example is the increase in understanding of the geothermal system responses each time the individual reservoirs are perturbed through adjustment of location and volume of production and reinjection wells; and
- That the transition will result in a phasing out of fossil fuels and that this will be replaced (and more) by new generation based upon wind, solar and biofuels.

The implications for the regional council are clear: the transition from fossil fuels and new growth in renewable electricity generation will be either regulated by the Crown (in the exclusive economic zone (EEZ)) or by territorial authorities as a land use. Regional and inter-regional integration will remain a regional function as currently required by section 30(1)(gb) RMA, for the strategic integration of infrastructure with land use and exercised through the regional policy statement.

4. Energy resources – existing and potential

4.1 Introduction

4.1.1 Three energy services

All of our use of energy can be fitted into three classes. They are:

- Heating, which can include, cooling and refrigeration (heat itself is a form of energy carrier)
- Lighting either through heat (fire and incandescent wire) or excitement of electrons producing photons
- Motion – linear and rotational movement.

4.1.2 Energy carriers and storage

Electricity is an energy carrier, as are chemical bonds and heat. Carriers can be used to transport / transmit energy or to store it. There are four primary energy carriers and storage types. They are:

- Chemical: sourced from fossil fuels (petroleum, coal, wood, and natural gas) or synthesised from renewable electricity based on hydrogen.
- Electrical: batteries and capacitors
- Heat: local use so no real long-term storage
- Mechanical: springs, rotational mass.

An energy carrier does not produce energy; it simply contains energy imparted by another system. There are two types of energy - potential and kinetic - and these are reflected in the range and types of energy carriers. For example, while energy is able to be transported from one location to another as chemical bonds, e.g., a liquid transport fuel – they are effectively being carried in 'stored form'. By way of contrast, electricity is an energy carrier with the flexibility to be transmitted using transmission grids or stored using batteries for later use.

4.2 Overview of natural resources containing energy

The energy contained within natural resources of the Waikato region are either chemical (molecular bonds) in biomass, or physical as kinetic states of matter (either differential air pressure or water flow), geothermal enthalpy (the amount of heat and kinetic energy in geothermal fluid) or photons from the sun. The following sub-sections introduce the different energy-containing natural resources.

4.2.1 Astronomical

The two key ways astronomical energy is imparted to the resources of the region are from the sun (solar) and the gravitational interactions between the sun, the earth and the moon as they affect the movement of marine tides.

Solar

Most of the renewable energy available comes either directly or indirectly from the sun. Even fossil fuels were originally the bio-products of Palaeozoic summers sequestered and processed for tens of millions of years. Solar-influenced renewable energy sources include:

- Sunlight (heat and photovoltaic)
- Biomass (solid, liquid and gas)
- Wind (kinetic air pressure)
- Hydro (rainfall and kinetic energy) and
- Wave (rotational kinetic energy).

The process by which energy is released by all stars including the Sun is known as fusion. There are approximately 30 start-up companies trying to replicate this process on earth to provide affordable, sustainable, carbon free energy on earth. On such company is Openstar Technologies in Wellington[8] with an estimate of fusion as a process being 10 years into the future.

Marine currents and tides

Coastal tidal currents, and to an extent, oceanic currents are influenced by celestial bodies. Tides are the rise and fall of coastal water caused by the gravitational attraction of water by the sun and moon. The rotation of the earth creates two tidal cycles per day. At 28-day intervals the alignment of the sun, earth and the moon (lunar cycle) combine to create stronger tides (spring) and at other times weaker (neap) tides. Local bathymetry can concentrate tidal flows into areas of highly energised currents. These tend to be off headlands and in harbour/estuary channels.

While the drivers of coastal tides are broad in effect, it is the local coastal geography and current technology that determine the availability of this energy source. The existing technology to access the kinetic energy of concentrated tidal currents is like that used for wind; vertically anchored two-or-three-bladed turbines. Water has a much higher density to air (about 800 times) so the turbines are smaller in diameter, however, to allow navigation in all sea states and over all tidal ranges, they must be deployed where the water is deep enough. Most current marine turbine designs are designed to be deployed in harbour channels of between 25 and 35 metres in depth.[9]

There is limited opportunity to access marine tidal currents aside from harbour entrance channels, with only the Colville channel between the Coromandel peninsula and Great Barrier Island having significant flow. However, none of the harbours in the region have channel depths in the required range. This is discussed further in Section 4.4.6.

Gravity is an astronomical property essential to the storage of potential energy of water in hydro systems.

4.2.2 Geological

Energy from within the earth comes in many forms and three of these are useful to provide energy services to modern society. Geologically sourced energy is stored as heat in rocks, transferred to the surface by upwelling and tapped groundwaters referred to as geothermal fluid, chemically as fossil fuels in the form of coal, oil and gas, and atomically in the form of radioactive minerals or nuclear energy.

Fossil fuels contain carbon and can exist as:

- A solid, such as in coal, lignite and peat, or sequestered in old and disused products made from plastics and tyres typically found in municipal waste streams,
- A liquid, such as in tar and oil, or
- A gas, such as in methane.

The Waikato has significant fossil fuel resources in sub-surface coal and surface peat.[10] The region is not known for oil and gas, but coal has a long history of mining, and there are 14 known coalfields between Maramarua in the north and Mokau in the south. Peat has historically been mined in the Hauraki plains which, along with drainage for pastoral agriculture has resulted in subsidence and oxidation leaving 220 km^2 of land below sea level and a climate adaptation liability. Drainage alone accounts for a further 43km^2 of peat land below sea level in the Waikato River catchment.

Nuclear energy (fission) is a low greenhouse gas-emitting energy source, however, there is no social licence to develop a nuclear generation capacity at this time. This technology has high costs needs to address, residual waste management issues and the requirement for large quantities of cooling

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[8] Openstar technologies Limited. OpenStar Technologies

[9] Energy Efficiency Conservation Authority and SKM, Regional Renewable Energy Assessment 22 June 2006.

[10] Crown Minerals Act 1991 No 70 (as at 23 December 2023), Public Act 2 Interpretation – New Zealand Legislation. **Coal** means anthracite, bituminous coal, sub-bituminous coal, lignite, and peat; and includes every other substance worked or normally worked with coal.

water favouring coastal locations. This is difficult with climate change-driven sea level rise and the tectonic history of the country. Recent international experience of a nuclear plant in similar tectonic situation (Fukushima) exposed and highlighted this risk.[11] This form of energy is inconsistent with the national anti-nuclear weapons stance which has been widely interpreted to also include nuclear energy. It has therefore not been progressed in this report.

Energy is also stored at the boundary of sticking tectonic plates where pressure builds up until released as an earthquake. This form of energy is unusable with current technology and can be destructive to renewable energy infrastructure and electricity transmission.

4.2.3 Other energy

Manufactured products or processed natural materials have embodied caloric value, and at the end of their economic life are sometimes burned, releasing energy as heat along with greenhouse gas emissions. Waste timber as well as virgin wood is covered under biomass, however, where space is a premium - as is the case in some European countries - and the generation of electricity comes from fossil fuels, combustion of municipal waste is seen as a solution to reduce greenhouse gas emissions.

Typically, the composition of municipal waste is 60-70 per cent renewable products[12] (paper, card, and compostable organics) with the remainder predominantly plastics and end of use tyres. This renewable fraction is less than the national electricity generation of renewable sources at over 85 per cent.[13] The alternative is to return products derived from fossil fuels back to the ground, sequestering the carbon and preventing release into the atmosphere. The high fraction of fossil-derived products means that combustion of municipal waste creates higher greenhouse gas emissions than the current electricity generation fuels and detracts from the transition to a low emissions economy.

To be economic, waste to energy plants rely on a continuous stream of high calorific value waste often sourced from outside the municipal catchment areas. As an example, the recent proposal to generate 15 MW of electricity from municipal waste at Te Awamutu[14] relies on specific waste streams from outside the region. The combined waste generated annually from kerbside collections in the Waikato and Bay of Plenty regions is 135,663 tonnes. The plant is proposing to burn 166,525 tonnes a year. This includes:

- 10 per cent combustible materials from vehicle recycling (17,529 tonnes),
- 20 per cent end of life tyres (35,058 tonnes),
- 20 per cent plastics (35,058 tonnes), and
- 45 to 50 per cent municipal solid waste (~87,880 tonnes).

Waste to energy projects take fossil carbon that is already sequestered in the form of manufactured products that can be buried and releases them to the atmosphere in the form of CO_2 adding to the regional emissions profile, contrary to the council's strategic direction of a transition to a low emissions economy.

4.3 Non-renewable sources of energy

4.3.1 Coal

The Waikato region is the predominant source of coal in the North Island, with production primarily sourced from the Huntly East and Rotowaro mines, and on the west coast in the Mokau area. There

[11] World Nuclear Association, Fukushima Daiichi Accident Fukushima Daiichi Accident - World Nuclear Association (world-nuclear.org)
[12] southland-murihiku-regional-energy-strategy-2022-2050-final.pdf (greatsouth.nz)
[13] Energy in New Zealand 2023 | Ministry of Business, Innovation & Employment (mbie.govt.nz)
[14] Te Awamutu waste-to-energy plant: Environment minister asked to get involved - NZ Herald

are an estimated two billion tonnes of coal remaining in the ground in the 14 known coalfields between Maramarua and Mokau. This compares with the New Zealand total recoverable coal reserves, which are estimated to be around 8.6 billion tonnes.

Waikato coal fields

A significant part of this resource is more than 300 metres deep, and extraction to date has mainly been of the shallow coal resources. Significant shallow coal resources exist in the historically important coal fields of Rotowaro, Huntly and Maramarua, with significant underground opportunities in the other major coal fields at Waikere, Kawhia, Mangapehi and Mokau.

Underground mines in Huntly have reached a maximum depth of 300 metres. About 40 per cent of the region's coal resources are deeper than this and therefore economically inaccessible using existing technology. New technologies and utilisation methods have been investigated and pilot projects commissioned to allow access to deeper resources in the north of the region. These include investigation of underground gasification and coal bed methane. Preliminary work in 2009 showed that coal bed methane in the Waikato is a very clean, high quality natural gas with less than two per cent CO_2 on extraction, and the methane resource in the North Huntly coalfield could contain gas equivalent to 25-200 PJ of energy. However, there were other potential issues with the technology, including contamination of surrounding groundwater (potentially in contravention of Te Ture Whaimana o Te Awa o Waikato - the Vision and Strategy for the Waikato River[15]), land subsidence in an area that is susceptible to surface flooding and desirable for urban growth, and the greenhouse gas implications and financial liability of a fossil fuel.

For these reasons and the effect on greenhouse gas emissions, the extraction of coal and its use in the region is not discussed further as it will not have an ongoing role in the transition to a low emissions economy. However, an overview of the fossil fuel thermal generation in the region is

[15] Vision-and-Strategy-Reprint-2019web.pdf (waikatoriver.org.nz)

provided below. It is also noted that Genesis Energy currently holds a stockpile of imported coal at Rotowaro of around 900,000 tonnes for electricity generation at Huntly power station.

4.3.2 Existing thermal generation

The existing thermal generation 'fleet' in the region has an installed capacity of 1,378.8 MW and there is a further 360MW consented but not built. Most thermal power stations (except the part of Kinleith Mill burning hog wood fuel and the Hampton Downs station burning landfill biogas) are exclusively fuelled by fossil fuels.

The cost of fossil imports is not steady, cannot be guaranteed and is influenced by global geo-politics, as is the supply. The international cost of emissions pricing is also uncertain. Intuitively, the costs of New Zealand exports and our global competitiveness are high for New Zealand which has higher fossil fuel costs than trade competitive countries[16]. We may be more competitive and deliver higher value for producers if exports are produced and are emission free.

Below is an overview of the existing fossil fuelled thermal power stations in the Waikato region:

Station	Ownership	Type	Size (MW)	Commissioned	Consent dates
Huntly 1	Genesis Energy	Coal/gas steam turbine	750	1981	2012-2037
Huntly 2				1983	
Huntly 4				1985	
Huntly 5		Gas combined cycle	403	2007	
Huntly 6		Gas/diesel open cycle	50.8	2004	
Kinleith Mill		Wood/gas cogeneration	40	1998	Expired (s.124 protection). Under application for renewal
Te Rapa	Fonterra Ltd	Gas/diesel cogeneration	44	1999	2019-2045
Hampton Downs	Enviro NZ	Gas to energy using landfill gas	20	2009	2001-2036
Fonterra Hautapu	Waipā Networks	Diesel cogeneration	71	2020	2020 (lapse date 2025)-2030

[16] B Hickey When the Facts Change | Podcasts | The Spinoff

Station	Ownership	Type	Size (MW)	Commissioned	Consent dates
Kawhia Road, Ōtorohanga	Nova Energy	Gas turbine	360	Not yet exercised	2017 (lapse date 2027)-2052

4.4 Renewable sources of energy

Renewable resources are those limited only by the technology required to access them. With most of the renewable energy coming from the sun (solar, wind, hydro and wave), the direct energy received at the earth's surface changes over the course of a day. Renewable sources of energy are therefore variable and have defined periods (intermittency). This section describes the renewable energy- resources within the Waikato region and existing and proposed uses of the resources.

4.4.1 Solar

Thermal solar

This energy is often referred to as thermal solar and uses the infra-red part of the electromagnetic spectrum. It is the warmth felt from sunlight and can be used directly to dry fibre (wood), clothes, and food for storage. It can also be used directly to heat water for low temperature uses like domestic water heating, swimming pool heating, or for space heating in buildings. Such uses tend to be distributed. It may also be concentrated using mirrors and lenses into utility-scale projects for high temperature use and electricity generation.

In the Waikato latitudes, exposure to the sun's energy only happens once a day for about 50 per cent of the day (daylight), however, this may not be when the energy is needed. Solar energy (heat) may be temporarily stored by heating thermal mass or concentrated as molten salt.

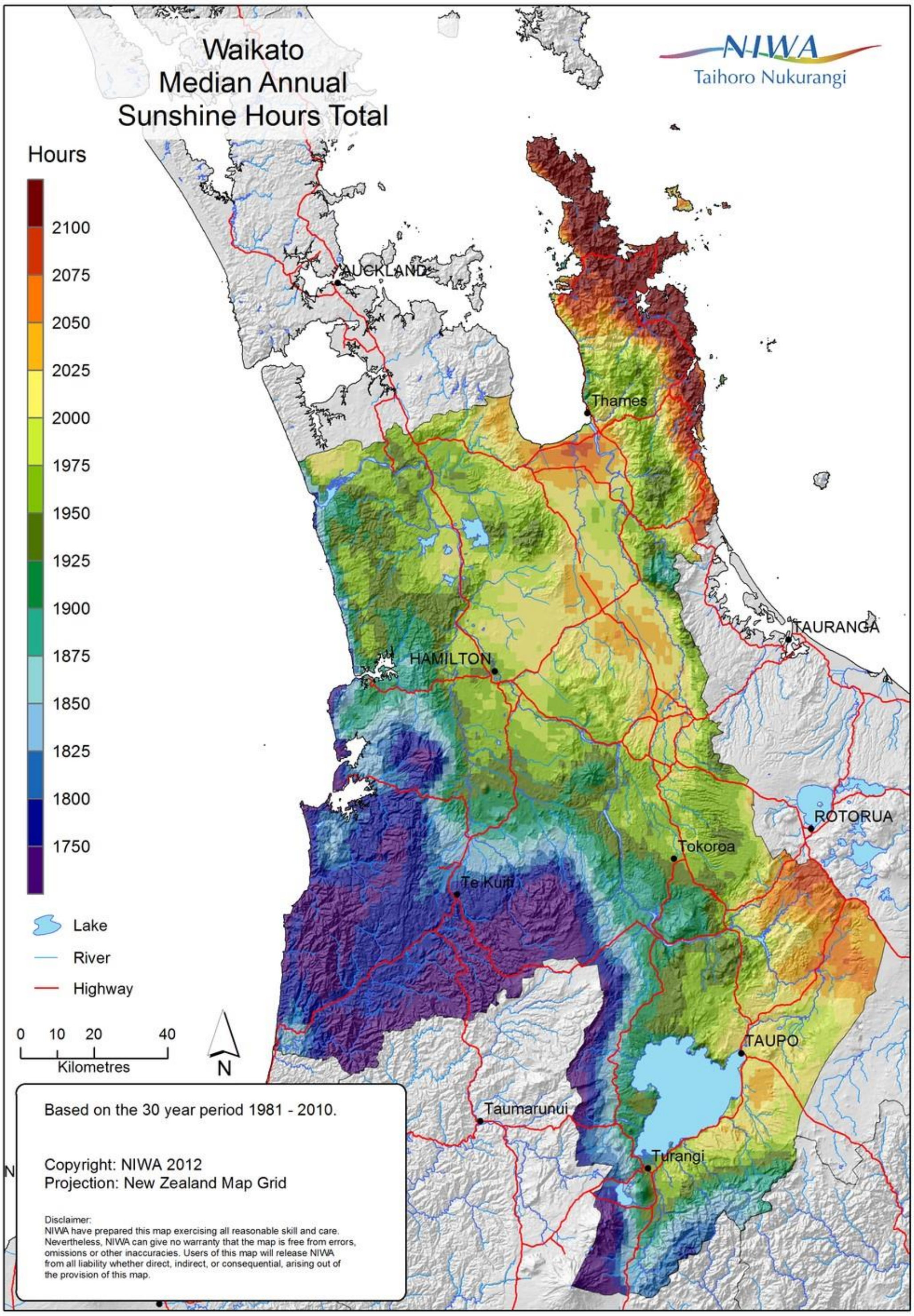
In addition to solar's diurnal period, seasonal differences in incident radiation allow the temperature differential between the atmosphere and the ground to be exploited using ground source heat pumps. This is often referred to as using geothermal energy as it is from ground sources, but is in reality 'delayed solar'. In this way, thermal solar energy can be used for warming as well as cooling.

Photovoltaic solar

In addition to the sun's heat energy, energy also reaches the earth's surface in the form of photons which can be transformed into electricity using solar panels.

Although the seasonal and daily daylight hours are fixed by the orbit and rotation of the earth and are highly predictable, the prevailing wind and regional topography combine to give a gradation of annual sunshine hours from an annual median of 1750 hours in the Waitomo district to an annual median of over 2100 hours on the east coast of the Coromandel peninsula. The distribution of median annual sunshine hours in the Waikato region is shown in the following map:[17]

[17] Waikato | NIWA



Solar PV panels are scalable from individual residence applications to utility scale depending on the amount of available land. Although solar PV can generate electricity on overcast days, it is strictly diurnal and therefore the generation can be planned for and managed, especially when coupled with battery technology. It is reliable and flexible as it can be deployed in rural and city settings and even on lakes in floating arrays. The Upper North Island sits in the country’s sunbelt and the Waikato region north of Hamilton lies between 36 and 38 degrees south. This is equivalent to San Francisco south or southern Spain, areas with mature solar electricity industries.

Rooftop solar PV panels are the most popular form of distributed generation in the region and are increasing. The current (30 November 2023) generation ‘fleet’ of over 7,000 systems totals 48.6 MW with most of the installations in the northern part of the region, as shown in the following table.

Lines Company	Coverage	Installations	Total Capacity (MW)
Counties Energy	Includes some of Auckland region	1,760	10.0
WEL Networks	Waikato / Hamilton	2,550	16.7
Waipā Networks	Waipā	1,140	8.2
The Lines Company	King Country	207	1.8
Unison	Taupō Includes some of Bay of Plenty region	259	1.3
Power Co	Thames / Coromandel	1,785	10.6
Total		7,701	48.6

Solar panels have become cheaper over the decade[18] (see figure below) and as a result there has been a significant (38-fold) increase in network connections, most of which connect to the networks of the distribution line companies.

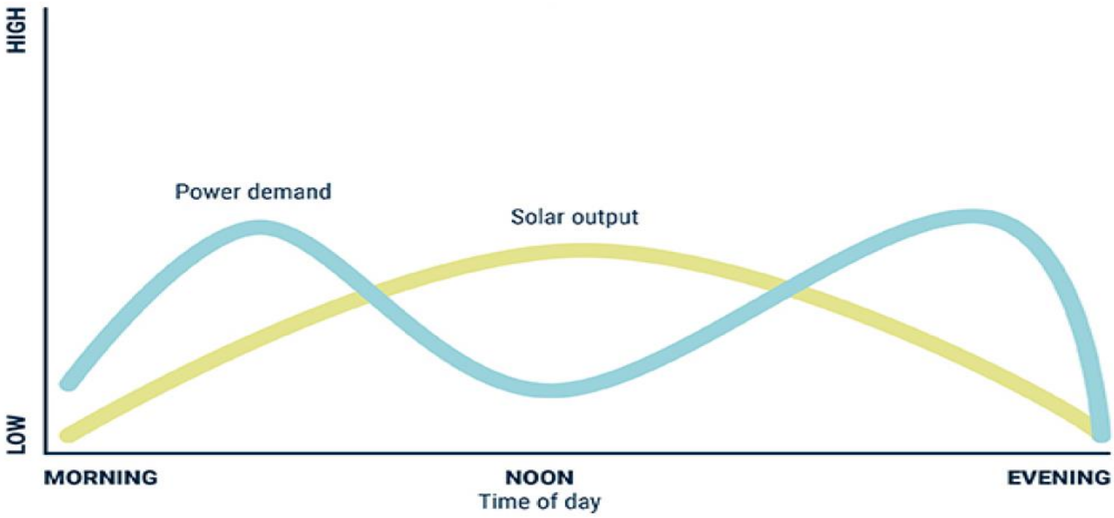
(Approx. prices for a 3kW solar power system over the last 16 years)

In the above figure, an increase in the cost of panels for a three-kilowatt system post 2021 was a result of COVID 19 supply chain disruptions and increasing demand. Installation Control Point (ICP) connections have steadily increased over the decade and most of these are for residential use.[19] This increase is shown in the following table:

ICP Connections	2013	2015	2017	2019	2021	2023
Waikato (All)	171	579	1,566	2,623	3,595	6,558
Waikato (Residential)	133	515	1,452	2,443	3,298	6,051
New Zealand (All)	1,821	6,158	14,460	23,863	39,951	61,240

The electricity output of solar PV panels follows the daytime sunlight and does not match the typical daily energy use of households or businesses as shown in the following stylised figure[20].

[18] Prices For Solar Power Systems In New Zealand | Pricing Guide (mysolarquotes.co.nz)
[19] Electricity Authority - EMI (market statistics and tools) (ea.govt.nz)
[20] Electricity Authority Te Mana Hiko, Solar power Solar power | Electricity Authority (ea.govt.nz)



Solar energy output rises and falls with the sun and the weather. Household peak power demands are typically in the morning and evening when the sun is low/non-existent and generation output is low/non-existent.

There are no grid-connected property-scale solar generation sites in the region, but there are 908MW of known consented and proposed projects. These projects are listed in the following table:

Station	Ownership	Area (ha)	Size (MW)	Stage	Consent expiry
Waerenga	Waerenga Solar Farm Limited and Transpower NZ Limited	85-90	180	Consented	Provides for operation for 40 years from commercial operating date (expires two years after cessation of generation).
Rangiriri	Rangiriri Solar Farm Limited and Transpower NZ Limited	69	130	Consented	Provides for operation for 40 years from commercial operating date (expires two years after cessation of generation).
Tauhei	Harmony Energy	182	147	Consented	2057
Komata North	Komata North Solar Limited	6	4.5	Consented	N/A
Waiterimu	Waikato Solar Farms Limited and Transpower New Zealand Limited	63	140	Proposed	N/A
Lake Whangape Energy Park	Glenergy Limited		248	Proposed	N/A
Whitianga	Lodestone Energy		54	Proposed	N/A
Waharoa	Lightyears Solar		4.5	Proposed	N/A

Large, property scale solar arrays are modular and, if near transmission infrastructure, can be constructed and commissioned relatively quickly. The modular design allows scaleability to fit the location and terrain, conferring certainty and predictability of effects that converts to rapid deployment. Indeed, provided there is grid access and depending upon scale, it is possible to design, consent, construct and commission solar generation stations often within a single year.[21]

The typical configuration of proposed utility scale solar projects is for multiple arrays of panels mounted on posts close to the ground. They are a land use change from the dominant pastoral dairy farming with the first sites being close to grid entry points. This significantly reduces the project costs as transmission infrastructure not only involves capital costs but also consenting requirements and potential negotiations with multiple landowners.

Farm scale installations diversify the rural environment in the transition to 'agivoltaics', enabling dual use of the same land. An example of agrivoltaics is shown below:

The move to dual land use agrivoltaics has multiple drivers. Not only does it contribute to the transition to a low emissions economy, but it reduces the nitrogen contamination of groundwater from the existing land use.

Rainfall in the northern part of the region has changed over the past 60 years with each decade receiving less and less rainfall and the trend is continuing (see map in section 4.4.4). Not only is the overall average rainfall decreasing but the way it is received has also changed, resulting in weather extremes with extreme rainfall events that flood low lying paddocks followed by extended drought-like conditions. This is challenging for pastoral farming, particularly for agricultural products that have a high water footprint, such as milk and beef. Climate drivers are not limited to water; as temperatures increase, dairy cows produce less milk and conditions become advantageous for less nutritious invasive grass species like Kikuyu.

The option of combining pasture with solar PV arrays, has the advantage of retaining the agricultural land use while at the same time providing shade to grazing animals. Bovines (dairy or beef) are too large and have the habit of rubbing against the structures, damaging them. Sheep have the advantage of smaller size, having lower water footprint, a reduced nitrogen load to the land and no need to 'mow' the areas around the panels.

The current land use allows most if not all land to grazed, with stock being moved to higher ground when areas become inundated. This is not an option with expensive electricity generation infrastructure which are fixed and cannot be moved in times of flood. This means that some areas that were previously grazed are now able to be re-wilded with consequential biodiversity, soil conservation, carbon sequestration, water quality and hydrological benefits.

[21] Sunny Side Up – How to build a sustainable solar industry in Aotearoa, Aurecon, BNZ, Elemental Group and Energy Estate, Workshop, Christchurch, 29 June 2022.

Solar PV panels may also be mounted on floating arrays, such as artificial impoundments and lakes. There is interest in using the degraded lakes in the north of the region (Lake Waikare) and also opportunities as part of the region's hydro lakes. The latter would benefit from the co-location of grid access. Floating panels have the advantage of not interfering with existing land use, however, they do have a negative impact for navigation (recreation) and for light penetration through the water. This would not be an issue in the northern lakes with high suspended sediments load as this restricts light to the upper 200mm of the water column.

Example of a floating solar farm, Thailand (REUTERS)

4.4.2 Biomass

Solid biomass

Solid biofuels is a generic term covering non-fossil material of biological origin which may be used as fuel for heat and electrical generation. This fuel category has transitioned from an emphasis on waste disposal to a mainstream renewable fuel alternative to coal and gas for domestic, commercial and industrial heat. Solid biofuels are now being engineered to consistent specifications and becoming a reliable, quality energy source.[22]

Biomass contains energy stored in chemical bonds and is extremely flexible as a resource to offset the use of fossil fuels either as feed stock for manufacturing processes (e.g. recyclable plastics) or burned directly for process heat or for electricity generation, or it can be distilled for portable transport fuels. In short, most energy services and economic activities where we currently use fossil fuels can be achieved by using biomass and derivatives. Fuelling an industrial process or electricity generation with biomass requires a certainty of supply.

Long-term supply contracts are critical to ensure access to fuel. Typical sources can include forestry waste (sawdust and trimmings), or bespoke energy crops. Biomass can be transported to an

[22] Solid Biofuel Classification Guidelines (usewoodfuel.org.nz)

industrial site; however, this incurs the penalty of greenhouse gas emissions from the haulage. An alternative is to ensure security of supply and limit haul distances by cropping close to the use.

Biomass fuel pellets are produced by densification of wood or herbaceous residues and are produced to specific standards according to the feedstock used. Pellets are typically used in three different scales of heat plant:

- Small – generally for residential home heating;
- Medium – generally for small to medium sized commercial/institutional/industrial heat plant; and
- Large – generally for large industrial process heat plant and for substitution for coal, or for cofiring with coal or low-grade hog fuel such as bark.

Biomass fuel pellets are able to be consistently produced to specified standards because they are an engineered product. In small scale heating applications such as residential home heating, the electronic control of the heater operation and the consistency of the quality of the wood pellet fuel provides a means of controlling combustion emissions. As a controlled heat source, this ensures that emissions are within Regional Plan rules and avoids the need for monitoring emission outputs as they are controlled by the technology and fuel inputs. In larger heat plants where air discharge resource consent conditions require external monitoring and reporting, the amount of monitoring can be reduced significantly because of the consistent quality of the fuel input. Control of fuel quality assists combustion plants to operate within consent conditions.

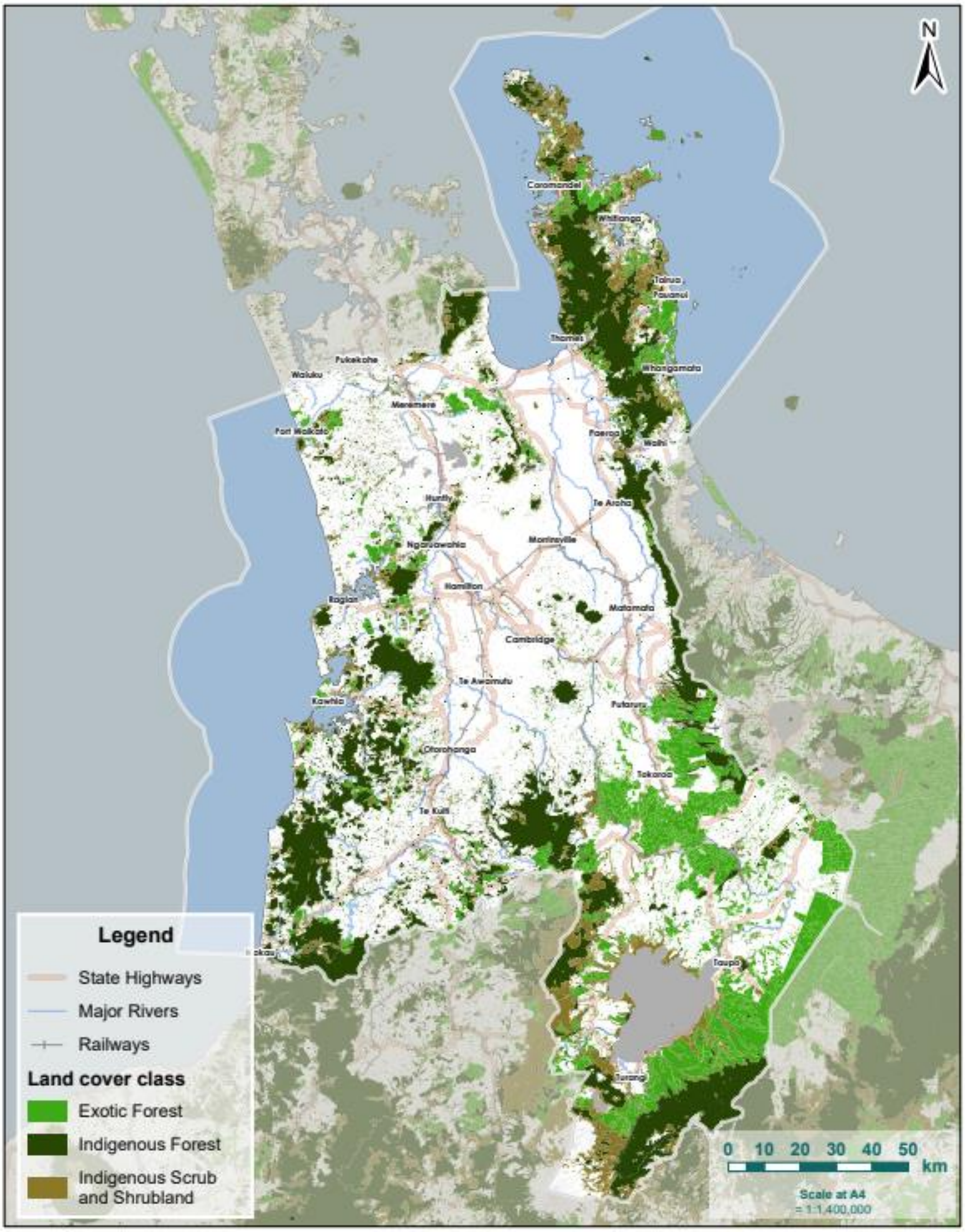
Black torrefied or steam-expanded compressed pellets can be used as a coal substitute, able to be stockpiles in quantity outdoors.

There are synergies to substituting bespoke biomass crops for fossil fuels beyond reducing carbon emissions. Increases in temperature and reduction in rainfall projected for the northern parts of the Waikato region under all climate change scenarios mean that it is becoming harder to authorise the discharge of wastewater contaminants into waterways during the summer months. Alternatives will need to be found and the opportunity to transition land use to include energy cropping will allow irrigation of wastewaters at times when even tree growth will be challenged.

The co-location of North Island production forests with development geothermal systems also creates potential synergies enabling the use of geothermal heat to dry timber, which is traditionally fuelled by using wood waste, freeing up this resource to be used directly as wood pellets or as a feedstock for the distillation of biofuels, including sustainable aviation fuel. Processed wood pellets typically have a moisture content of between 5-10 per cent, whereas other firewood can have a moisture content of up to 85 per cent[23].

The map below shows the location of exotic and indigenous forests in the region:

[23] Wood Pellet Fuel Supplier | Commercial & Residential Heating Options (naturesflame.co.nz)



Solid biofuel can be classified by major types or sources of materials, for example: wood chips, hog fuel, densified wood fuels, urban derived wood fuels, or firewood, and by their specific characteristics such as: particle size, moisture content, ash content, and energy content.

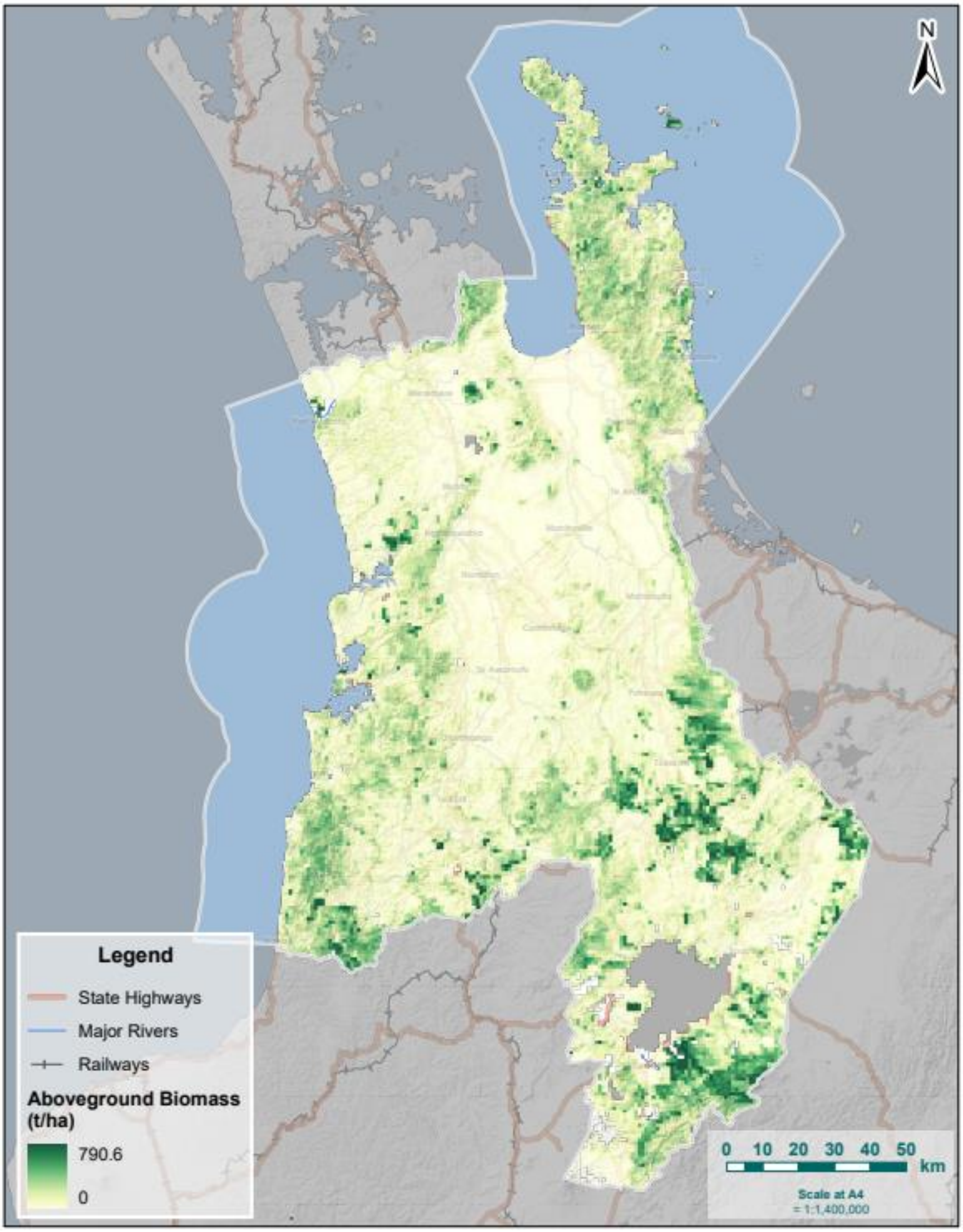
The main types of solid biofuels are characterised in the following table adapted from the Solid Fuel Classification Guideline[24]:

Fuel type	Description	Source
Wood chips	High quality cut pieces between 5mm and 100mm	Forest plantation, forest by-product including slash and untreated used wood

[24] Solid Biofuel Classification Guidelines (usewoodfuel.org.nz)

Fuel type	Description	Source
Hog fuel	Varying size and shape created by crushing with rollers	Forest plantation, forest by-product including slash
Wood pellets	Wood that has been pulverised and mechanically compressed under heat and high pressure to a consistent size	Offcuts and sawdust from milling
Urban wood fuel	Urban sourced wood	Urban sourced wood residues, e.g. pallets from construction and packaging and demolition material – not limited to 'used' wood and can include urban tree trimmings etc
Briquettes	Densified fire logs	Forest plantation, forest by-product including slash and untreated used wood
Torrefied Wood	Thermally modified wood – completely desiccated. Drop in replacement for coal. Good storage characteristics	Forest plantation, forest by-product including slash and untreated used wood.
Steam expanded wood	Processed exploded wood fibres – completely desiccated. Drop in replacement for coal	Forest plantation, forest by-product including slash and untreated used wood. Processing can use geothermal steam
Herbaceous Biofuels	Fibrous fuels in variety of forms including chips, hogged, pelletised or baled in a variety of sizes	Miscanthus, switchgrass or straw including cereal crops
Firewood	Larger pieces of wood	Forest plantation, forest by-product including slash and untreated used wood

The following map shows the aboveground biomass availability in the region. This provides an extra dimension to the previous land use/vegetation map by not only identifying where the vegetation types occur, but how much is available to be used. It identifies the location of vegetation and combines it with an estimation of height and density using synthetic aperture radar imaging. The estimates are low resolution (1km^2) which is sufficient to indicate tonnage at district boundary level, but insufficient for a property scale estimate.



The following table contains the aboveground biomass estimations of three land cover classes for territorial authority area in the Waikato region:[25]

Territorial authority	Native Forest (tonnes)	Grass and other (tonnes)	Plantation/exotic forest (tonnes)
Thames-Coromandel District	134,364	24,191	47,432
Hamilton	51	625	18
Hauraki District	34,806	22,878	5,642

[25]Above ground biomass estimations were derived from data available in NASA's Global Ecosystem Dynamics Investigation mission. Due to the coarse resolution of the open-access data, the estimations for the Waikato region were interpreted on a 1 km by 1 km grid. Finer estimations can be derived using higher-resolution Synthetic Aperture Radar satellite images and regional LiDAR data.

Matamata-Piako District	25,234	25,356	1,612
Waikato District	62,839	90,650	41,538
Ōtorohanga District	74,483	49,034	11,786
Rotorua District	9,972	32,600	42,989
South Waikato District	28,533	36,434	150,979
Taupō District	186,176	52,469	199,181
Waipā District	11,419	31,692	2,097
Waitomo District	182,223	96,790	33,951

Liquid biofuel

Biofuel is derived from animal fats (tallow) cellulose feedstock – forestry, algae, or captured CO_2 energy from food waste. There are no biofuels processing factories in the Waikato region. Maize is a recognised feedstock to bio-ethanol production, and is grown in the region mostly in support of pastoral farming. The EECA/SKM 2006 Regional Renewable Energy Assessment noted the region's pastoral farming economy and the opportunity to switch land use to biofuels as the regional already produced 40,000 tonnes of maize from 4000ha of arable land and that there were 45,000ha of arable land available. It must be noted that the process of cropping requires liquid fuels for the cultivation, haulage and often processing and this lowers the net output of fuels.

33,466 tonnes were grown for grain from 2,885ha in 2002.[26] In the same year, 501,312 tonnes of maize silage was grown from 23,872ha.[27] This would produce 213,911,200 litres of ethanol.

Bio-diesel can be made from animal fats through an esterification process. Beef tallow is the most common form of animal fat used in this process. There are animal renderers servicing the pastoral dairy industry in the region, but there is no good understanding of the amount of tallow produced regionally. In 2022 New Zealand exported 140,000 tonnes of beef tallow worth NZ$286.14million.[28] Of this, most (77 percent) was exported to the United States, with the rest going to Singapore.

Other feedstocks for liquid biofuels including vegetable oil have been identified and are available on the Bioenergy Association website.[29]

There are no liquid biofuel production facilities in the region, however, the market drive towards decarbonising the aviation industry and the use of sustainable aviation fuels (SAFs) will require a future energy strategy to address this opportunity.

Biogas

Biogas[30] or bio-methane is derived from liquid (farm effluent, industrial and food waste at a range of scales). It is an energy-rich mixture of gases produced as biological materials are broken down by bacteria in the absence of air or oxygen. The main gaseous components of biogas are methane (CH_4) which makes up 60-70 per cent of the gas, carbon dioxide (CO_2) which usually accounts for 25-35 per cent of the biogas produced, and the remainder is water vapour and impurities e.g. nitrogen or hydrogen sulphide, depending on feedstock and digester design.

The discovery, production and use of biogas for heating and lighting pre-dates the discovery of petrochemical derived methane. Biogas is generated in large-scale digestion plants or from landfills and provides a source of energy for electrical generation, process heat and transportation. Once

[26] Area harvested for hay, silage or balage in the Waikato Region, New Zealand - Figure.NZ
[27] AIMI New Zealand survey of maize areas and volumes: June 1, 2022, a2cd1eb5-337f-500f-ab6b-3fac3b821a82.pdf (far.org.nz)
[28] Beef Tallow global exports and top exporters 2023 (tridge.com)
[29] WLB01_LiquidBiofuels-biodiesel-bioethanol-sources-details.pdf
[30] Biogas and Biomethane in NZ - Unlocking New Zealand's Renewable Natural Gas Potential (beca.com)

cleaned of impurities it is indistinguishable from natural gas and can be blended and distributed through the Firstgas Group's pipelines.

There are three major biogas producers in the region:

- Hamilton City Council[31] wastewater treatment plant digester
- Fonterra Tirau[32] biodigester
- Over 4,000 dairy farm effluent ponds in the region. This provides an opportunity for distributed biogas to offset fossil sourced fuels used on farms.

The Reporoa Organics Processing Facility, owned by Ecogas[33] is an example of a biogas plant within the region. The facility, which opened in 2022, is New Zealand's first large-scale (75,000 tonnes annually) food waste-to-bioenergy facility. The facility converts organic waste from businesses and kerbside food scrap collections throughout the North Island into renewable energy products. This occurs through the process of anaerobic digestion, a natural process where micro-organisms break down organic waste, to generate electricity, heat, and biogas, as well as a fertiliser product.

Ecogas, in conjunction with Clarus, is currently undertaking a project to build a gas upgrading plant at the facility. This will enable the biogas to be refined and upgraded into biomethane which will be injected directly into the national gas pipelines by the middle of 2024. It is understood this will allow supply to 7,200 homes avoiding 11,000 tonnes of fossil derived carbon dioxide per year[34].

Work by Dairy NZ[35] shows that on farm anaerobic digestion and biogas of dairy effluent does work, however selling electricity to the grid is unlikely to be cost effective due to the way the energy sector operates in New Zealand and the small amount of energy likely to be produced from an average dairy farm. Additionally, the methane in the biogas collected is flammable so all safety regulations must be met.

Landfills

The Hampton Downs landfill collects landfill gas – predominantly methane and carbon dioxide from bacterial breakdown of organic material - and generates 40,000MW per year[36] of baseload electricity.

Station	Ownership	Type	Size (MW)	Commissioned	Current consent granted	Consent expiry
Hampton Downs	Enviro NZ	Gas to energy using landfill gas	20	2009	2001	2036

4.4.3 Wind

Wind is the movement of air particles from high to low pressure areas. It is generated by changes in pressure driven by heat such as the difference between the heating effect over land and water or between the tropics and temperate regions. Warmer air is less dense and rises, and cooler air replaces it, creating wind. The energy takes the form of kinetic energy of air molecules, and these can be used to drive sails and rotor blades. As air pressure is related to temperature, wind can be considered as a derivative of solar energy.

[31] Hamilton City Council WWTP Digester | Bioenergy facilities
[32] Fonterra Dairy, Tirau | Bioenergy facilities
[33] Reporoa Organics Processing Facility — Ecogas
[34] Energy and Environment (Vol 21, No 14, 6 May 2024
[35] energy-capture-systems-effluent-tech-note.pdf (dairynz.co.nz)
[36] Hampton Downs landfill a powerhouse of energy and responsibility. | Auckland Wide Cut Price Bins

The kinetic energy of wind is available terrestrially as well as in offshore environments and has been used for millennia in both stationary (pumping and milling) and mobile (sailing ships) situations. Modern technology allows use of wind for electricity generation.

New Zealand's geographic location is in the 'roaring forties' or those latitudes between 40-50 degrees south named by 19th century sailors for the year-round gales. The lack of significant land mass in these latitudes allows winds to circulate unimpeded above the Southern Ocean.[37] For these reasons, over the past 15 years this area has been referred to as the "Saudi Arabia of wind". The quality of the resource varies according to location and topography. The best (strongest, less disturbed, and most predictable) occurs offshore, while onshore wind is affected by topography with proximity to the coast and elevation being key factors.

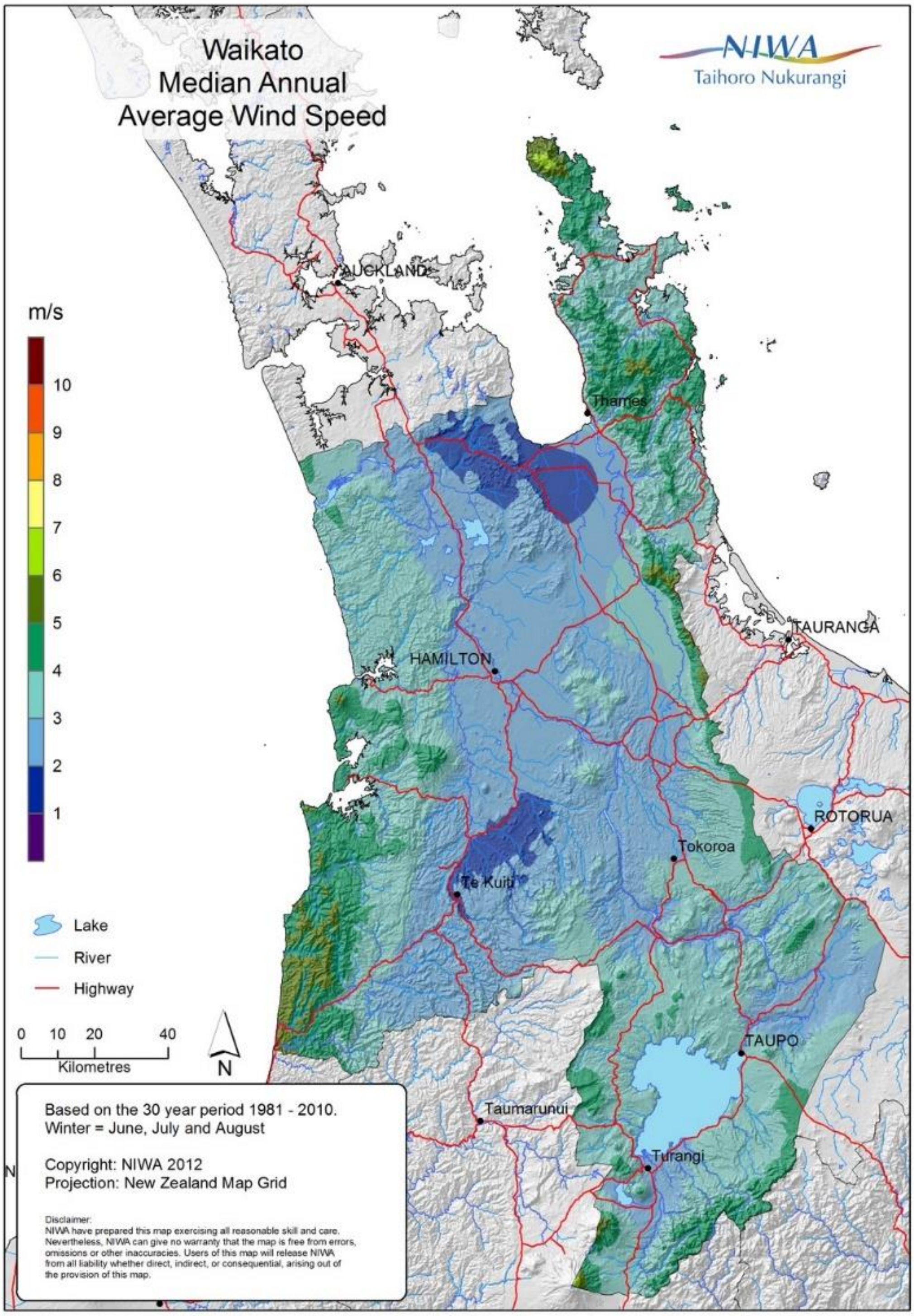
Wind energy is variable, however, given the range of latitude covered by the country and the range of daily weather experienced, there is a good chance that it will be windy somewhere. Reference to Transpower's Live data base[38] indicates how much electricity is generated at any point in time across the country. This ranges from a few megawatts to near the current installed capacity of over 1.2 gigawatts.

The map below shows this spatial variation as the median annual average wind speeds over the terrestrial Waikato region:[39]

[37] Why is NZ so windy? We explain the Roaring Forties! | WeatherWatch - New Zealand's Weather Data & Alerts Authority

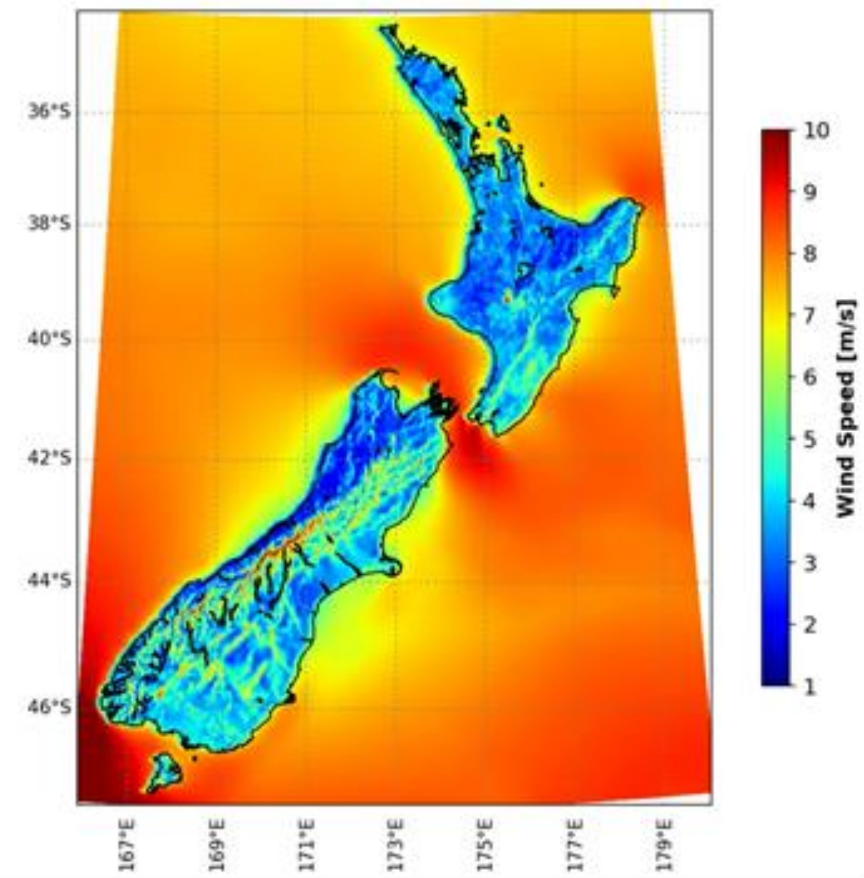
[38] Consolidated live data | Transpower

[39] Wind speed | NIWA



The modelled windpower potential for New Zealand's marine environment allows the west coast Waikato resource to be seen in context to the rest of the country in the map below[40].

[40] NIWA Wind power Analysis of 5-year annual mean wind speeds (April 2018 – March 2023) NIWA NZCSM Forecast model.



(**PLACEHOLDER MAP** – To be confirmed with NIWA)

In 2021, six per cent of New Zealand's electricity was generated from wind. It is estimated that this will increase to between 20 and 34 per cent.[41]

Over recent decades, the wind energy sector has settled upon the tower mounted, three bladed horizontal axis turbine design to access wind energy as illustrated in the following picture:

[41] Climate Change Commission and New Zealand Energy Scenarios TIMES-NZ 2.0 modelling.

Onshore wind turbine – West coast New Zealand

The low density of air means that to be efficient, the swept area of the blades (the disc) is very large. The larger the disc, the more electricity that can be generated. However, there is a practical limit to the size of wind turbines when they are deployed on land. This is to allow road transportation to site. While tower sections can be transported in sections, the blades are a one-piece design and are very long, often too long to negotiate the radius of road corners.

Constraints imposed by road designs limit the physical size of individual turbines on land to blade lengths of 60-80 metres, giving a hub height of 90-130 metres. Additionally, onshore wind turbines require a significant foundation anchor in the order of 1,200-1,600 tonnes of steel-reinforced concrete per tower. Designs of this size produce between 2.5 and 5.5 MW each. In the New Zealand situation (high quality wind resource), the embodied emissions (carbon footprint) for the structures, construction and deployment on land are neutralised within a year of renewable generation.

In contrast, there are no such logistical constraints to the size of offshore deployment of turbines and they can be designed and sized to take advantage of the increased resource strength at sea within the limits of current materials and construction technology. For this reason, offshore turbines are larger than those on land. It is estimated that by 2035 (around the time that wind turbines are proposed for deployment in the Exclusive Economic Zone off the Waikato west coast) that turbine blades of 120-130 metres will be the norm. Turbines of this size will have hub heights of 100-150 metres and produce up to 17 MW each.[42]

[42] FULLTEXT01.pdf (diva-portal.org)

Proposals for offshore wind turbines (Waikato west coast) are mostly in the Exclusive Economic Zone, greater than 12 nautical miles or approximately 22 km from shore.

Amenity and ecological effects of onshore and offshore deployment varies. Whereas the main amenity impacts of onshore wind turbines are typically visual and audio, the noise of the coastal environment (wave crash etc) tends to negate any sound of turbine blades and the visual impact attenuates with distance. The following illustration shows the typical visual effects of offshore wind turbines from a vantage point at sea level. The curvature of the earth means that a higher vantage point such as a coastal cliff may make the structures more visible.

Typical responses of observer impact from existing northern hemisphere wind farms show this trend in the following table:

Distance	Observational impacts	Noise impacts
0.5km	Significant	Quieter than background noise
1km	Significant	Inaudible
2.5kms	Prominent, potentially significant	"
5kms	Not prominent, visual effects are moderate	"
10kms	Not prominent, visual effects are slight	"
20kms	Distinguishable, visual effects are negligible	"
25+kms	Difficult to distinguish	"

Wind Energy Association Conference: Wellington September 2023

BlueFloat Energy has prepared a visual representation of how proposed turbines would appear from Port Waikato,[43] which shows it would be difficult to distinguish from the shoreline during the day. The turbine towers would need to be lit at night to conform to navigation avoidance requirements which would make them more visible at that time.

The ecological effects of offshore and onshore wind turbines are also different. Both have the potential to affect birds as they share the same environment. Birds generally have good eyesight and many hunt visually and may be able to keep away from turbine blades during the day. Others migrate between land and sea at dawn and dusk which may make them more vulnerable to onshore deployment near the coast. For those deployed many kilometres offshore in the Exclusive Economic Zone, the disc heights would need to be high enough to avoid flight heights of seabirds.

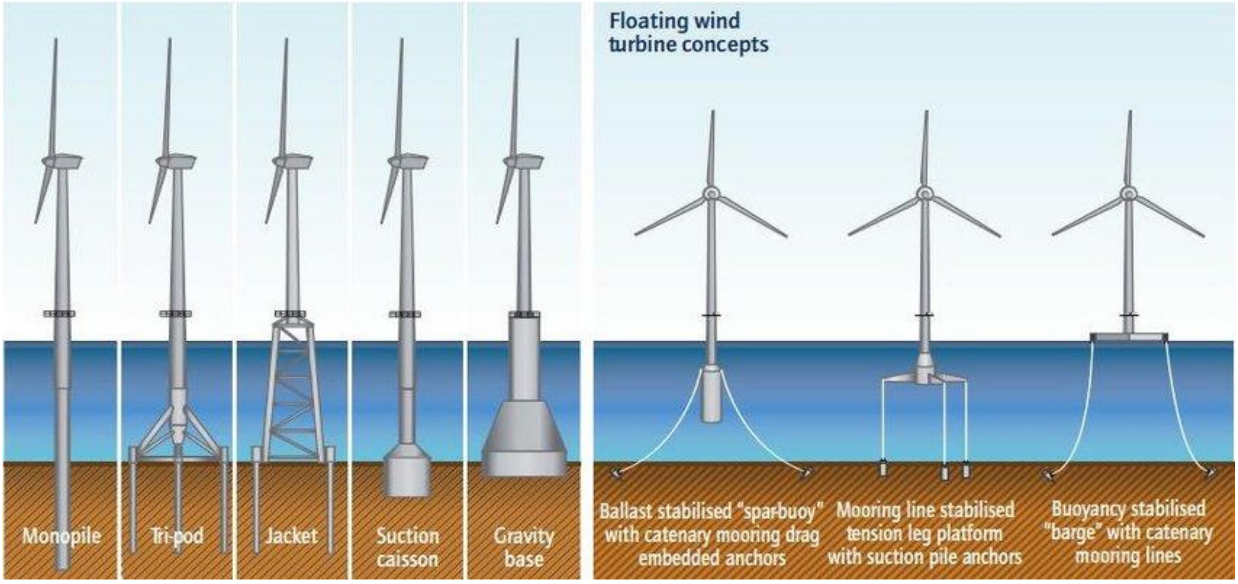
Offshore deployment of wind turbines introduces new environmental effects to the seabed, sea surface and marine water column. Each turbine needs to be positioned sufficiently away from neighbouring turbines so that interference effects are minimised. This means that these wind farms cover many square kilometres, and there are connecting cables to nodes and offshore substations.

[43] Waikato | BlueFloat Energy

Each wind farm would also require transmission cables through the Coastal Marine Area that connect to land.

To avoid collisions with the structures on the surface and the disturbance of cables on the seafloor, the wind farm will deny large vessel navigation and any seafloor disturbance, e.g. mining or bottom trawling. This would create a de-facto sanctuary for some marine species. The mere existence of structures in a visually homogenous environment can attract some pelagic species and some of them will form aggregations with the potential to create recreational and commercial sport fishing opportunities with associated economic and community benefits.

In contrast to the onshore anchors, there are a range of opportunities to anchor offshore turbines to the seafloor, each with differing costs and benefits. In general, the biggest effect on the seafloor will be though construction disturbance of those structures that are directly fixed to the seafloor. Anchored floating turbines will have a lower construction impact but may have ongoing impacts from anchoring chains. The range of fixed and floating anchor designs are illustrated in the diagram below:[44]



Typically, fixed anchors are used in shallow waters below 50m depth, and floating structures in depths greater than that. Floating structures are more complicated and more expensive. With the variety of anchoring designs and options available and the nascent industry, it is not possible to estimate the time it would take to neutralise the greenhouse gas emissions from offshore generation. Although the total area occupied by marine wind farms is large, the estimated seabed footprint of marine turbines is 50 square metres[45].

[44] ResearchGate
[45] Elemental Group and Venture Taranaki Te Puna Umanga2021.

Reserving marine space for structures would allow recreational fishing and tourist activities[46] such as fishing or sightseeing. The exclusion of large vessels and seabed disturbances would also offer sanctuary to endangered marine mammals (e.g. Māui dolphin) which are already under threat from terrestrial toxins, predation and climate change influences to food distributions. The base structures can be expected to act as artificial reefs that once 'seasoned' with encrusting marine life can be expected to provide habitat and shelter for reef species.

Anchored offshore floating structures in north-eastern New Zealand waters have been shown to attract and aggregate pelagic species in what would otherwise be considered a visually homogenous environment[47]. Marine species can also be expected to aggregate around structures that extend throughout the water column creating opportunities for targeted fishing techniques around the Waikato Coastal Marine Area and beyond.

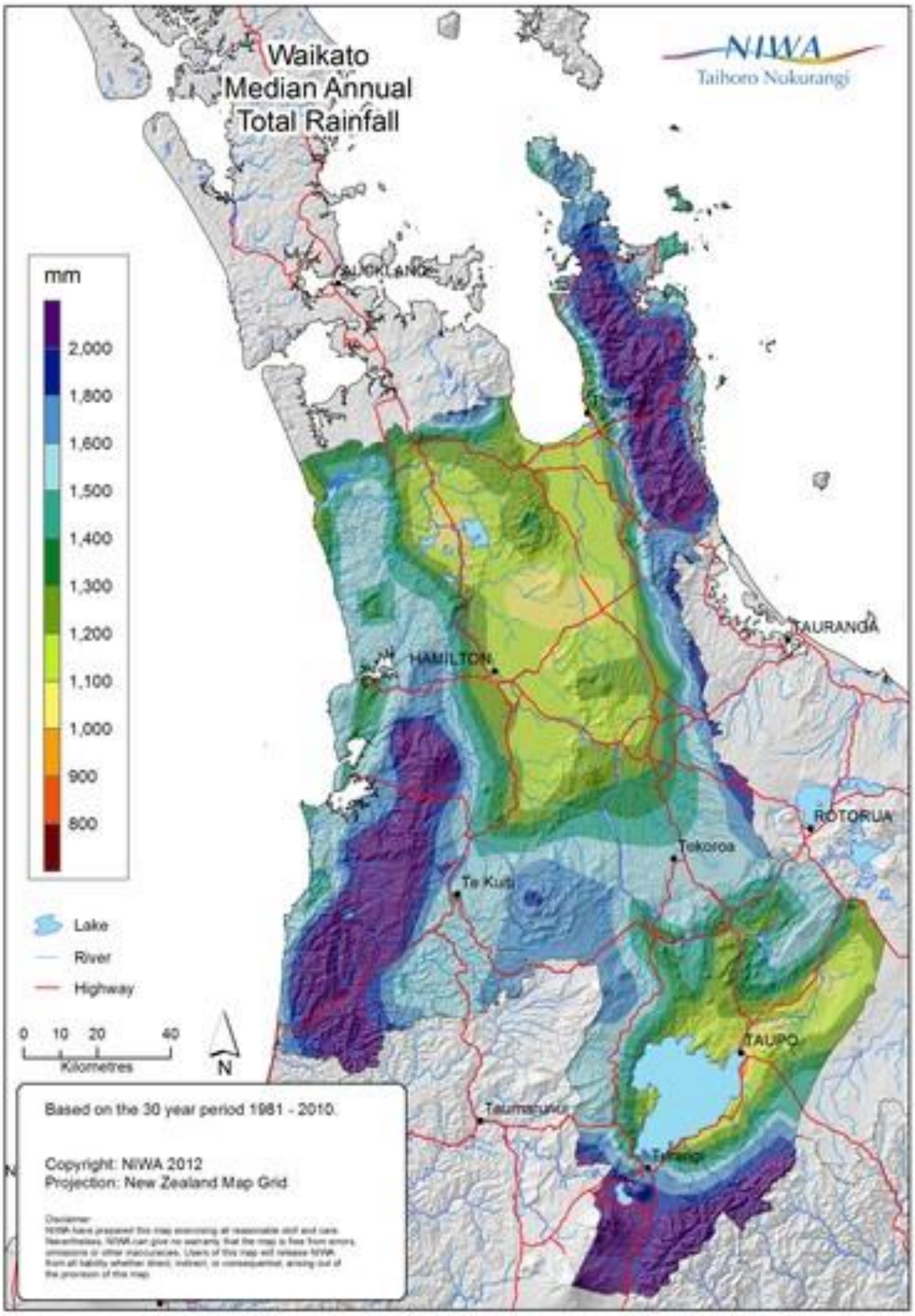
There is only one wind farm in the Waikato region with a further nine proposed, three of which are offshore as in the following table:

Station (currently operating)	Ownership	Number of turbines	Size (MW)	Commissioned
Te Uku	Meridian Energy / WEL Networks	28	64	2011
Station (proposed)	**Ownership**	**Number of turbines**	**Size (MW)**	**Stage**
Taumatatotara	Ventus Energy	8	48.4	Consented
Kaimai	Ventus Energy	24	100	Proposed
Waikato Offshore Wind – Phase 1	BlueFloat Energy and Elemental Group	54	810	Proposed
Waikato Offshore Wind – Phase 2	BlueFloat Energy and Elemental Group	Unknown	1,125	Proposed
Waikato Offshore Wind	Copenhagen Infrastructure Partners and NZ Super Fund	Unknown	1,000	Proposed
Waikato Offshore Wind	Oceanex	67	1,000	Proposed
Waiuku	LET Capital	13	85	Proposed
Glen Massey	Vestus	25	150	Proposed
Hapuakohe	Manawa Energy	Unknown	230	Proposed

46 https://blog.nwf.org/2019/09/a-new-home-for-fish-how-offshore-wind-turbines-create-artificial-reefs/
47 Dickie BN 1986 Fish Aggregation Devices in the North-eastern New Zealand Situation 1985-1986 Summer Season, Unpublished report for the NZ Fishing Industry Board.

4.4.4 Hydroelectricity

Hydroelectricity is the non-consumptive use of water enabled by a combination of rainfall and topography (elevation and storage). These characteristics come together in the southern parts of the region. The map below shows the median annual rainfall in the Waikato region:[48]



Analysis of rainfall over the last 60 years[49] (see the graphic below) shows that the most recent (2011-2020) decade recorded the lowest average rainfall, compared to previous decades, and this is pronounced in the Coromandel Ranges and the lowlands north of a line from Hamilton City to Te Aroha.

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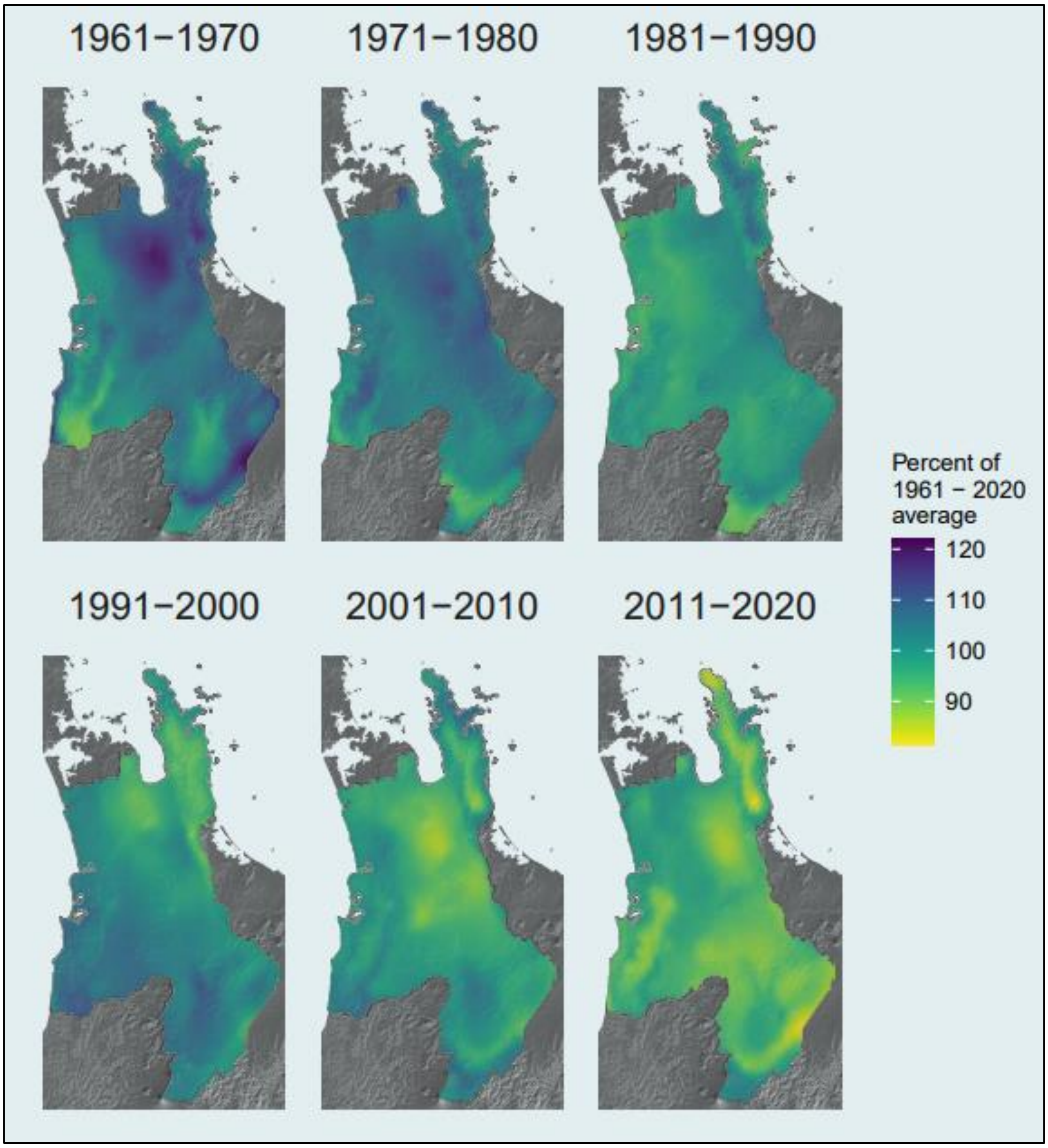
[48] Waikato | NIWA

[49] Te oranga o te taiao Waikato State of the Environment 2022 https://www.waikatoregion.govt.nz/assets/WRC/7364-SOE-report-2022-WR.pdf



The decreasing decade upon decade of rainfall comes from existing measurements and shows that the climate has been changing for a while and while this trend is projected to continue, the way rainfall is being delivered is also projected to change. As the atmosphere becomes increasingly energised (hotter) we can expect it to hold more moisture releasing it as severe events. The corollary is that at other times we will be in extended droughts.

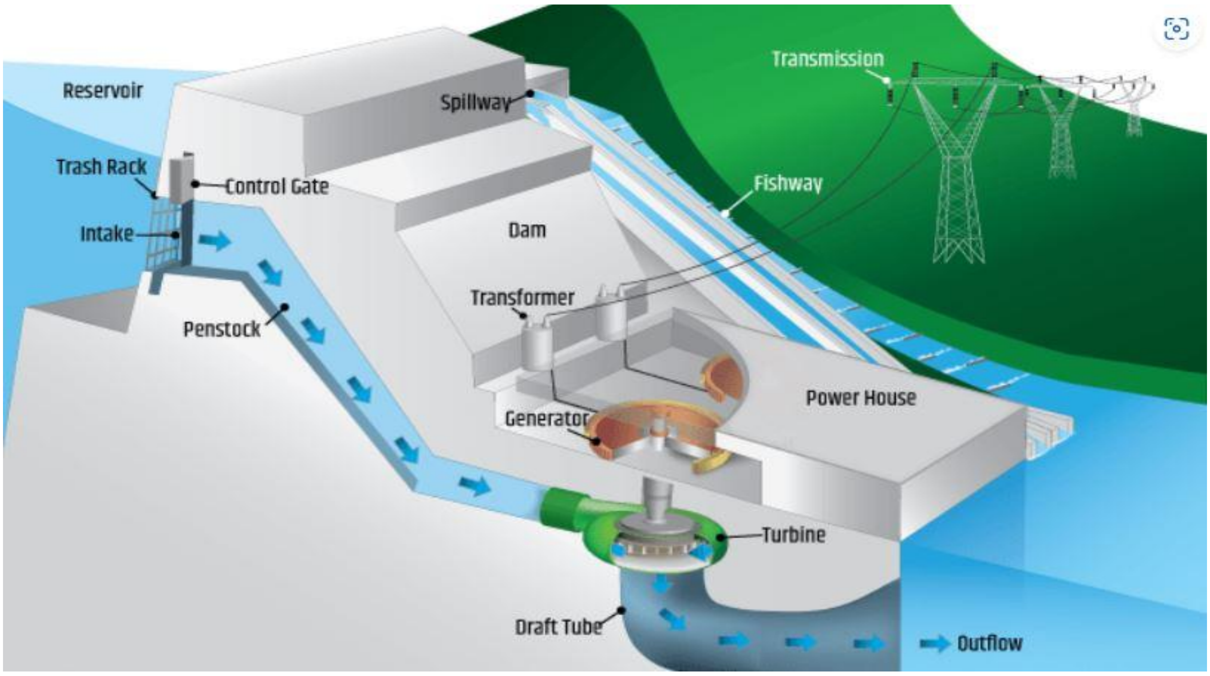
This is implications, not only for the availability of freshwater, but also the way we use water[50] and its use for hydroelectric generation, which is a neutral allocation of water and can provide useful water storage.

Existing hydro generation

The Waikato dams impound water into reservoirs for release when needed. Once released, the potential energy of stored water is converted to kinetic energy and flows through turbines, connected to generators to produce electricity. The water may be released to meet changing electricity needs or other needs, such as flood control, recreation, fish passage, and other environmental and water quality needs. The following is a stylised representation of an impoundment dam[51]. Hydro power has the advantage of being very responsive to fluctuations in grid conditions and can be dispatched and generate full power in less than one minute. This makes

[50] LetsTalkWaterDocument.pdf (waikatoregion.govt.nz)
[51] Types of Hydropower Plants | Department of Energy

hydro power a very valuable peaking option, provided there is sufficient water (fuel) in the system. The following figure shows the major components and structure of a typical hydro power station:



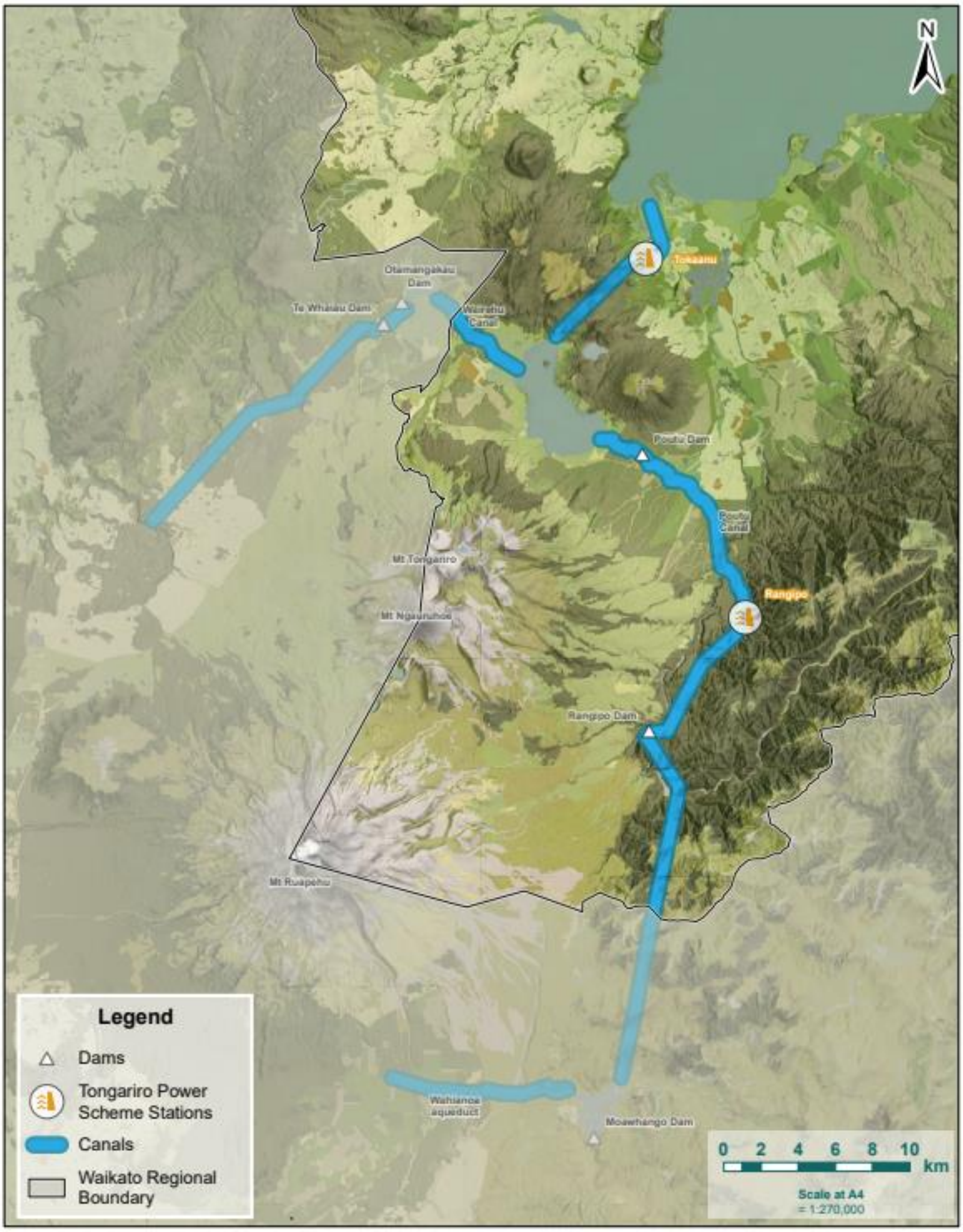
The Karapiro dam below is an example of an impoundment dam:

There are two major hydroelectric power schemes on the Waikato River system: one above lake Taupō, which includes diversions from the Horizons region; and one below. In addition, several smaller stations are located on tributaries.

The major scheme upstream of the lake is owned and operated by Genesis Energy and is known as the Tongariro Power Scheme. It was built in the late 1960s and early 1970s. The scheme diverts the headwaters of the Whanganui (western diversion) and the south-eastern tributaries from Mt Ruapehu, including the Whangaehu, and Rangitikei rivers (eastern diversion) along with the Tongariro river through tunnels and canals, so that they flow through the Tokaanu power station.

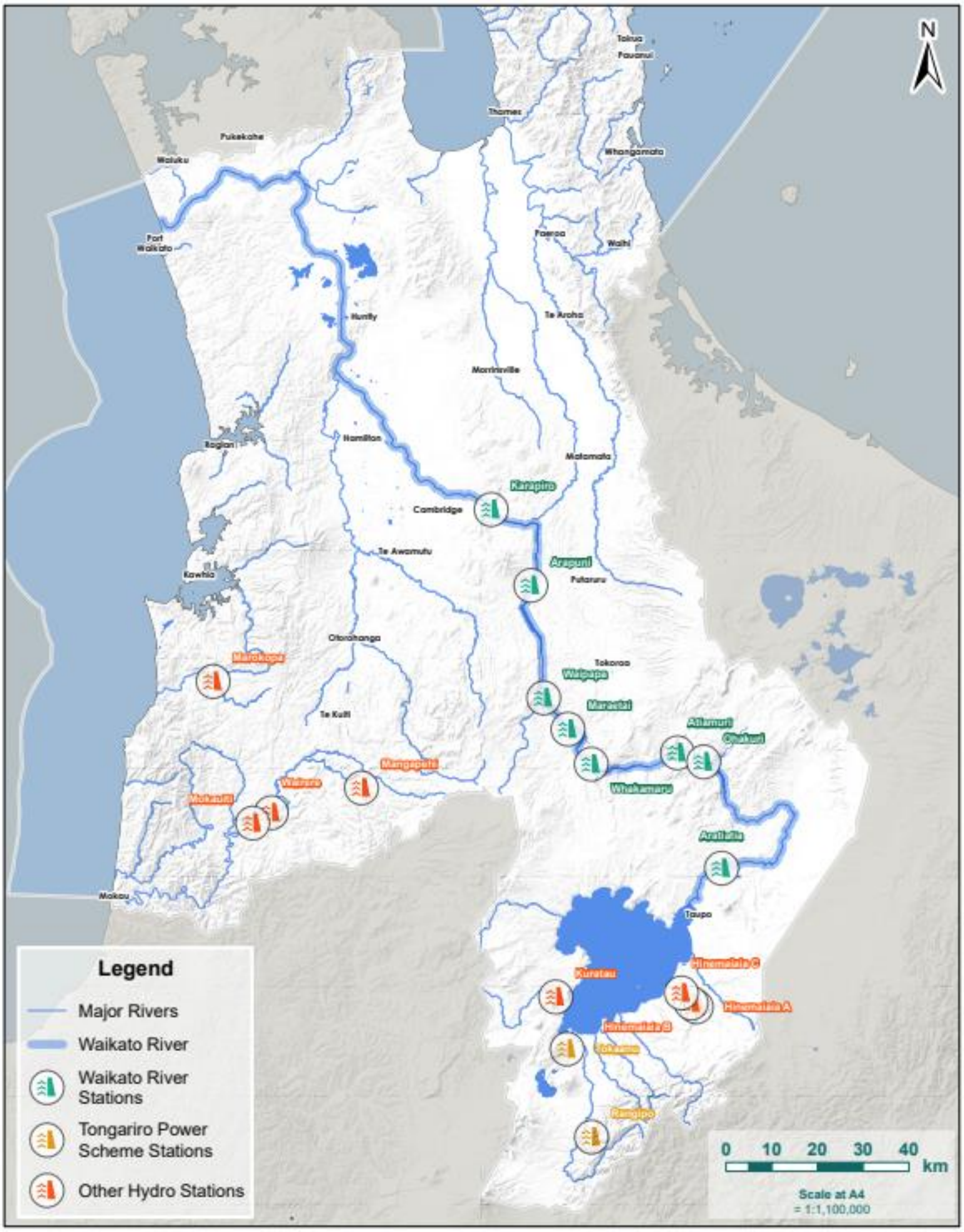
Upon completion, the scheme had two large generation sites: the Rangipo underground power station (120MW) and the 240MW Tokaanu power station. In 2008, a small (1.8MW) power station was added at the end of the Wahianoa aqueduct, part of the eastern diversion, but not in the Waikato region.

The Tongariro power scheme diversions add 19 per cent to the annual inflow to lake Taupō and therefore contribute not only to the downstream electricity generation, but hydrology and water allocation opportunities in the Waikato region. In the wake of decisions to decarbonise electricity generation and an increased understanding for the need to cover dry hydrological years, there has been a proposal to increase the height of the Moawhango dam to increase storage so as to ameliorate the effects of low rainfall. The following map shows the location of inter-regional diversions and canals associated with the Tongariro Power Scheme:[52]

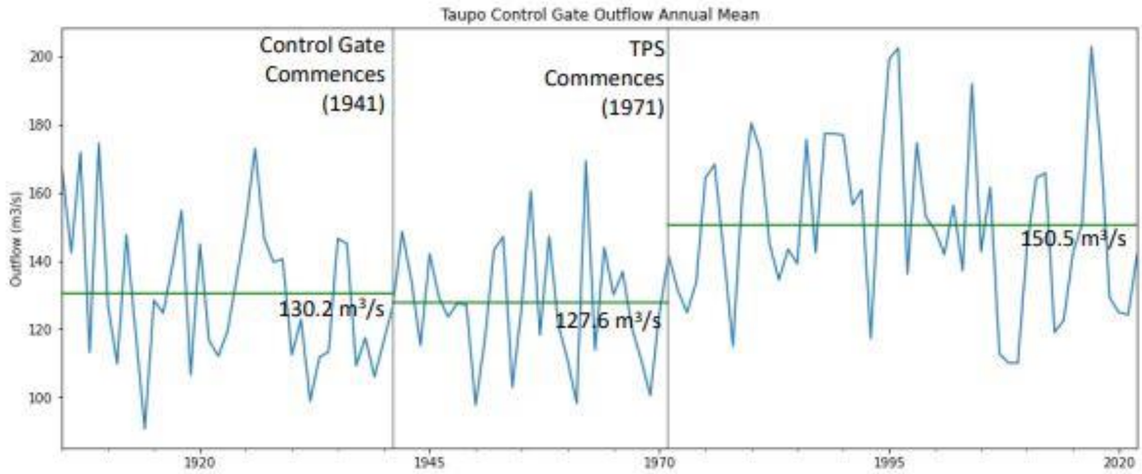


[52] Tongariro power scheme – Economy and the environment – Te Ara Encyclopedia of New Zealand

The following map shows the hydro stations in the Waikato region, and identifies the power schemes they form part of:



Mercury NZ owns and operates the hydro system below lake Taupō. This system is made up of eight hydro stations between lake Taupō and Karapiro south of Cambridge. The control gates were completed and commissioned in 1941 and maintain the lake Taupō level within a one metre operational range, providing for significant hydro storage (>600 million cubic meters) while at the same time allowing other uses of the lake and its water. The gates control the entire system with the series of dams and power stations operating in a cascading run-of-river mode with limited capacity to store water that maintains an operational buffer in the order of one to two weeks. In contrast, the storage in Lake Taupō is up to three months. The dramatic impact of the Tongoriro power scheme on annual average flows from Lake Taupō at the control gates is shown in the following figure.[53] Green lines are average flows of the respective periods:



The kinetic energy of the Waikato River waters was first used for hydroelectric generation in 1914 by the Waihi Gold company. A 400m channel was cut into a bend in the river in an area of natural rapids near Horohora, giving a nine-metre head, and turbines were installed to produce 6.3MW of electricity. The station was upgraded in 1924 to 10.3MW and supplied electricity to residents and dairy industry in the wider Thames valley. The Horahora power station was submerged and flooded with the creation of Lake Karapiro in 1947.

The second large hydro station to be built on the Waikato River was the Arapuni dam, built between 1924 and 1929 and was the first of the Waikato River Hydroelectric Power Programme between 1929 and 1966. Not long after completion, seismic issues showed up as cracks in the structure and the dam was repaired, extended and after wartime delays was completed in 1946 with a capacity of 146MW.

The remainder of the Waikato Hydro Electric Power Programme was completed in the following decades with the completion of the Aratiatia dam and power station in 1964. The Waikato Valley Scheme has used most of the river's natural fall, with each dam and power station discharging into the headwaters of the next downstream lake. Although originally designed as a system of ten dams, the eight that were constructed leave little room for creation of new generation and as a result the Waikato Valley can be considered a mature hydro system.

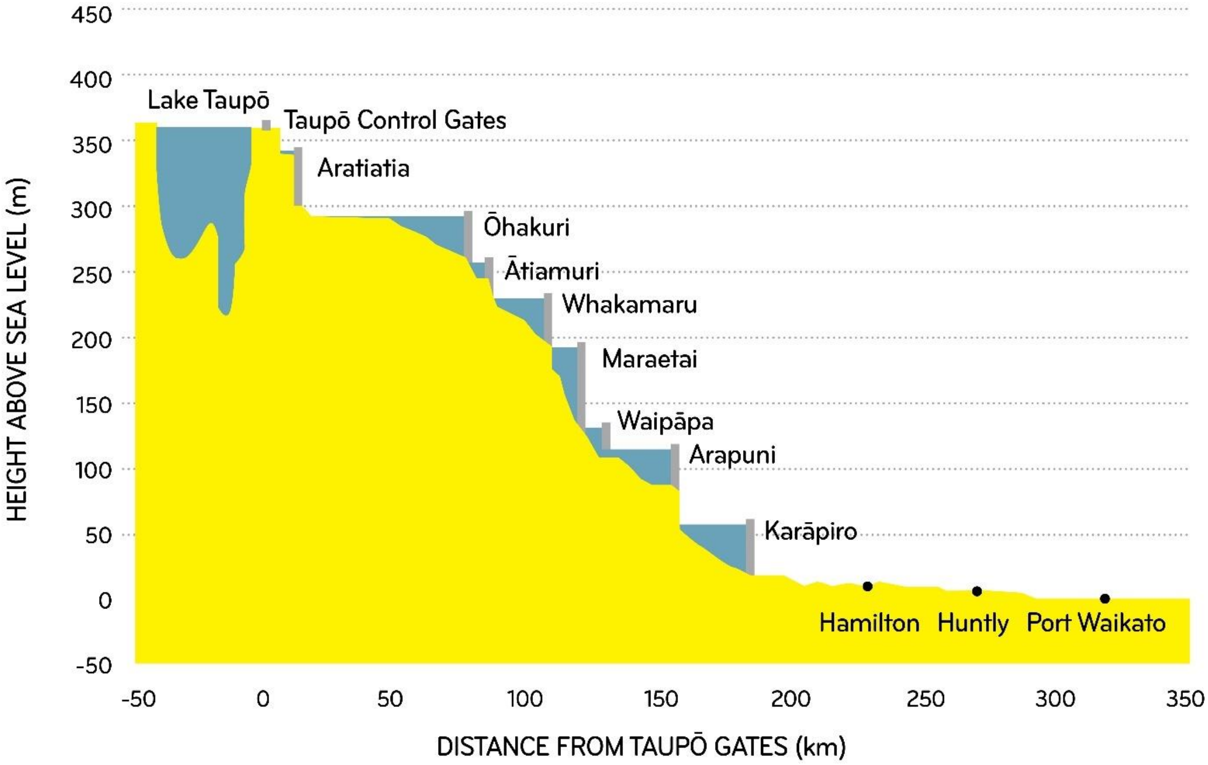
The benefits of renewable hydroelectricity are increased by the creation of several lakes that are used for recreation and in the case of Lake Karapiro, a national and international rowing, canoeing and waka-ama sporting venue. There are also water quality and hydrological consequences of creating large scale impoundments. In addition to a loss of white-water opportunities and flooded land, the impact of flooding the Orakei Korako geothermal system resulted in a loss of taonga.

Lake Ōhakuri was formed in 1961 when Waikato River was raised by approximately18 metres at Orakei Korako from 271 to 289.6 metres above sea level. An estimated 75 per cent of the geothermal system's hot springs were drowned by the creation of Lake Ōhakuri, including approximately 70 geysers and 200 alkaline hot springs.[54] The remains of the system's surface expression above the lake level include 100 sinter-forming springs and 35 geysers.

Any future increases in generation capacity will come from the regular and scheduled maintenance activities and replacement of plant with newer technologies. This is incremental and not a step

[53] Trends in hydrology and water resources (waikatoregion.govt.nz)
[54] E.F. Lloyd, Geology and Hot Springs of Orakeikorako, New Zealand Geological Survey bulletin 85, NZ DSIR, Wellington 1972

change in capability (e.g. Karapiro power station had an, as built, installed capacity of 90MW, and is now generating approximately 110MW). The almost total use of the Waikato River's potential energy for hydroelectric generation is illustrated in the following figure:



Source: Mercury NZ

Below is an overview of the existing hydroelectric generation stations in the Waikato region:

Station	Ownership	Scheme	Size (MW)	Commissioned	Consent timing
Rangipo*	Genesis Energy	Tongariro Power Scheme	120	1983	2004-2039
Tokaanu			240	1973	2004-2039
Hinemaiaia A	Manawa Energy Limited	Taupō	1	1952	2003-2036
Hinemaiaia B	Manawa Energy Limited	Taupō	1.3	1966	2003-2036
Hinemaiaia C	Manawa Energy Limited	Taupō	2.8	1982	2003-2036
Kuratau	Manawa Energy Limited	Taupō	6	1962	2002-2026
Aratiatia	Mercury	Waikato River	78.5	1964	2006-2041
Ōhakuri			112	1962	
Ātiamuri			80	1962	
Whakamaru			126	1956	
Maraetai 1			252	1954	
Maraetai 2			108	1971	
Waipapa			51	1961	
Arapuni			198	1929 & 1946	
Karapiro			110.1	1947	

Station	Ownership	Scheme	Size (MW)	Commissioned	Consent timing
Mangapehi	Southern Generation Limited Partnership	Te Kuiti	2	2008	2018-2053
Marokopa	Southern Generation Limited Partnership		2	2010-11	2011-2043 2017-2043
Mokauiti	King Country Energy	CNI	1.9	1925	2007-2032
Wairere	King Country Energy	Mokau River	4.6	1925	2005-2032

*Moawhango Dam is part of the Tongariro Power Scheme Horizons region.

The future of hydroelectric generation

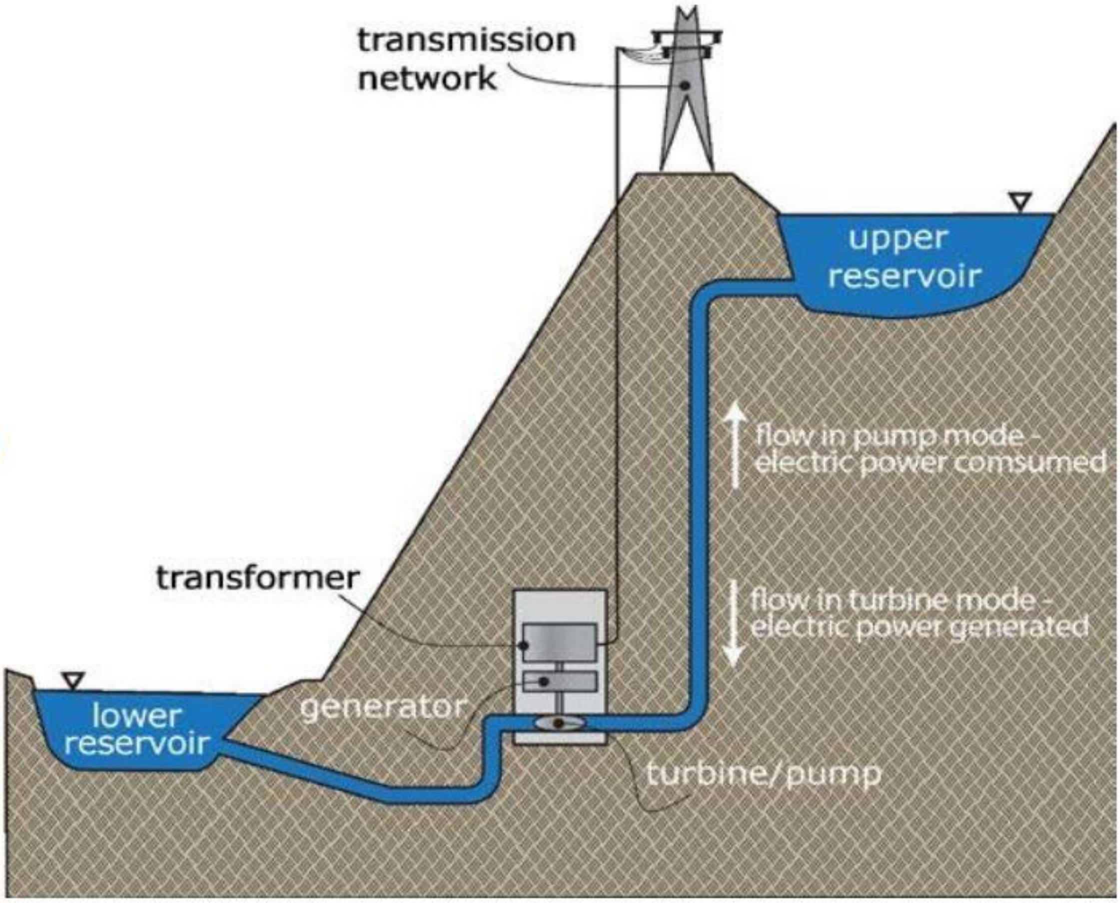
Tongariro Power Scheme consents authorising the diversion of waters from the Whanganui and Rangitikei catchments expire in 2039. These will need to be reconsented and one of the outstanding matters for consideration will be the relationship the river has with tangata whenua and the impact that the diversions have on the resilience of these river catchments and their life supporting capacity in the face of increasing climate change impacts.

With increasing demand for renewable energy, the phasing out of fossil fuelled generation to firm up the transmission grid and increasing climate impacts, the prospect of a dry hydro season leaving insufficient storage to meet generation demands becomes more acute. This has prompted the investigation of alternative storage and generation mixes known as the New Zealand Battery Project. Part of the initial investigation was a single solution pumped hydro project in Otago at Lake Onslow. The incoming government stopped investigations on cost grounds, however, the idea remains live for smaller distributed pumped hydro projects to meet the challenge. Three proposals have been identified in the Waikato region that will need to be addressed in any future regional energy strategy. They are:

- Between Whakamaru and Tokoroa
- West of Lake Taupō and
- Creating more storage by increasing the height of the Moawhango Dam.

Pumped storage hydropower is elevating water using low-cost, off-peak solar or wind generated electricity, to increase its potential energy so that its immediate dispatch characteristics can be used to generate electricity at times of high load to create certainty and resilience of the supply grid. The following is a stylised representation of a pumped hydro system:[55]

[55] Schematic of pumped storage hydropower system. | Download Scientific Diagram (researchgate.net)



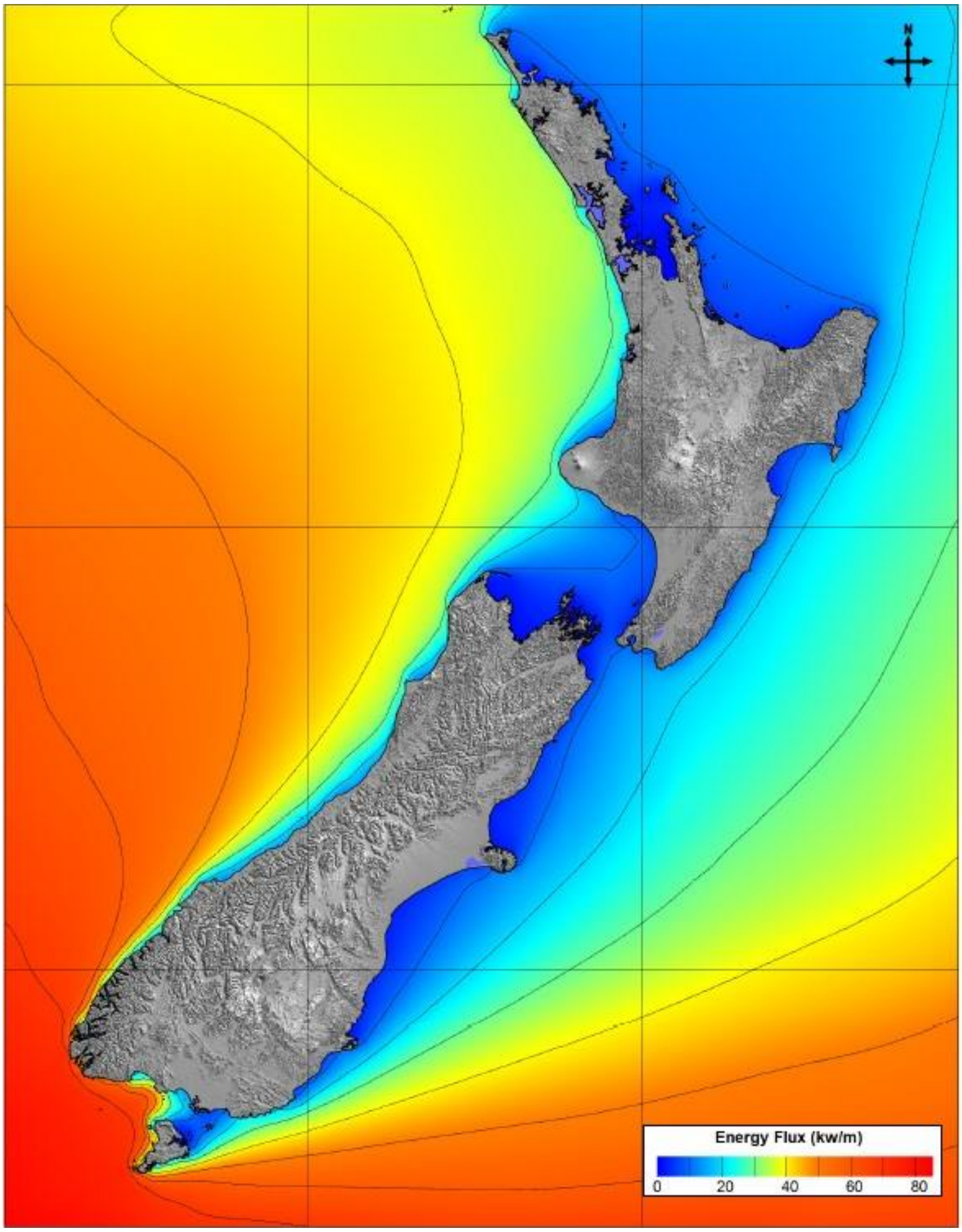
4.4.5 Wave

Wave energy is one of three types of marine power generation and is directly related to the sun (via wind). The other two, tidal and ocean currents are astronomical and are discussed in the next section and are accessed by using marine turbines. The use of marine energy and in particular wave energy is less developed than other renewable sources. Its use has been characterised by much experimentation with trial machines.

Wave power potential is estimated to be between 35-45 kW/m off the Waikato West coast, 15-25 kW/m off the East coast, and <15kW/m in Te Kapa Moana (Firth of Thames).[56]

The map below shows the energy flux in kW/m around New Zealand:

[56] The Power of Many?. Coupled Wave Energy Point Absorbers Paul Young MSc candidate, University of Otago Supervised by Craig Stevens (NIWA), Pat Langhorne. - ppt download (slideplayer.com)



NIWA

Wave energy is derived from wind blowing over the surface of the water and the friction creating ripples which turn into waves. The size of the waves and the energy that has been imparted to them is a function of the duration of the wind and this is measured by the distance of open sea available to the wind, or the fetch. The map graphically demonstrates the impact that New Zealand's location in the 'Roaring Forties' has on wave energy received, primarily from a south-western direction.

Waves are classified into two groups – those at the point of propagation (where the wind is blowing, called a 'sea'), and those that extend beyond the area of propagation (known as a 'swell'). Much of the swell that affects the West coast of New Zealand originates in the ocean to the south of Australia. On the West coast of the Waikato region, the most frequent swell direction is from the southwest, occurring nearly 40 per cent of the time.[57] The frequency of swells less than one metre

[57] Gorman, R. M., Bryan, K. R. & Laing, A. K. 2003. Wave hindcast for the New Zealand region: Nearshore validation and coastal wave climate. New Zealand Journal of Marine and Freshwater Research, 37, 567-588.

is about 20 per cent, while swell over two metres occur approximately 35 per cent of the time. Heavy southwest swells are particularly noticeable in winter and spring.[58]

Because wave energy is a function of wind, there is a known relationship between steady wind speed and wave heights in open sea, as noted in the table below:

Wind speed (km/hr)	Associated Wave height (m)
10	0.5
20	1
30	2
40	3
50	4
75	7
100	11
125	13+

The southwesterly origin of New Zealand's wave energy explains the concentration of coastal ports and the use of coastal space for recreation and for aquaculture on the east coast.

Wave power is extremely complex. There is no consensus on which technology to use to extract the energy value from waves as the water motion is three dimensional, determined by wind speed and fetch. There is the up-and-down heave of the waves, the back-and-forth surge, and the pitch or rolling motion that surfers capture. This is different from the unidirectional flow of water, in a hydro or tidal situation, the heat of geothermal reservoirs and the linear motion of wind once a turbine is oriented into it.

For this reason and the added complexity created by operating in an extremely harsh (corrosive) environment, wave energy remains a nascent technology, barely beyond piloting stage with most energy-capturing devices targeting a certain dimension of wave movement.

Bathymetry and the land-water interface adds additional complexity to the ability to extract wave energy. As water depth shallows, the energy in waves is attenuated by friction with the seabed, waves become higher and break, losing much of their energy as run up onto beaches. Wave energy devices that rely on a fixed shore will always be targeting the least amount of energy.

The design of marine wave generation devices is diverse; targeting energy at the surface, the seafloor and at the coastline. A recent PhD thesis[59] reviewed the current knowledge of marine wave energy devices and site selection, and that when selection methods were applied in the New Zealand situation. Twelve suitable wave energy sites were identified. These were clustered in four regions on the south and west coasts, including the Waikato region. The study found there were 116 companies actively developing 130 wave energy devices. Of these, 41 were assessed to be at an advanced technology level.

The devices can be classified depending upon their technology and the aspect of wave energy they are targeting. While there are many types of wave energy conversion devices at trial stage. Generally, there are five distinguishing features between the more mature types:

[58] Waikato ClimateWEB.pdf (niwa.co.nz)

[59] Bertram D 2021. An integrated site and device selection methodology for the ocean wave energy sector; (Thesis, Doctor of Philosophy (PhD)). The University of Waikato, Hamilton, New Zealand. Retrieved from https://hdl.handle.net/10289/14331

- Wave Point absorber floating devices, anchored to the sea floor, absorbing energy from multiple directions. They convert the motion of the buoyant but submerged upper body relative to the base, into electrical power. They can be deployed as a submerged array.
- Surface attenuator devices, comprised on multiple floating segments generating from differential relative motion between segments, which powers a generator.
- Oscillating water column devices – a closed device pressurising air and using wave-driven 'wind' for generation. Trapped air is allowed to flow to and from the atmosphere via a turbine, which can rotate regardless of the direction of the airflow, generating electricity on the rise and fall of wave heights.
- Anchored structures with submerged flapping appendages that generate electricity through the relative motion of the water. Also included are shore-mounted devices with surface flapping appendage.
- Coastal mounted devices such as overtopping terminator device which captures water from waves and generates from returning flow to the sea using low-head turbines.

In 2006, the Aotearoa Wave and Tidal Energy Association (AWATEA) was established to foster a vibrant marine energy sector in New Zealand. The association progressed several initiatives including a proposal for a joint marine energy and education centre modelled on successful international examples, designs to access the deep high energy tidal current of Cook Strait, and surface wave energy as per the picture below.[60]

[60] Making waves work: wave energy trials underway in Wellington | NIWA


NIWA

This latter project from a consortium of two Crown Research Institutes (Industrial Research Limited and NIWA) and a private company (Power Projects Limited) used a hinged spar buoy targeting the energy from water motion as pitch and heave. In this device, the larger hull sits in the water like an iceberg, while the smaller “float” at the sea surface pivots off the hull in response to the changing wave height. The relative motion between the two provides the energy for a hydraulic motor/generator to produce the electricity.[61] This project also involved the University of Auckland and trial deployments in Wellington’s Evans Bay, and Lyttleton.

As a nascent industry, most devices are still in the experimental and trial stages, however, the Pelamis P2 surface attenuator device,[62] an example of a sea surface attenuator, was progressed to the stage of being connected into the Scottish electricity grid in 2012, as pictured below:

[61] Craig Stevens NIWA/University of Auckland, Marine Renewable Energy Research and Development in New Zealand in the Pre-Offshore Wind Era, Submission to NZ Science review 2923
[62] Pelamis Wave Power P2 Demonstration at EMEC | Tethys (pnnl.gov)

European Marine Energy Centre

While there have not been any proposals to deploy wave energy converters off the Waikato west coast, the resource exists and there is new interest in jointly deploying wave energy converters with offshore wind structures in the future.

University of Waikato Civil Engineering staff and students have been investigating the potential for offshore deployment and testing of wave energy devices[63] to further research into this opportunity. Focus is on the Waikato region's west coast. This is an emerging area of global academic and commercial interest and in the northern hemisphere is satisfied by the European Marine Energy Centre based in the Orkney Islands. It allows commercial testing of marine energy designs and has been used internationally by more than 11 countries[64]. There is no equivalent testing centre in the southern hemisphere, limiting the research potential for developing marine energy conversion designs for our conditions as it is expensive to deploy experimental designs on the other side of the world. Initial investigation by University of Waikato[65] has identified Kawhia and environs as a potential research site with world class marine conditions along with local engineering, and academic support. There is a potential for regional development opportunities with international relevance.

4.4.6 Astronomical (tidal power and ocean current power)

Gravitational forces drive the rise and fall of coastal tides and to some extent oceanic currents. The movement of water around and through topographic and bathymetric restrictions such as headlands and harbour entrances can create strong local currents which are entirely predictable. Compared to some places with tidal ranges of up to 16 metres, New Zealand's modest tidal ranges in the order of a few metres is not an obvious location for accessing tidal energy. However, there are some areas where the coastal shape creates substantial flows. Technology is also evolving to extract energy from slower flows.

In 2008, the Energy Efficiency and Conservation Authority commissioned a report to identify suitable locations for marine tidal energy.[66] It found there were three locations in New Zealand with

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[63] D.V. Bertram, A.H. Tarighaleslami, M.R.W. Walmsley, M.J. Atkins, G.D.E. Glasgow. Renewable and Sustainable Energy reviews. ELSEVIER A systematic approach for selecting suitable wave energy converters for potential wave energy farm sites - ScienceDirect

[64] EMEC - The European Marine Energy Centre (orkney.com)

[65] A. Frith & R Wilson Site selection methodology and facility design framework for an offshore, mobile marine energy testing facility. Dissertation submitted in partial fulfilment of the requirements for the degree of BE(Hons) University of Waikato.

[66] Marine energy resources: Ocean wave and tidal current resources in New Zealand, report prepared by MetOcean Solutions for the Energy Efficiency and Conservation Authority.

an open-coast tidal resource: Cook Strait, Cape Reinga and the waters surrounding Stewart Island. None are in the Waikato region.

The energy contained in currents and waves is 830 times denser than air and can be accessed in similar ways, e.g. through rotating turbines, which can be made smaller because the same flow generates several hundred times more power. However, it is a harsh operating environment. Large, enclosed harbours such as the Kaipara harbour (the largest in the southern hemisphere) can have strong diurnal tidal streams of around five kilometres per hour. A proposal to deploy an array of 200 turbines[67] in the harbour entrance was made using submerged turbines with a diameter of 20 metres, leaving 10 meters of navigable water.

The two significant west coast harbours (Whaingaroa (Raglan) and Kawhia) do not have the same tidal exchange and do not have the same channel depth. Both have maximum depths of around 10 metres at the entrance, leading to the conclusion that unless micro-scale systems are developed, there is little prospect of tidal energy from the Waikato region contributing to the transition to a low emissions economy.

4.4.7 Geological

Geothermal fluid is groundwater that is heated within the earth by natural processes (either friction of tectonic plate movements, residual heat from the creation of the planet or radioactive decay) to a temperature above 30 °C. (Note – the earth has a natural subsurface heat gradient of approximately 10 °C /kilometre). The hot fluid is very flexible and can be used directly for its heat value for space heating, balneological and low temperature industrial processes, or in high volume, high temperature situations for electricity generation. Geothermal energy is considered renewable[68], and it has an advantage over other renewable resources in that it is independent of diurnal and climate variation. It is therefore best suited for continuous supply or 'baseload' uses.[69]

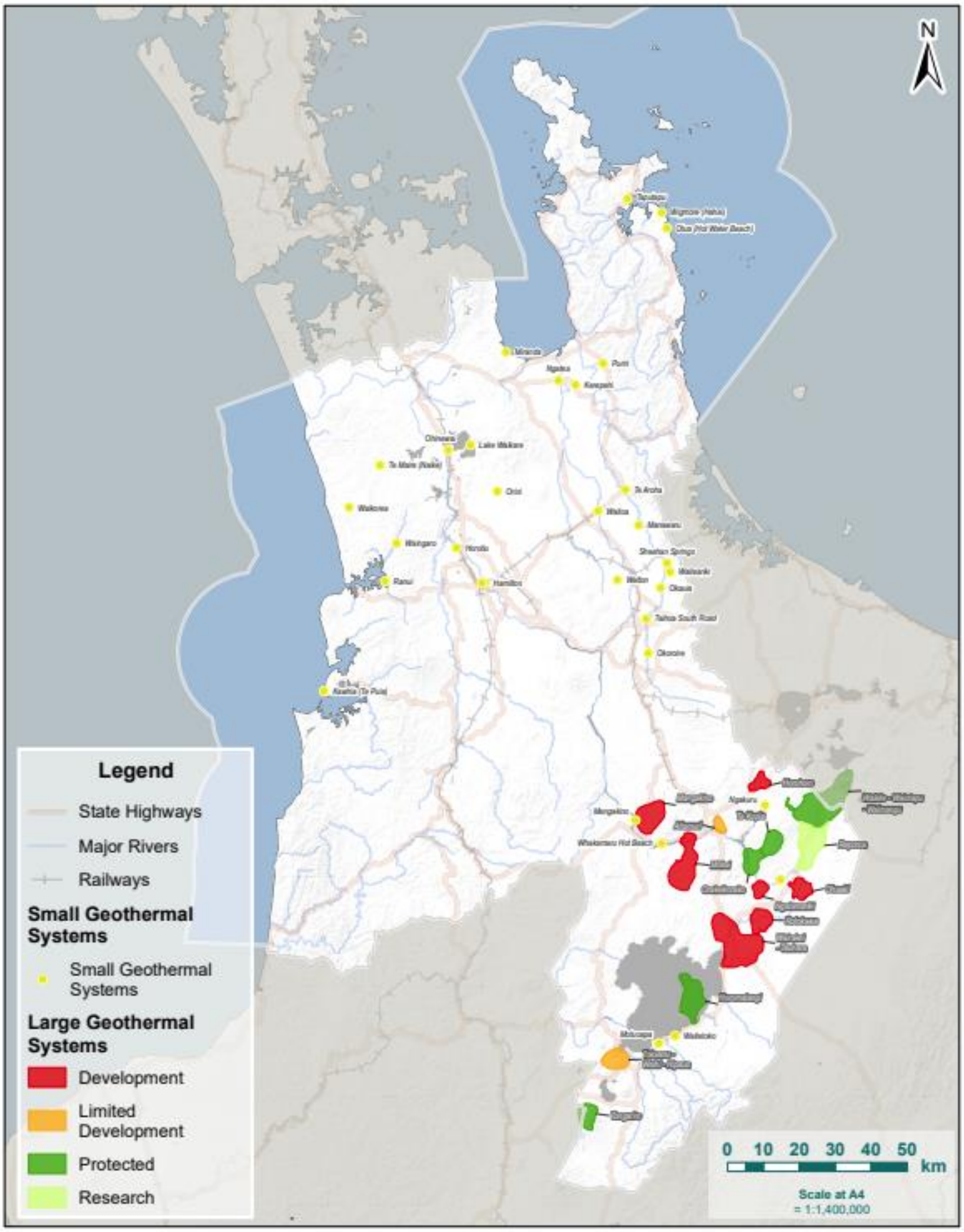
The Waikato region has approximately 70 per cent of New Zealand's geothermal systems. These are valued for electricity production, direct heat applications, science and tourism and are clustered around the Taupō volcanic zone. Tangata whenua have a cultural and spiritual relationship with the systems. New Zealand has the fifth highest installed geothermal electric capacity in the world and geothermal energy provides about 18 per cent of New Zealand's electricity supply, most of it coming from the nine geothermal power stations.

The extent of the known geothermal resources is mapped below:

[67] Consents for 100 turbines granted by Northland Regional Council 2008.

[68] The present developments are basically long term heat mining operations that will eventually either have to "rest" their takes to let reservoir temperatures recover or drill for the deeper, hotter resource.

[69] Geothermal in New Zealand |Systems, Electricity and Uses (nzgeothermal.org.nz)



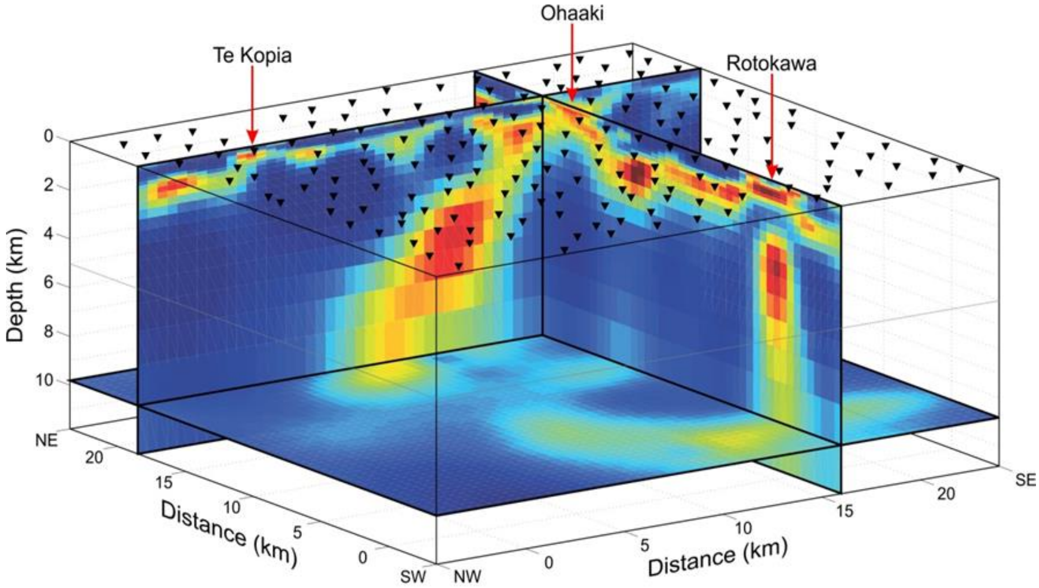
Geothermal systems are three dimensional, having both surface expression and an underground foundation. Drilling, measuring the resistivity characteristics of the groundwater, other geophysical, geochemical, geological surveys, and modelling are the only way we can understand the sub-surface characteristics of geothermal systems. These can be projected into a 3D image of each system.

The figure below shows the 3D extent and relationships of three large geothermal systems in the Taupō volcanic zone. It is an example of resistivity inversion models generated from a 3D Magnetotelluric (MT) modelling project conducted by GNS[70]**.** The objective of the project was to image subsurface resistivity structure to approximately 10 km depth beneath the area covered by GNS MT array measurements in the Waikato region.

The figure below shows the intersection of two vertical cross sections and a 25km x 25km horizontal plane at 10km depth. It provides detail of the subsurface resistivity structure associated with two of

[70] Bertrand et al., JVGR (2025) in session_160602_08.pdf (jogmec.go.jp)

the large geothermal development systems in the Waikato region, Rotokawa and Ōhaaki, and a protected system; Te Kopia.



Access to and use of geothermal heat and fluid is not like wind, solar, or to a lesser extent hydro, which all occur above ground and have limited potential adverse effects. Some factors that make use of geothermal resources' different can be seen from past experience.

Geothermal is flexible energy (heat) as it can be used directly, or the steam used to convert to electricity for distribution. Access to and use of geothermal fluid and energy is regulated by a proven policy (internationally recognised) and regulatory regime that has facilitated the recent expansion of geothermal energy for electricity generation. This has been driven by the large electricity generators, however, there are still potential opportunities to use the energy contained within geothermal systems more efficiently but less flexibly by using the heat directly at the location where the resource exists. This use is enabled by the current Waikato policy/plan regime as it has the co-benefits of creating other wellbeing opportunities for regional development (e.g. local employment). This contrasts with the grid export of the energy out of region. Examples of this approach are the multiple use of the Mokai geothermal system by Tuaropaki Trust[71] using geothermal energy for electricity generation, milk drying, greenhouse heating and green hydrogen fuels. The geothermal fluid also contains minerals such as silica and lithium that can be used in industrial processes.

The removal of large volumes of fluid from a geothermal reservoir can lead to the collapse of some relatively soft strata once they are dewatered, particularly lacustrine layers (relatively recent sedimentary layers from geological ages when an area was covered by a lake). This subsidence can cause damage to surface and sub-surface infrastructure and buildings and subsequent loss of property values. This is particularly relevant on the edge of subsidence areas, where the differential subsidence rate (the rate one part of a connected infrastructure unit such as a road or building subsides compared to another part of the same unit) is highest. Flooding may occur if the subsidence occurs on land adjacent to a water body. Some examples of impacts of removal of fluid from geothermal reservoirs are:

- The operation of the Wairakei Geothermal Power Station has led to land subsidence of more than 15 metres in places.
- The present town of Taupō was in-part created to service the tourists who came to experience the many geysers and sinter springs at Wairakei valley, Spa Sights, and Waipahihi. The development of the Wairakei system transitioned the surface features from fluid dominated to steam, most notably Karapiti (Craters of the moon).

[71] https://tuaropaki.com/our-story/our-history/

- The Waikato River flows over the Ōhaaki Geothermal System, where two metres of subsidence has led to large areas of farmland becoming inundated, with some roads, buildings, other infrastructure and culturally significant sites now underwater. Ecologically significant wetlands have become too deep to support wetland ecosystems. Bunds have been built to protect land and infrastructure.
- Also at Ōhaaki, the first production wells were openly discharged to the air for several years with the intention of creating a steam reservoir similar to Wairakei. Unfortunately, the same management practice that worked for Wairakei was not suited to the specific characteristics of the Ōhaaki system. This led to premature depletion of the reservoir and draining of the Ōhaaki ngawha. This ngawha was a large clear sinter-lined pool with a surface area of 650 square metres overflowing across extensive white terracing. It was a taonga of Ngāti Tahu, who built the Te Ōhaaki o Ngatoroirangi Marae nearby, after their original main marae at Orakei Korako was drowned after the Ōhakuri hydroelectric dam was created on the Waikato River.

Another adverse effect from early geothermal development was the contamination of surface water. Several hydro lakes of the Waikato River downstream of Wairakei Power Station hold sediment that is heavily contaminated by arsenic as a result of the Wairakei Power Station discharging up to 160,000 tonnes per day of geothermal fluid pre-RMA. This has occasionally resulted in fish kills when water temperature changes lead to the release of the arsenic from sediments into the water column.

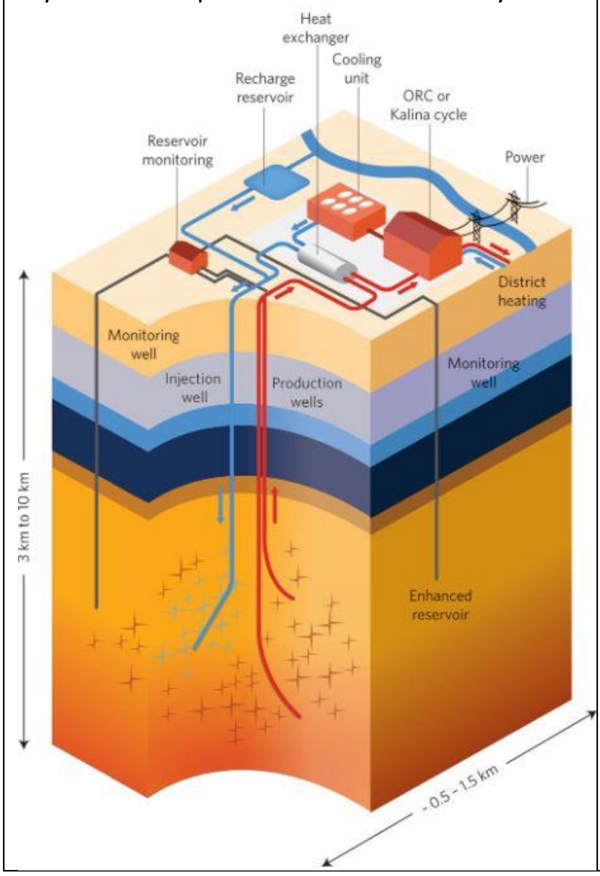
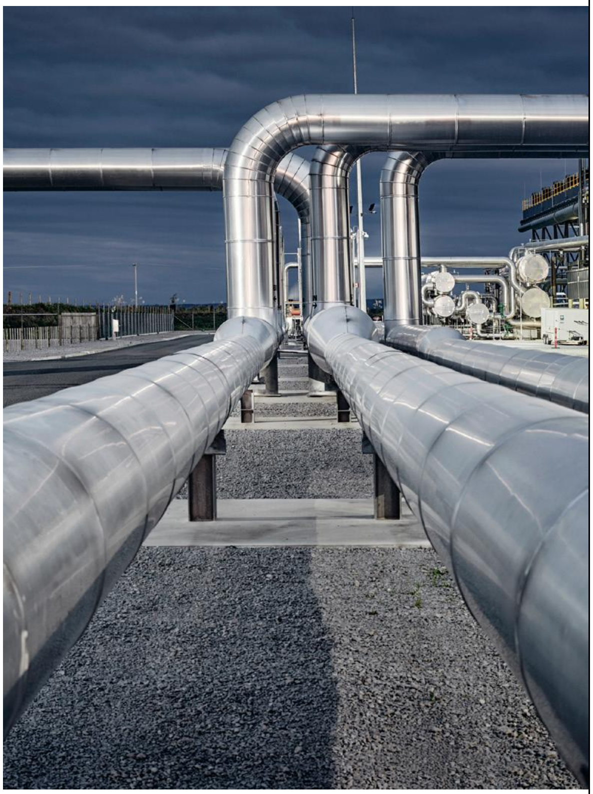
In addition to the large geothermal systems associated with the Taupō volcanic zone and the subduction of the Pacific tectonic plate, the resource has surface expressions in a number of places, each with different temperature, chemical and ultimately biological characteristics. These characteristics are described in the following table:

System	Maximum Temperature (˚C)	Flow rate (l/s)	Comments
Hamilton	27	11	Wells drilled to 135m. Previously known warm wells including on the NE corner of Victoria St and Claudelands Bridge. Warm well on Aberfoyle St Wells drilled by Government - now abandoned. There are anecdotal reports of warm springs in the Waitawhiriwhiri stream that runs through Dinsdale and Maeroa but they have not been searched for. Well on Victoria St and Claudelands Bridge used to heat an office block and is the former site of a warm spring previously used by Ngati Wairere, which now can't be found.
Horotiu			
Kawhia (Te Puia)	53		
Kerepehi	57	Low flows (<1 l s-1) usually in the form of diffuse seeps	Several shallow wells (~50 m). A bore drilled to 92.3 m (Bore Beck) in the north has reportedly used warm water to heat greenhouses indicating warm water exists in this area.
Lake Waikare	78 in vent; 70 (in drillhole)		
Manawaru	58		
Mangata (Mangatawhiri)			Hot water encountered in coal exploration drillhole.
Miranda	63.8 in spring, 64 in drillhole	>7	Used for Olympic size swimming pool, public sauna pool, children's pool and 4 private spa tubs.
Motuoapa	51 in the minor hot water flows, 47.5 next to springs at 1m depth		

System	Maximum Temperature (˚C)	Flow rate (l/s)	Comments
Ngatea	30	1	
Ohinewai	23.2 from field measurement. Between 60-100 calculated from geothermometers		A number of springs and warm wells drilled to shallow depths. Shallow wells provide some domestic, farm and industrial uses.
Okauia	40	1.5	Two shallow bores (20-30m) on eastern side of system. Four deep (200 -350m) boreholes outside the immediate hot spring area: ~1 km to the north-west; ~2 km to the east; ~3 km to the south; and ~2 km to the south. Used for public bathing pool, private thermal pool, youth camp showers.
Okoroire	43	56	Used for bathing.
Otua (Hot Water Beach)	63	<2	Two wells drilled.
Puriri	17	<1	
Ranui			
Sheehan Springs	23	100	
Taihoa	44		
Taputapu	49		
Te Aroha	59 (85°C in drillhole)	0.9	Several wells drilled in the area to provide thermal waters for recreational purposes. Most of the wells became cold and were closed while others have broken down and been neglected. Mokena Geyser, an artificially made drill hole, still remains and periodically erupts. Used for more than 100 years for several uses, including bathing, swimming and balneology. Some wells and springs are connected to a commercial hot pool complex e.g., Mokena Geyser outflow is diverted to the swimming pools.
Te Maire (Naike)	44	10	
Waikorea	54	0.04	
Waingaro	54	5.7	Used for bathing - Waingaro hot springs complex.
Waiteariki	35		
Waitetoko			
Waitoa	50	2	A few wells deeper than 100m.
Walton	32	2	
Whakamaru Hot Beach	92		
Whangairorohea	42 and 56 for two of the hot spring features		Shallow groundwater wells.
Whitianga	53	5	2006: a well on Cook Drive produces 5 litres/second. The Lost Spring geothermal pool complex.
Wigmore (Hahei)	27		One well present.

Existing geothermal generation

Although the 'fuel' is free, accessing geothermal heat is a complex and expensive undertaking. Not only is the resource found underground, but its response to use must be inferred by remote sensing of the respective area and other geo-science surveys, then reservoir models are developed on theoretical understanding of geology, geophysics and geochemistry and the empirical responses of similar systems elsewhere. None of this is precise and it is only when a system is developed and used that the response can be known. Even then it is patchy as all the action occurs thousands of metres under the ground. This up-front work is expensive and then the sub-surface infrastructure (production, monitoring and re-injection wells) need to be completed alongside above ground pipework and generation and transmission equipment. The below graphic and photo demonstrate this system:

Stylized development of a Geothermal system	Nga Awa Purua Geothermal power station
	

Below is an overview of the existing and proposed geothermal power stations of the Waikato region:

System	Station/ unit no.	Owners	Type	Size (MW)	Commission	Consent granted	Take T/day	Consent expiry
Wairakei - Tauhara	Wairakei A	Contact Energy	Flash steam	127	1958	2022	280,000	2058
	Wairakei		Binary	5	2005			
	Poihipi		Flash steam	50	1997			
	Te Mihi		Flash steam	166	2014			
	Te Huka unit 1	Contact Energy	Binary	26	2010	2010	213,000	2045
	Te Huka unit 2		Binary					
	Tauhara		Flash steam	174	Due for completion in 2024	2010		
	Te Huka unit 3		Binary	50	Scheduled for commercial operation 2024	2022		
Ōhaaki	Ōhaaki	Contact Energy	Flash steam	53	1989	2013	40,000	2048
Mokai	Mokai	Tuaropaki power	Binary	106.8	2000	1994	40,000	2024**

System	Station/ unit no.	Owners	Type	Size (MW)	Commission	Consent granted	Take T/day	Consent expiry
		company *			No new plant commissioned	2020	11,000	
Rotokawa	Rotokawa	Mercury & RJV	Binary	3.4	1997	2016	75,500	2053
	Nga Awa Purua	Mercury & RJV	Flash steam	140	2010			2053
Ngatamariki	Ngatamariki	Mercury & RJV	Binary	136	2010	2010	60,000	2045
	Ngatamariki OEC5 expansion		Binary	37	No commercial decision has yet been made to progress the unit.	2023	24,000	2058
Reporoa	Reporoa	Genesis	N/A	90	Proposed[72]	N/A	N/A	N/A

*Tūaropaki Trust and Mercury

**Application submitted for replacement resource consent (duration of 35 years) for ongoing operation

Wairakei geothermal power station

Below is a table of national annual electricity generation (GWh) from geothermal energy at five yearly intervals[73] which shows the changes in electricity generation:

Year	1980	1985	1990	1995	2000	2005	2010	2015	2020
Generation	1,206	1,165	2,011	2,039	2,756	2,981	5,559	7,479	7,834

These figures include some continued generation from Bay of Plenty (Kawerau) and Northland (Ngawha), but mostly reflect the increase in investment following reviewed Waikato regional geothermal policy in 2006. Not only did the geothermal policy review result in an increase in generation, but the consenting times also reduced from a pre-policy duration of six years (reconsenting of Wairakei power station) to six months as in the following table.

[72] Energy News, www.energynews.co.nz (accessed Friday 2 January 2024)
[73] Electricity statistics | Ministry of Business, Innovation & Employment (mbie.govt.nz)

Project	Date lodged	Decision date	Time taken	Grant	Appeal
Nga Awa Purua – 140 MW, Mighty River Power & Rotokawa Joint Venture – WRC Hearing process – Commissioned	1/6/2007	15/1/2008	6 ½ months	Yes	No
Te Mihi – 166 MW, Contact Energy – Application called in after being lodged with WRC. Decision date was that of the Board of Inquiry. – Commissioned	31/7/2007	3/9/2008	14 months	Yes	No*
Ngatamariki – 110 MW, Mighty River Power & Rotokawa Joint Venture – WRC Hearing Process – Commissioned	6/11/2009	10/5/2010	6 months	Yes	No
Tauhara II – 220 MW, Contact Energy – Directly lodged with EPA (post 2009 RMA Amendment) – Consented,	19/2/2010	10/12/2010	10 months	Yes	No*

**Board of Inquiry Process allows appeals on Points of Law only.

5. Spatial distribution of electricity generation

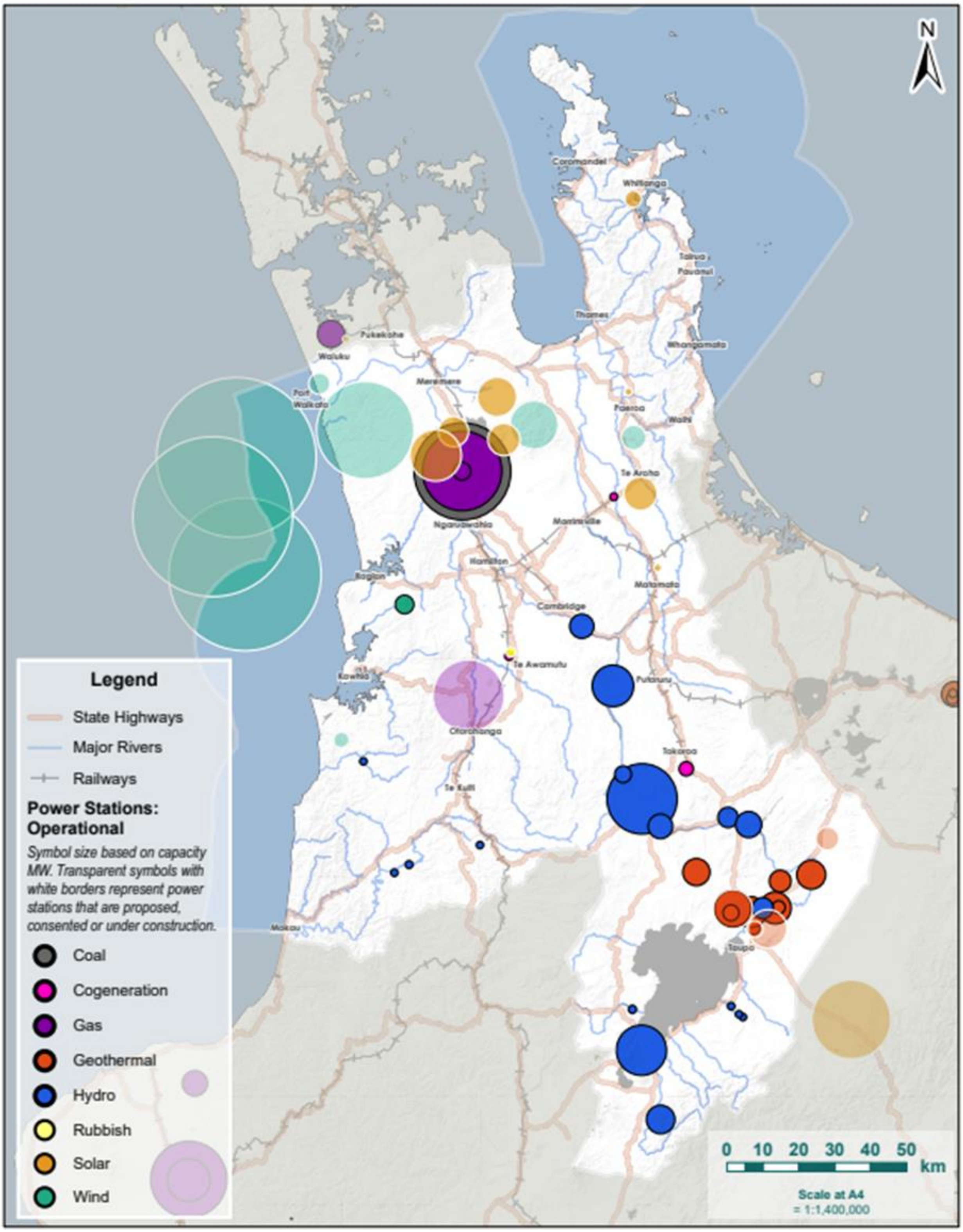
Electricity generation from renewable resources is locationally determined as the energy is only found in association with the resource. This may not be where the energy is needed and therefore it must be converted into a form that allows transporting (transmission) to a location of demand.

While the energy from sunlight is a ubiquitous resource and the energy content can be captured and converted efficiently in most places, the locational constraints are secondary and relate to proximity to the transmission grid and whether there is an alternative more valuable use of the land. By way of contrast, energy from water requires sufficient water at an elevation that allows it to be released down tubes (penstocks) and to spin a turbine before being discharged. It is the kinetic energy of the water that is either used as mechanical (rotational force) or more commonly converted into electricity.

Existing generation relies on water: either hot water and steam (geothermal), elevated water (hydro) or bulk water (for cooling of thermal stations) - these are regional council-intensive consenting responsibilities as water is a national resource and is allocated by regional councils subject to national direction and under the obligations imposed by the Treaty of Waitangi.

In the future, electricity generation will require the existing hydro and geothermal generation which are found in the south of the region, but new sites will be more focused on wind and sunlight found in the north. These sources of energy are not consentable resources under the Resource Management Act 1991 and are regulated on the effects of the technology used to capture the energy and are therefore a land use, or a territorial authority function and along with biomass has implications for private property rights. A regional role exists in relation to any use that affects water or for the strategic integration of infrastructure with land use. Proposed generation is focussed in the north of the region as it is this area where the current pastoral land use is increasingly becoming challenged from reduced rainfall, is close to the high demand centre of Auckland and is where the national grid is strongest.

The following figure graphically illustrates this shift in the locus of future utility scale, grid connected electricity generation. The existing generation has historically focused on the southern part of the region using hydro and geothermal resources with long transmission lines to the major demand. These are regulated directly by the regional council. Future generation is focused towards the northern part of the region.


N
Coromandel
Whitianga
Tairua
Pauanui
Thames
Whangamata
Pukekohe
Waiuku
Port Waikato
Meremere
Paeroa
Waihi
Te Aroha
Ngaruawahia
Morrinsville
Hamilton
Raglan
Matamata
Cambridge
Te Awamutu
Kawhia
Putaruru
Otorohanga
Tokoroa
Te Kuiti
Taupo
Mokau
Legend
State Highways
Major Rivers
Railways
Power Stations: Operational
Symbol size based on capacity MW. Transparent symbols with white borders represent power stations that are proposed, consented or under construction.
Coal
Cogeneration
Gas
Geothermal
Hydro
Rubbish
Solar
Wind
0 10 20 30 40 50 km
Scale at A4 = 1:1,400,000

6 Electricity transmission and distribution

6.1 Introduction

Electricity is an energy carrier and must be created before it can either be stored (via battery) or transmitted as electrons through a conductor to a site of use. The electrical force that ‘pushes’ electrons is the 'voltage' and the number of electrons that flow in a wire is the 'current'.

Generators convert kinetic, or moving energy of water, steam, air and combustion gases, into electrical energy, usually by rotating a turbine connected to a rotor. Turning an electromagnetic rotor inside a series of surrounding conductive wire coils induces an electrical current which is then sent along wires to a transformer. The transformer changes the electric current into the transmission grid.

Not only does the electricity generated (supply) from renewable sources vary but the requirement for electricity (load) also changes over a day, a week and seasonally. This means that not only does the transmission system need to balance the supply with the load, but it must also have sufficient capacity to meet the maximum or peak load for electricity and match it with generation from a range of renewable sources from a range of locations – often not in the same place as the load.

The infrastructure that takes electricity from places where it is generated to where it is used is known as the ‘national grid’ and is owned and operated by Transpower, a 100 per cent state-owned enterprise.

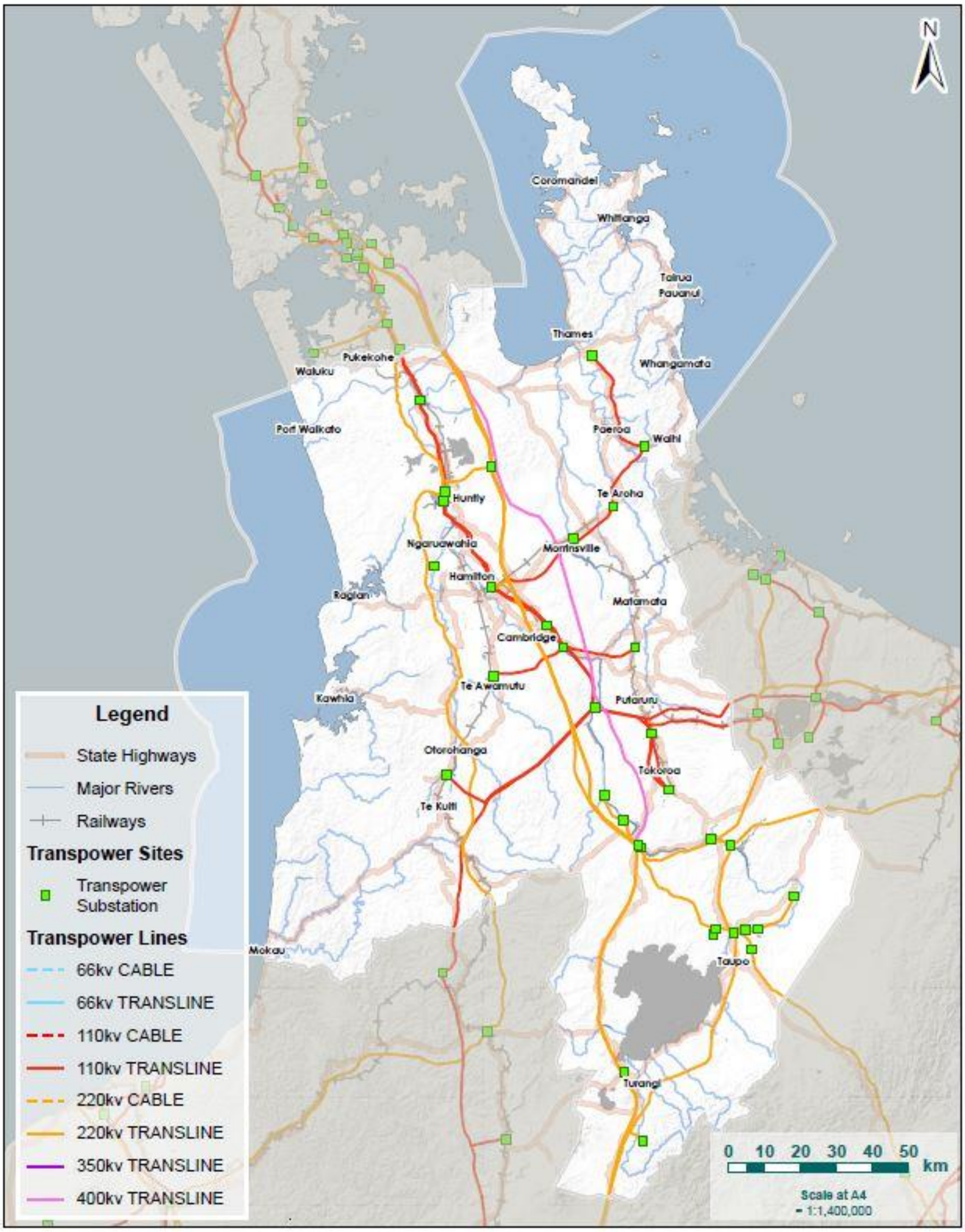
6.2 Transmission and distribution infrastructure

Power is generated at power stations across New Zealand. Generators make electricity from primary energy sources by harnessing water, wind, sun, geothermal energy, coal and gas. The electricity produced is too powerful to feed directly into homes.

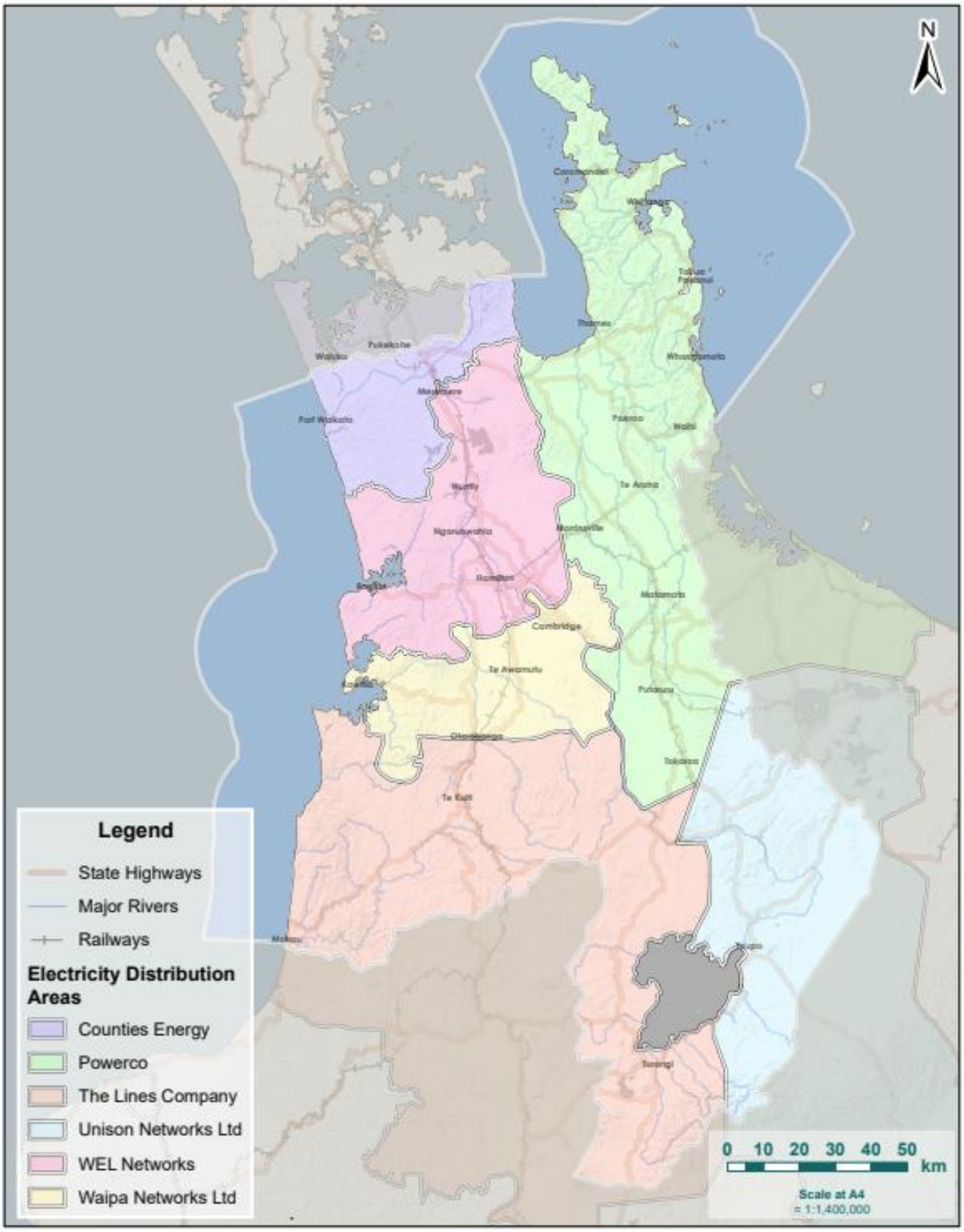
From power stations, electricity flows through large transmission lines which carry it to substations. This electricity is sent at high voltage, and a small proportion is lost along the way as heat in the power lines. Keeping the voltage high ensures that as little electricity as possible is lost along its journey.

Distribution lines carry electricity from substations to homes, schools and businesses. Transformers at the substation change the electricity current and voltage to make it suitable for local wires and consumption. The electricity enters homes through meters, where it is measured, and into power outlets, where it is ready to be used.

Electricity is a just in time carrier of energy and uses a network of wires (overhead, underground, and undersea) to connect generation sites through substations to points where it is distributed for use. This is referred to as a power grid, with the best feature of a power grid being that everything is connected. It is also a weakness that needs to be addressed to achieve resilience and security. National transmission assets in the Waikato region are shown in the following map:



The following map shows the six lines companies in the Waikato region which distribute electricity from national grid exit points to final users. Lines companies and their roles are described further in Appendix 5.



The national electricity grid and local distribution networks connect electricity producers with users (generation with load) and electricity is a just in time energy carrier that must either be used, when generated or generated when required. This is a problem for grid / network operators with increasing generation from intermittent sources such as solar (PV) and wind. One solution is to store excess renewably generated electricity for later use when demand requires it. The industry solution to this is to use large Lithium-ion batteries for short term (hours) balancing.

Storing energy as electricity has the advantage of not requiring it to be generated at short notice (although the technology is available with hydro generation available in seconds). Batteries are instantaneous and can be used to support the grid until generation picks up or the load can be reduced through appropriate demand management actions.

Batteries do not come without cost and require cooling as well as degradation of the chemical structure over time and use can reduce their storage capacity. Research to address this is ongoing as it not only effects grid support infrastructure but also EV batteries, which can be used to balance domestic electricity load. Lithium-ion batteries are now able to be rejuvenated, back to 80% of original capacity rather than being disassembled and recycled[74].

To date two distribution networks have installed battery support in the region for load shifting and to reduce blackouts in remote areas, these are shown in the following table:

Station	Operator	Size MW	Commissioned
Rotohiko	WEL Networks	35	2023
Whangamata (CBD standby power)	PowerCo	20	2020

In the future the region will see grid scale battery storage installed at Huntly[75] in the first instance. This is initially expected to be of a scale that can support the whole national grid, up to 400MW storage that can discharge over two hours. The first stage is expected to be developed in the next 18 months with final completion by 2035.

6.3 Future electricity transmission requirement

In a recently completed report on the security and resilience of the New Zealand power system[76], Transpower identified four key factors that would drive the transition over the coming decade. They are:

1. Decarbonisation of the electricity industry – reducing greenhouse gas emissions by increasing renewable generation while reducing reliance on gas and coal fuelled generation
2. Decarbonisation of the wider economy – reducing the use of fossil fuels by increasing electrification throughout the economy including process heat and transportation
3. Distribution – increasing adoption of distributed energy resource (DER) such as solar photovoltaics (PV), electric vehicles (EV), batteries and smart appliances throughout the power system, and
4. Digitisation – increasing the volume of data and the digital tools necessary to manage increasing energy resources and complexity.

This can be expected to transform the power system from a centralised to a decentralised system where more energy sources are located outside the main grid and as a consequence, challenge existing industry operating boundaries. An increase in variable and intermittent energy sources (wind and solar PV) are expected to meet the increasing demand for electrification of transport and process heat. Changes are also expected in the switch from passive to active consumers who can feed excess generation into distribution networks and manage their electricity usage. This is summarised in the following table:

[74] Direct capacity regeneration for spent Li-ion batteries, Joule, Direct capacity regeneration for spent Li-ion batteries (cell.com)
[75] Genesis shifts approach to renewable energy; large battery planned at Huntly, RNZ Audio Player
[76] Opportunities and challenges to the future security and resilience of the New Zealand power system, March 2022. Appendix-A-Phase-1-final-report.pdf (ea.govt.nz)

Key trends	Current	2030
Decarbonised: Transition to 100% renewables	• 85% renewable electricity • Mostly synchronous generation • Security of supply managed by market • Thermals to meet peaks and dry years • Small amount of DER	• 100% renewable electricity • More asynchronous and inverter-based generation • Will energy-only market manage security of supply? • New solutions needed for peaks and dry year • Increased reliance on DER
Decarbonised: More electrified economy	• High reliance on electricity in the economy • Electricity not relied on heavily for transport • Few, traditional demand growth sources – new industry, new housing	• Very high reliance on electricity in the economy • Electricity relied on heavily for transport and in industry • Many different demand growth sources – hydrogen, data centres, EVs, process heat
Distributed: More distributed electricity system	• Small amount of DER • Limited performance requirements in the Code but small penetration means this is not yet an issue • Limited use of demand-side and battery technology to manage peaks	• Millions of DER able to manage peaks in real-time (EVs, batteries, smart appliances) • Multi-directional power flows • More consumer participation and more market players • Potential issues caused by inverter-based DER
Digitised: Increasing digitisation and use of digital tech	• Increasing data and data management requirements • Gradual use of automation for control and switching • Increased use of data-driven decision making	• Increased complexity and volume of data • Expectation from operators and customers that controls, and communications will be automated and data-driven • Opportunities to improve consistency and efficiency

The development of large-scale offshore wind electricity generation will have effects that need to be accommodated and will require investment to upgrade transmission infrastructure. Transpower has modelled the impacts on the North Island grid from large scale offshore wind using six plausible scenarios presented at the Wind Energy Association Conference in September 2023. The two most likely areas are South Taranaki and West coast Waikato. The findings show that the cheapest options (in terms of grid upgrade costs) would be from large scale wind from Waikato, and that large scale wind into Taranaki would need to be used within the region or incur significant transmission upgrade costs. It was noted that splitting generation inputs to both Taranaki and Waikato would greatly reduce overloading in the central North Island. The table below outlines costs for six offshore wind scenarios:

	Offshore development option	**Implications for North Island Grid**
1	1 GW in the Taranaki (Brunswick substation)	Approximately $130-$180 million reconductoring sections from Strafford to Brunswick and from Brunswick to Wairakei and a tactical thermal upgrade.
2	2 GW into Taranaki (1GW into Stratford and 1GW into Brunswick)	Additional $1 billion investment – Reconductoring and construction of new line between Stratford and Huntly – would also require a tactical thermal upgrade.
3	1 GW into Waikato (Huntly substation)	Cheapest at about $30 million to $50 million with tactical thermal upgrade.
4	2GW into Waikato / Auckland (1GW into Huntly and 1GW into Glenbrook)	Requires "limited tactical upgrades" costing approximately $80 million to $120 million. And would require special protection schemes to control circuit loading (voltage and frequency).
5	Large offshore wind into Taranaki (e.g.900MW) with local offsetting industrial load (e.g. 700MW)	200MW able to be exported without any transmission upgrades.
6	>1GW into Taranaki and >1GW into Waikato / Auckland (either Stratford or Brunswick for Taranaki and Huntly or Glenbrook for Waikato/Auckland)	Greatly reduces the potential for overloads.

An example of overhead transmission lines - Transpower 220KV line Lincoln, Te Wai Pounamu, South Island

An understanding of the market pressure that already exists to electrify the economy can be found from Transpower's updated and published new connection enquiries information.[77]

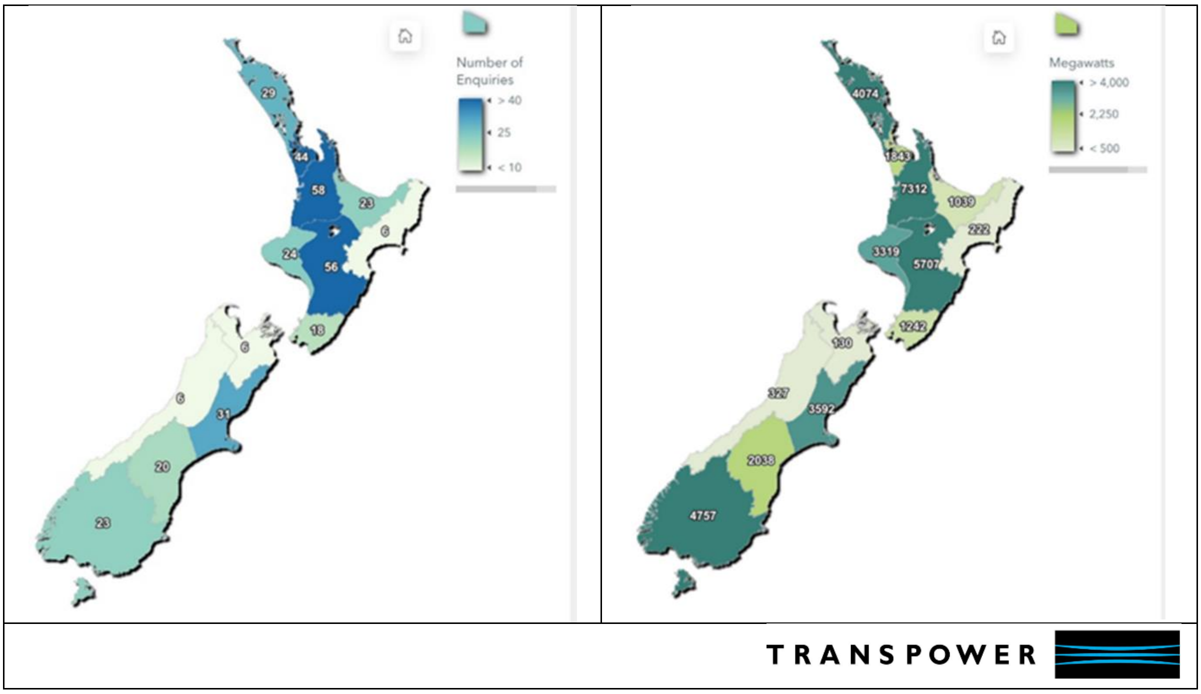
Nationally as at 20 December 2023, there were 372 enquiries for new grid connections of 41,709 MW generation, battery storage or load. This is in contrast to the single digit number of connection enquiries nationally in the years prior to 2019[78]. Transpower's dashboard is presented sub-nationally through 14 planning regions, which unfortunately do not align with the 16 local government regions. However, it does give an appreciation of the level of interest in connecting to the national grid with a focus on the Waikato region. Three of Transpower's planning regions either wholly or in part cover the Waikato administrative region: Waikato, Auckland (in part), and Central North Island (in part).

These three planning regions have the largest number of enquiries for connection of new generation and new load. Data from the website does not differentiate types of load, however transportation (EV charging) and data centres are specifically separated out, as is battery storage which can be both a load (when the batteries are being energised) and a generation source when they are being discharged. The following figure shows the number of enquiries across the three relevant

Transpower planning regions as at 3 February 2024:

Number of enquiries / planning region	Potential new MW / planning region

[77] Transpower New Connection Enquiries [Transpower New Connection Enquiries (arcgis.com)]
[78] Opportunities and challenges to the future security and resilience of the New Zealand power system, March 2022. Appendix-A-Phase-1-final-report.pdf (ea.govt.nz) Page 38



Transpower have reprocessed their enquiries database for April 2024 and aligned with the Local government administrative boundary of the region. Enquiries can be further analysed into entry (supply) or exit (demand), as outlined in the following table:

Waikato Administrative region	Size (MW)	Numbers
New Enquiries	8,988	73
Wind	4,501	12
Hydro	122	1
Geothermal	240	2
Solar	3,239	29
Battery Storage	350	3
Other (inc thermal)		7
Substations	130	2
Transport	40	1
Data centres	0	0
Other load	366	4

From the above table the, Waikato's contribution is significant totalling 25 per cent of the anticipated future activity. The enquiries focus on new supply in the Waikato and Central North Island, particularly with solar and wind, and for new load in Auckland with specific reference to data centres and transport infrastructure.

6.4 Managing electricity demand

There are two clear demand management options for shifting the peak demand. They both rely on not using electricity during certain 'peak demand' times – typically, between 7:00 and 11:00 and between 17:00 and 21:00. The two options use different mechanisms for the same outcome:

- The first mechanism is electricity pricing: making it cheaper, thus incentivising users to plug in appliances that are not time dependent e.g. EV charging, or clothes washing and drying outside peak hours. This requires active management by the user.
- The second mechanism is externally reducing the load: this is known as ripple control and requires electric hot water heaters to be able to be switched on and off externally, by the distribution network company. This option is passive for the householder and uses the high

specific heat of water to retain temperature (energy) in an insulated container which is reconnected and reheated once the peak is over.

6.5 Pricing of Energy Infrastructure

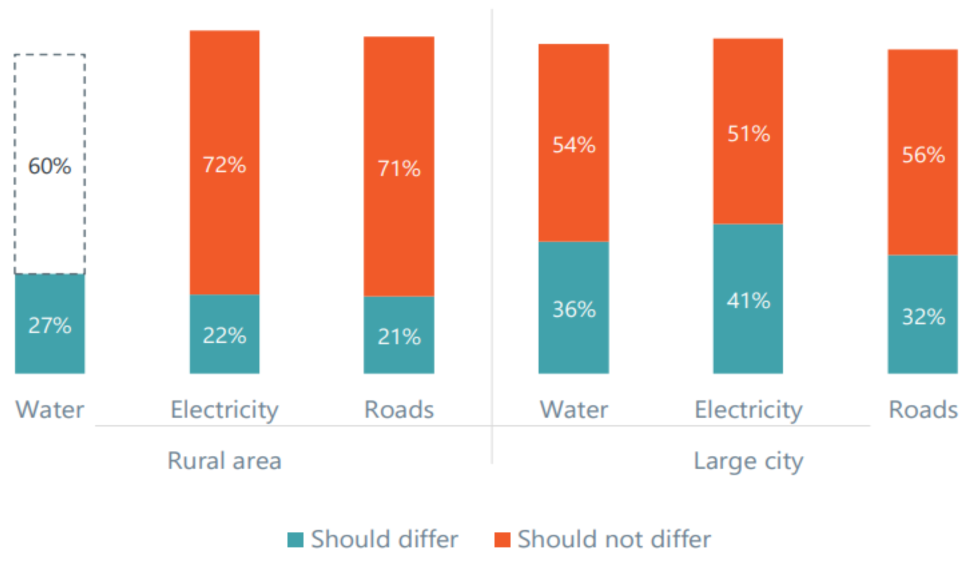
Lines charges pay for the construction, maintenance and decommissioning of electricity transmission infrastructure.).

Te Waihanga has completed a national survey[79] with some regional responses as to how respondents considered charging for electricity infrastructure should be made. This includes time of use charging. The following figure shows that across the country, there is little to distinguish local views on whether the cost of electricity should or should not differ depending upon the time of use:

Percentage of respondents who agree it is fair that what households pay for electricity should differ, or should not differ, based on time of use

Few respondents thought it was fair to charge households based on the cost to supply infrastructure. Fifty-five per cent of survey respondents did not think it would be fair to charge for electricity infrastructure based on the cost of supplying services to households. Rural dwellers exhibited statistically higher disagreement with the fairness of cost-based charging. The opposite trend was seen for respondents living in large cities as seen in the following figure:

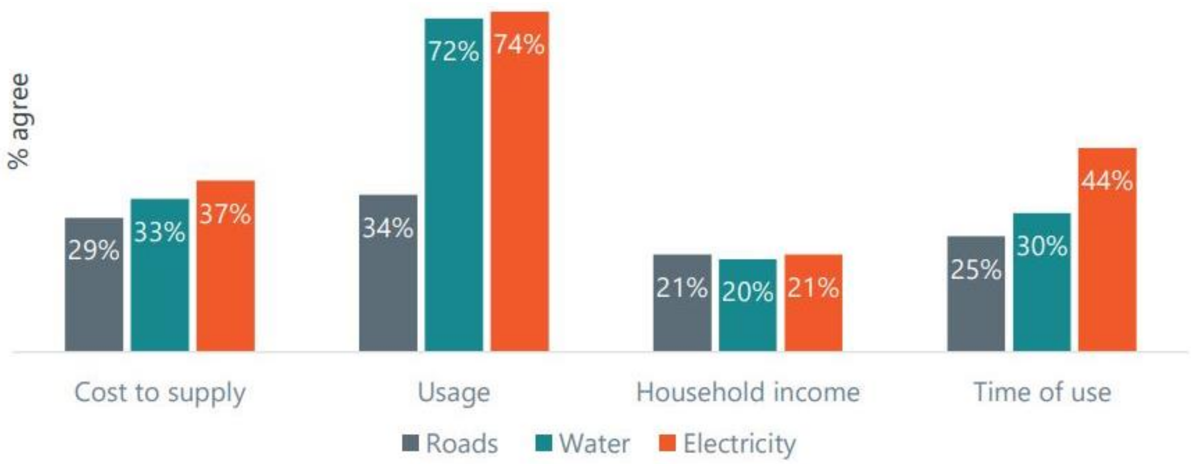
Percentage of respondents who agree it is fair that what households pay for water, electricity and roads should differ, or not differ, based upon cost of supply partitioned by size and location, where rural and large city response are compared to the average.



Overwhelmingly, for all infrastructure classes, (water, roads and electricity generation and transmission), most New Zealanders considered usage was the fairest way of charging for infrastructure, as shown in the following figure:

[79] what-new-zealanders-think-is-a-fair-way-to-pay-for-infrastructure-survey-insights.pdf (umbraco.io)

Percentage of respondents who agree it is fair that what households pay for roads, water, and electricity should differ based on cost to supply, usage, household income, and time of use



7 Renewable fuels and energy storage opportunities

7.1 Introduction

The importance of renewable energy stretches beyond its environmental impacts that drive climate change by contributing to energy security and resilience, as it reduces dependency on foreign fossil transport fuel imports and can provide energy access in remote areas. Last year (October 2022 to September 2023), New Zealand spent $11.3 billion on the importation of petroleum fuels.[80] This is nearly one billion dollars per month of produce that the country needs to sell overseas just for people to get around, get to work and get freight to factories and produce to ports.

We have the resources and the technology to replace imported transport fuels with indigenously derived alternatives, and to promote mode shifts. This will allow the export earnings previously spent on imported fuels to go to other uses such as increasing social and physical infrastructure in other dimensions and increasing the wellbeing of citizens.

We can reduce the greenhouse gas emissions from transport by electrification and by using public transport and synthesising some transport fuels from excess electricity generation when it is sunny and windy during times of low demand, referred to as Power to X.

Changing the demand for fossil fuels need not be limited to a direct substitution of fuel type, but would be enhanced with other actions that reduce demand for energy overall. This could include mode shifts with urban density increases near public transport opportunities, in line with the New Zealand national direction on urban development.[81] A climate resilient urban environment would be safer and a low-emissions design would be more affordable for people.

7.2 Green molecules

Green molecules (hydrogen and ammonia), also known as solar fuels, must be manufactured and are energy carriers that have the potential to decarbonise sectors that are challenging to electrify such as portable transport fuels. Green molecules provide viable energy storage options when renewable electricity production exceeds demand. Green molecules embody the principles of a circular economy, repurposing renewable electricity and atmospheric nitrogen into fuels and valuable chemicals, and back into their original components at the end of their life cycle.[82]

There are three green molecules that are being considered for energy storage from renewable generation of electricity, hydrogen, ammonia and bio-methane. They allow its later use and are an alternative to battery storage when electricity generation exceeds demand. They are analogues to the storage of energy in fossil fuels using similar but different technologies to deliver energy services. All green molecules derive from hydrogen, which is manufactured by electrolysis, that is by passing an electric current through water to separate in into hydrogen and oxygen gases. It takes 24 litres of water to produce one kilogram of hydrogen molecules (H_2). The stoichiometric value[83] is nine litres with a further 15 litres per kilogram needed to ensure minerals are removed that would contaminant the process.[84]

With appropriate technology, hydrogen can be used for energy storage, chemical feedstock for further products, electricity generation, heat, transportation (either in a fuel cell or through direct combustion as part of the fuel mix for existing compression ignition diesel engines in a dual fuel mode), and as an export product for international use.

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80 New Zealand: monthly import value of petroleum and products 2023 | Statista

81 National policy statement on urban development | Ministry for the Environment

82 Reneenergy.com Green Hydrogen vs Green Ammonia – Understanding Renewable Energy Sources Green Hydrogen vs Green Ammonia - Understanding Renewable Energy Sources - YouTube

83 A stoichiometric value of a reagent is the optimum amount where, assuming that the reaction proceeds to completion, all of the reagent is consumed. There is no deficiency nor excess of the reagent.

84 Sizing up hydrogen's hydrological footprint Sizing up hydrogen's hydrological footprint (nature.com)

Once used in a chemical reaction from which energy is extracted (e.g. a fuel cell), molecules return to their original components and do not add to the global greenhouse gas emissions.

Drawbacks with this energy are that water may not always be available and that alternative water sources may be needed such as wastewater or salt water, although these are less efficient and more energy intensive. This would result in less product for a given amount of sunlight or wind.

Hydrogen is the lightest and most abundant element. It forms a molecule consisting of two atoms but does not occur naturally on its own; it is always combined with other atoms as it requires very low temperatures (chilling to -253 degrees Celsius) and high pressure to exist as a singular molecule. Because of its small size, it is difficult to store and transport as it has the propensity to leak through container walls and to bind to other materials, altering their physical properties.

Combining renewable hydrogen with nitrogen from the air[85] creates green ammonia (NH_3) which has almost twice the energy density than hydrogen on its own. It occurs naturally in nature as part of the nitrogen cycle and therefore is stable at ambient conditions of temperature and pressure, and can therefore be transported more easily. Ammonia is already a significant industrial chemical for fertiliser manufacture and as a refrigerant, however, it is toxic, corrosive, and dangerous. These characteristics rule out its use as direct replacement for aviation fuel.

The infrastructure for ammonia transport and storage already exists, as does commercial and industrial expertise in its use. Along with existing uses, fuel and energy storage would need to be developed.

As green hydrogen is a precursor to green ammonia and is produced from renewable energy sources, green ammonia has a much lower carbon footprint than conventional ammonia production which relies on large amounts of coal. A significant advantage is the capability to store and transport it as an energy carrier. Use of an energy carrier for hydrogen not only requires an extra manufacturing (energy intensive) step, but if the end use is for green hydrogen (for example a fuel cell), an additional process step will also be required.

Converting hydrogen into ammonia and then back to hydrogen for use is very energy-intensive, using a third of the energy content. This is roughly the same as chilling hydrogen and because there is already existing ammonia transport and handling infrastructure, it may for safety reasons be appropriate in certain circumstances.[86] This only makes sense if there is an abundant supply of renewable green energy, potentially produced during low times of demand either by utility scale solar or large-scale wind.

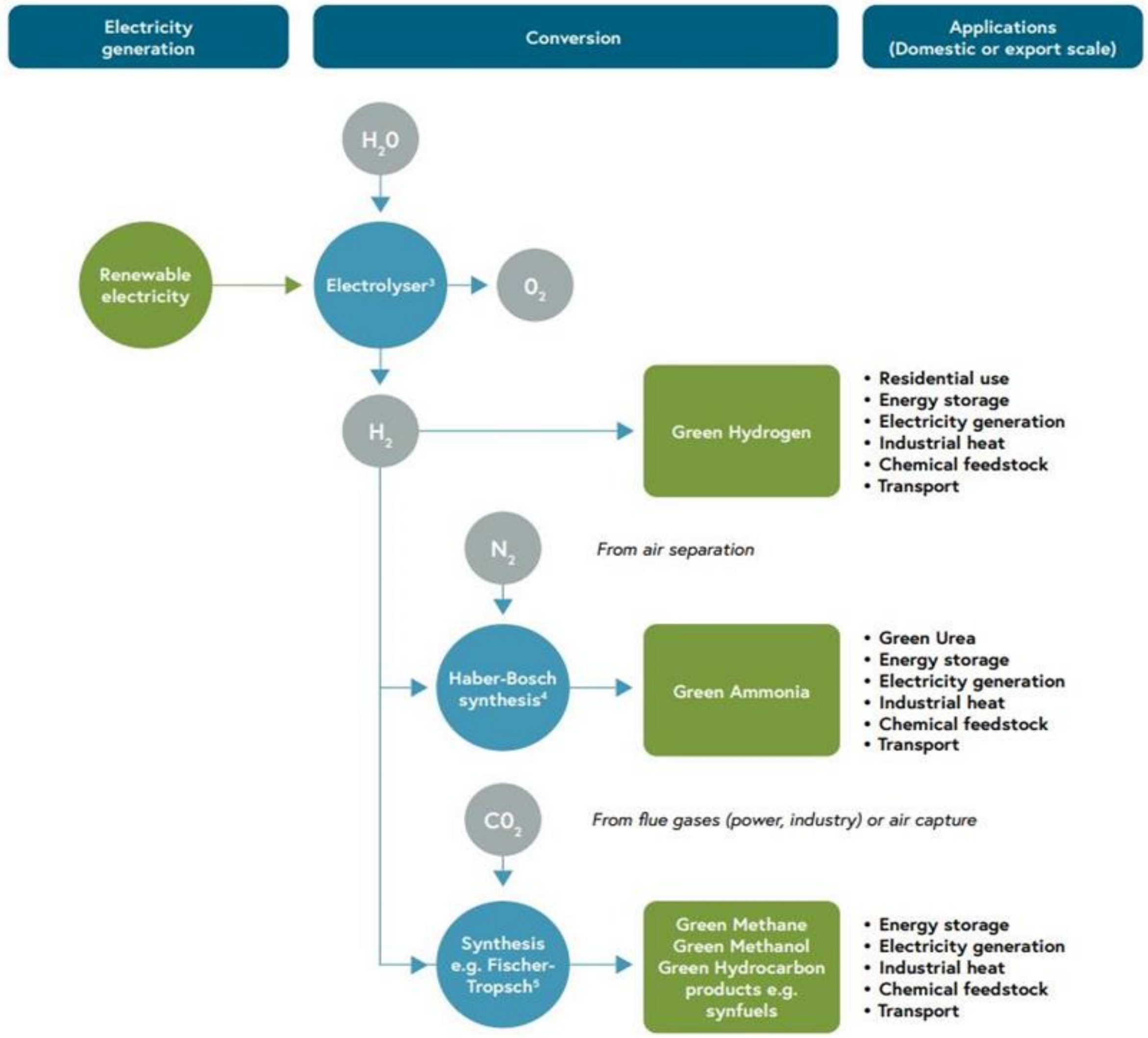
Both green hydrogen and green ammonia as forms of fuel storage are complementary with ammonia being a low-cost, long-distance transport and storage option that resolves these same problems with hydrogen. Ammonia can be combusted and used as a transport fuel but it has low flammability and this could reduce its potential.

Green methanol is a third green fuel/storage opportunity which combines green hydrogen with carbon dioxide, releasing oxygen gas. To maximise the benefits to a low emissions economy, the source of the carbon dioxide would need to come from the exhaust gasses following combustion of biomass from stationary industry or electricity generation. Alternative sourcing from fossil fuels would not assist the transition. Green methanol can be used as a drop-in transport fossil fuel analogue either domestically or for export, for process heat, electricity generation, or as a chemical feedstock for new 'green' industries.

[85] Air is 79 per cent Nitrogen.
[86] Robert E Service, Science Magazine, Ammonia – a renewable fuel made from sun, air, and water – could power the globe without carbon 2018

Green hydrocarbons are being actively researched as drop-in fuels to decarbonise hard-to-abate industries such as aviation. In addition to benefits such as fuel security and employment, they can be used both initially as a key input to producing e-Saf[87] that can be blended up to 50 per cent with fossil jet fuel, and in the longer term as a direct fuel.[88]

The above opportunities can be referred to as Power to X - a process by which renewable electricity is used in energy conversion pathways. This uses surplus electric power results in 'green' versions of products such as ammonia, urea, fertiliser, methanol, and liquid fuels.[89] Power to X activities come into their own thermodynamically if there is abundant cheap renewable energy available. The following diagram summarises the Power to X opportunities:



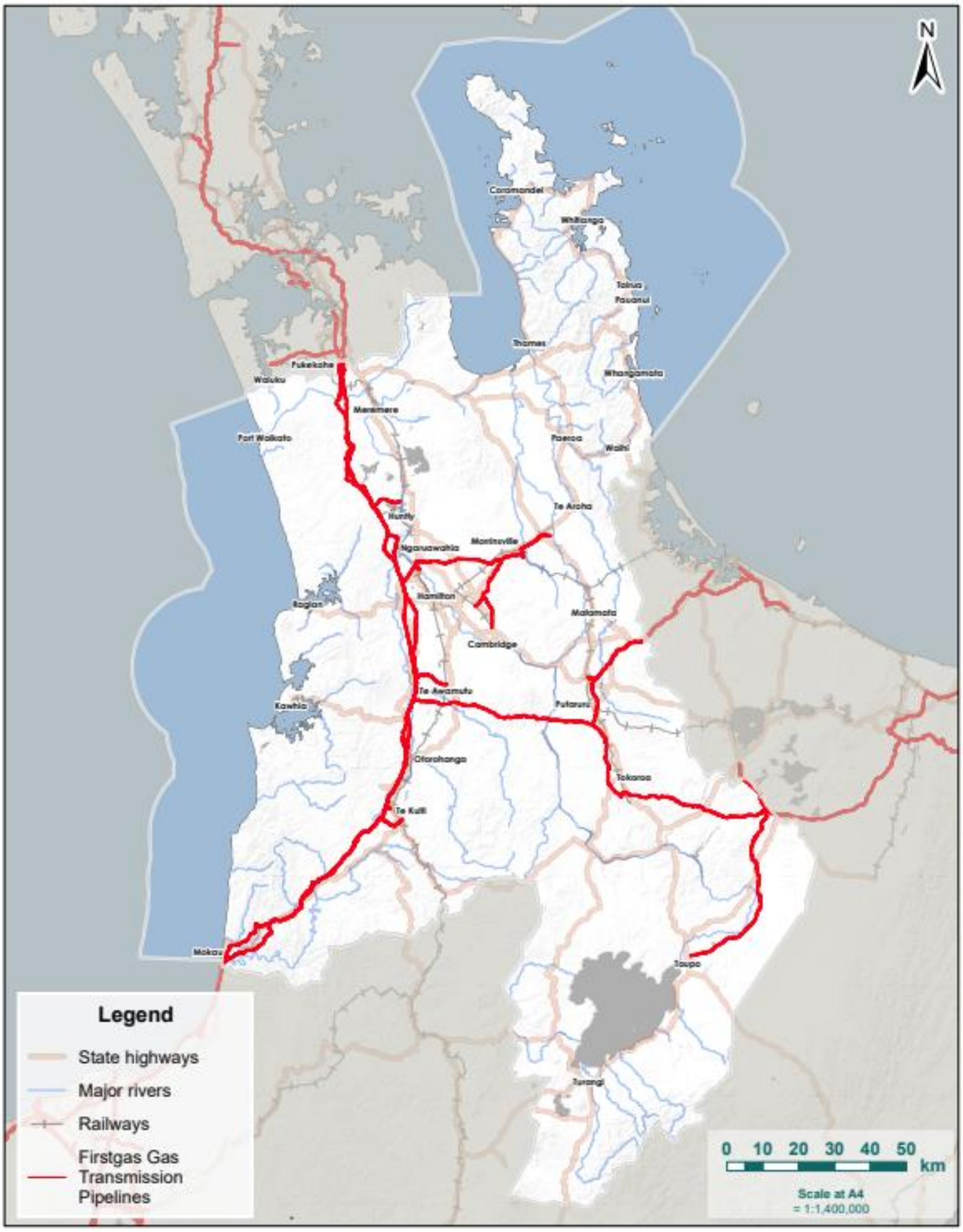
[87] e-Saf or Synthetic Saf which uses renewable hydrogen and CO2 as opposed to Biogenic SAF (bioSAF) which uses organic feedstocks (fats, oils, woody residues, and municipal solid waste, making up 0.1% of all commercial flights).

[88] NZ Herald, Hydrogen for planes: is this New Zealand's big chance? Grant Bradley 05 January 2024.

[89] Venture Taranaki, Power to X, Transforming renewable electricity into green products and services – Concept paper December 2021.

8. ‘Other’ Energy Infrastructure

Gas transmission infrastructure connects Taranaki region with the rest of the country has allowed primary processing and reticulated residential and commercial connections to other North Island centres. This is shown in the following map:



The gas pipeline infrastructure is a valuable resource that may offer the opportunity in the future to transmit an increased percentage of biogas products should these be produced. This is already proposed for the Ecogas organics processing facility at Reporoa with plans to refine biogas to bio-methane and inject directly into the national gas pipelines by the middle of 2024.

Depleted oil and gas reservoirs have proven ability to store gas as they have done so for millions of years. A gas transmission infrastructure that directly connects offshore reservoirs to potential, technology-dependent, onshore carbon capture facilities may have some future strategic value.

Experimental work is already in progress[90] to understand and trial capture of carbon dioxide from geothermal systems used for electricity generation and sequester this in the geothermal reservoirs.

[90] University of Canterbury Research programme for Carbon dioxide removal that includes geothermal and bioenergy sources 2024

9. Regulatory context

9.1 Introduction

Non-renewable energy sources have met most of New Zealand's recent development and energy demands. In particular, these sources have been fossil fuels for transports, industrial heating, fertiliser manufacture and, to a lesser extent, electricity generation (grid support). This is despite the abundance and availability of renewable sources of energy around the country.

Renewable energy resources face barriers which include high upfront costs, uncertainty securing use of natural resources without clear a policy framework, and the practicalities of delivering the energy to where it is needed. In 2005, the government made changes to the Resource Management Act 1991 to require all persons exercising functions and powers under the Act to have particular regard to the benefits to be derived from the use and development of renewable energy.[91] This was followed up with national direction in the form of the:

- National Environmental Standards for Electricity Transmission Activities Regulations 2009[92]
- National Policy Statement for Renewable Electricity Generation.[93]

Additional central government direction is the New Zealand Energy Strategy 2011 - 2021[94].

The Climate Change Response Act 2002[95] was enacted to ratify the Kyoto Protocol enabling New Zealand to meet its international obligations under the United Nations Framework Convention on Climate Change. The Act was amended in 2019 by the Climate Change Response (Zero Carbon) Amendment Act which was supported by all parties except the ACT Party. Among other things, the amendment established:

- A new domestic greenhouse gas emissions reduction target
- A system of emissions reduction budgets toward the long-term reduction target
- The Climate Change Commission
- The requirement for a National Adaptation Plan and an Emissions Reduction Plan.

9.2 Emissions Reduction Plan

For each emissions budget period, the Minister for Climate Change must prepare a publicly available emissions reduction plan that sets out the policies and strategies for meeting the relevant emissions budget. This is the mechanism for aligning central government policy and identifying partnering agencies that will be needed to work together in pursuit of the agreed climate goals.

The first Emissions Reduction Plan Te Hau Mārohi ki Anamata[96] was released by the government in May 2022. The plan brings together central government actions as well as the wider public sector to assist economic sectors in meeting the nation's emissions reduction budgets, as required by the Climate Change Response Act 2002.[97] It sets out how Aotearoa New Zealand will meet its first emissions budget and transition to a low emissions future.

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[91] Resource management Act 1991, Section 7(j), Resource Management Act 1991 No 69 (as at 24 August 2023), Public Act 7 Other matters – New Zealand Legislation

[92] Resource Management (National Environmental Standards for Electricity Transmission Activities) Regulations 2009 (SR 2009/397) (as at 20 May 2014) Contents – New Zealand Legislation

[93] National Policy Statement for Renewable Electricity Generation 2011 | Ministry for the Environment

[94] nz-energy-strategy-lr.pdf (mbie.govt.nz)

[95] Climate Change Response Act 2002 No 40 (as at 01 January 2024), Public Act Contents – New Zealand Legislation

[96] Emissions Reduction Plan: Aotearoa New Zealand's first emissions reduction plan | Ministry for the Environment

[97] Section 5ZG of the Climate Change Response Act 2002

The plan is divided into economic sectors and identifies partner agencies to implement the 289 individual actions, many of which are already in progress. In that respect, the plan unifies much of the emissions reduction activities of central government agencies (ministries, departments, and government entities).

The Resource Management Act 1991 states that local government must *have regard to* the Emissions Reduction Plan (and coincidentally the National Adaptation Plan), when making and amending regional policy statements, regional plans and district plans.

The Emissions Reduction Plan and the National Adaptation Plan are a pairing of the country's climate change response actions. The government is required to update the National Climate Change Risk Assessment and identify what needs to be addressed most urgently, and new adaptation plans and emission reductions plans will be developed to respond to those risks.

The Emissions Reduction Plan contains strategies, policies and actions focused on efforts to limit warming to 1.5 degrees Celsius above pre-industrial levels. It is also focused on meeting our emission reduction targets of net-zero long-lived gases by 2050 and a 24-47 per cent reduction in biogenic methane by 2050.[98]

Of the plan's 289 specific actions, 103 relate to the Energy and Industry sector chapter and a further 102 to Transport. Further analysis shows that central government considered local government authorities to be partner agencies in the delivery of 11 Energy and Industry sector targeted actions and 61 in the transport sector. Independent analysis by Waikato Regional Council officials considered the actions afresh and established that for the Waikato Regional Council (not local government sector), there were clear partnership relationships needed for implementation and elective opportunities for engagement as outlined in the following table:

Emissions Reduction Plan: Actions	**Energy and Industry**		**Transport**	
Central government as lead (from ERP)	103		102	
Local government as partners (from ERP)	11		61	
Potential regional engagement /advocacy (WRC analysis)	Yes 18	Potential 28	Yes 25	Potential 27

Additionally, the seven actions in the Planning and Infrastructure chapter all require local government participation in one form or another. This reflects that central government has delegated this aspect of natural resource allocation and land use management to the local government sector and requires the sector to have regard to the Emissions Reduction Plan when making decisions on policy statements and plans.

9.3 New Zealand Energy Strategy

Action 11.5.2 of the Emissions Reduction Plan requires the Ministry of Business, Innovation and Employment to prepare a National Energy Strategy.

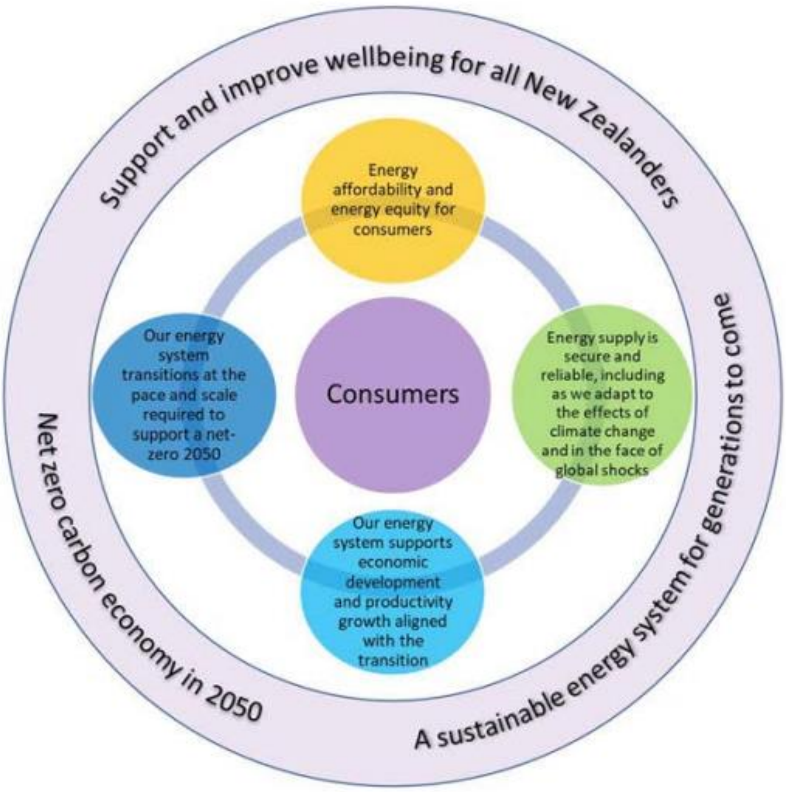
Engagement in the development of the National Energy Strategy is a key driver for the preparation of the Waikato Regional Energy Inventory. The Emissions Reduction Plan identifies the vision and high-level purpose of the national strategy. The vision is for a net-zero carbon economy in 2050, where energy is accessible and affordable, secure and reliable, and supports New Zealanders' wellbeing. The high-level purpose is to address strategic challenges in the energy sector, and signal pathways away from fossil fuels. It will cover all forms of energy and from both demand and supply sides. This includes electricity, gas, and liquid and solid fuels, and will look out to 2050.

[98] Section 5ZS of the Climate Change Response Act 2002

The strategy will have the following four high-level objectives:[99]

- Energy affordability and energy equity for consumers
- Our energy system transitions at the pace and scale required to support a net-zero 2050
- Energy supply is secure and reliable, including as we adapt to the effects of climate change and in the face of global shocks
- Our energy system supports economic development and productivity growth aligned with the transition.

The vision and objectives are illustrated below:



MBIE

It is intended for the objectives to be achieved while recognising the competing needs and opportunity to improve the elements of the energy trilemma (equity, security, and environmental sustainability) through a transition from fossil fuels to renewable sources.

It is understood that the new government intends to progress the preparation of a National Energy Strategy as identified in the First Emissions Reduction Plan.

9.4 Regional Interpretation

There is no requirement for the regional council to prepare a regional emissions reduction plan.

9.4.1 Strategic Directions

There are five regional strategic directions agreed by the Waikato Regional Council for the current term 2023 to 2025.[100] One is Whakaheke tukunga, the transition to a low emissions economy, where the council wishes to work with others to transition to a competitive low emissions economy that is fair for everyone and enhances community wellbeing for the future. Success in this direction will be measured in part by the delivery of an updated regional energy strategy and an increase in

[99] Terms of reference: New Zealand Energy Strategy (mbie.govt.nz)
[100] Takatū Waikato Making a Stand for the Waikato Waikato Regional Council - Strategic direction

access to and use of renewable energy by 2025. This inventory report is a precursor to that measure.

9.4.2 Climate Action Roadmap

The Climate Action Roadmap[101] is the Waikato Regional Council's integrated response to the changing climate. The council recognised early on that the impacts of a changing climate would affect regional communities but that it would also drive all the regional council's activities, whether that be in a service delivery role or regulatory context. Moreover, it was also recognised that all activities in the future would be subject to the limitations of a carbon constrained economy. The council saw climate change as a threat to some existing activities and a leadership opportunity to refocus programmes and actions to meet the needs of the regional community in a changing climate.

The roadmap was originally prepared in 2020 and reviewed in late 2023 and therefore can be considered up to date in respect of technical evidence and political intent. It covers the range of the regional council's activities and separates these into nine integrated pathways for action. These sections background the particular challenges facing each pathway and identifies the council's commitment in line with strategic directions on specific responses in the form of commitments.

There is a specific, energy and industry pathway, te pūngao me te ahumahi, which also identifies renewable energy opportunities for the region. The specific energy related commitments are listed as Appendix 3 and will in part be achieved through:

- Engagement and advocacy in the review of the second national Emissions Reduction Plan
- Engagement and advocacy in the preparation the New Zealand Energy Strategy
- The review and implementation of the Waikato Energy Strategy
- The review and implementation of the regional and district plans to:
    - Enable energy efficient developments and associated supporting infrastructure
    - Enable access to energy rich natural resources as a substitute for fossil fuels
    - Ensure land use provisions that enable renewable electricity and electricity transmission infrastructure are compatible with areas of outstanding natural features and landscapes.

9.5 Resource Management Act responsibilities

The council has multiple roles under the Resource Management Act 1991 relating to allocating access to natural resources containing energy and the management of environmental effects from the generation of electricity and its transmission to points of use. Moreover, the use of energy is also influenced by the policies and actions of the regional council, particularly as it relates to urban form and transport services.

The regional council has primary responsibility for access to the potential energy contained in water (s30(1)(d)(iii)) and for geothermal heat and energy (s30(1)(fa)(iii)). The potential energy contained in water is stored in impoundments or dams. Air pressure (wind) and sunlight are not consentable resources under the RMA and are therefore cannot be directly allocated under the current system. However, they are managed as an effect of a land use and regulated based on the effects of the technology used to access the energy. This is a territorial council function under s30(1) and is typically exercised as methods in a district plan.

The regional council coordinates this on a regional scale, as electricity generation facilities and transmission infrastructure are defined as infrastructure by the RMA,[102] as are pipelines for the transmission of gas and geothermal fluid. The Act confers powers to the regional council for the

[101] Climate-Roadmap.pdf (waikatoregion.govt.nz)
[102] Section 2.

strategic integration of infrastructure with land use through objectives, policies, and methods.[103] The only RMA instrument to fulfil this function is the regional policy statement as its purpose is to achieve integrated management of the natural and physical resources of the whole region.[104] Implementation of the regional policy statement is achieved through regional and district plans, as both instruments must give effect to the regional policy statement which does not in itself contain rules.

The regional policy statement is the singular document within each region to integrate and align regulatory settings for electricity generation and transmission infrastructure between districts and inter-regionally.[105] In general, district plans control land use except in defined circumstances when a regional plan can control the use of land.[106]

For electricity generation and transmission in the coastal marine area and onto land, the regional policy statement provides the integration mechanism. There is no district plan in the coastal marine area, as district plans end at the high tide level. The mandatory regional coastal plan fulfils both the land use planning and the resource allocation roles in this area. This plan must also give effect to the relevant regional policy statement.[107]

At the time of writing there is no integrating mechanism equivalent to the regional policy statement that would easily integrate activities in the Exclusive Economic Zone with those in the Coastal Marine Area.

9.6 Te Ture Whaimana o Te Awa o Waikato

Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River is the primary direction setting document for the Waikato River and its catchment, including the Waipā River.

Te Ture Whaimana establishes the vision "for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come". This vision is to be achieved through a set of objectives and strategies.

Te Ture Whaimana has unique legislative status in that it is deemed in its entirety to be part of any Waikato Regional Policy Statement.[108] Te Ture Whaimana also prevails over any inconsistent Resource Management Act planning instrument, including any national policy statement. Given this status, Te Ture Whaimana is an important document for any energy related freshwater and land use activities affecting freshwater within the Waikato River catchment.

9.7 Iwi Management Plans

Iwi management plans (IMPs) are documents developed and approved by iwi to address resource management matters within their rohe. These plans often contain information relating to specific cultural values, historical accounts, descriptions of areas of interest and significant sites, and consultation and engagement protocols for planning processes. Many IMPs set out objectives and policies/outcomes in relation to identified resource management issues. Councils must take iwi management plans into account when preparing or changing policy statements and plans under the Resource Management Act 1991.[109]

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[103] Section 30(1)(gb) RMA.
[104] Section 59 RMA.
[105] Section 61(2)(b) RMA.
[106] Section 31 RMA.
[107] Section 67(3)(c) RMA.
[108] Waikato Raupatu Claims (Waikato River) Settlement Act 2010 section 11.
[109] Sections 61, 64 and 73.

The IMPs in the Waikato rohe[110] contain numerous outcomes of relevance to both the supply and demand sides of energy. As electricity generation and transmission have potential to generate adverse environmental effects, many sections of IMPs relating to the natural environment require consideration, depending on the type of project proposed. This may include, for example, sections relating to freshwater, air, geothermal resources, coastal and marine environments, biodiversity, wetlands, and minerals. Many IMPs address climate change as a key issue, in terms of both mitigation and adaptation.

Some IMPs in the rohe contain specific chapters relating to energy and/or infrastructure, which may set out the view of the iwi or hapū on different forms of electricity generation, or environmental, cultural, or spiritual effects of concern. They may also address social and economic aspects relating, for example, to security and affordability of electricity supply for their communities.

Given that energy supply and demand have wide-ranging implications for the natural and built environments, and the social, cultural, and economic wellbeing of current and future communities, IMPs are an important resource for planning for the future of energy in the Waikato region.

9.8 Waikato Regional Policy Statement

Each region is required to have a regional policy statement, to be prepared by the relevant regional council. The purpose of the regional policy statement is to achieve integrated management of natural and physical resources within each region. This is achieved through objectives and policies establishing intra and inter-regional links in the resource management (regional and district) plans in the region. In this way it is a policy statement for the region.

The Waikato Regional Policy Statement[111] became operative in 2016 and includes the 11 of the 27 recommendations from the Waikato Regional Energy Strategy that specifically require the power of the Regional Policy Statement for effect. This is to provide clear consenting pathways via district and regional plans.

The Waikato Regional Policy Statement recognises the role renewable energy will make to the sustainable future of the region and nation, and also the opportunity for the efficient use of energy (low-emissions economy) in the land use decisions of the eleven district councils in the region. In this way, the regional policy statement addresses both the supply and demand sides of the energy equation and the transition to renewables directive.

Of the six regionally significant issues identified in the Waikato Regional Policy Statement, providing for energy demand is specifically mentioned, as is the need to manage the built environment; the latter referring to the need to use existing infrastructure efficiently, the increased need for the future infrastructure to respond to the demands from within and outside the region, and the need to enable efficient installation of that infrastructure.

Supply side matters are covered in a specific energy, infrastructure and transport chapter, and demand side elements are covered by the urban form and development chapter and development principles in Appendix 11, along with agreed Future Proof[112] maps. Because both district plans and regional plans must give effect to regional policy statements and each regional policy statement must give effect to national direction, a policy hierarchy is in place that directs resource management consent decisions for:

- Accessing natural resources containing energy
- Land use decisions to provide for electricity transmission infrastructure

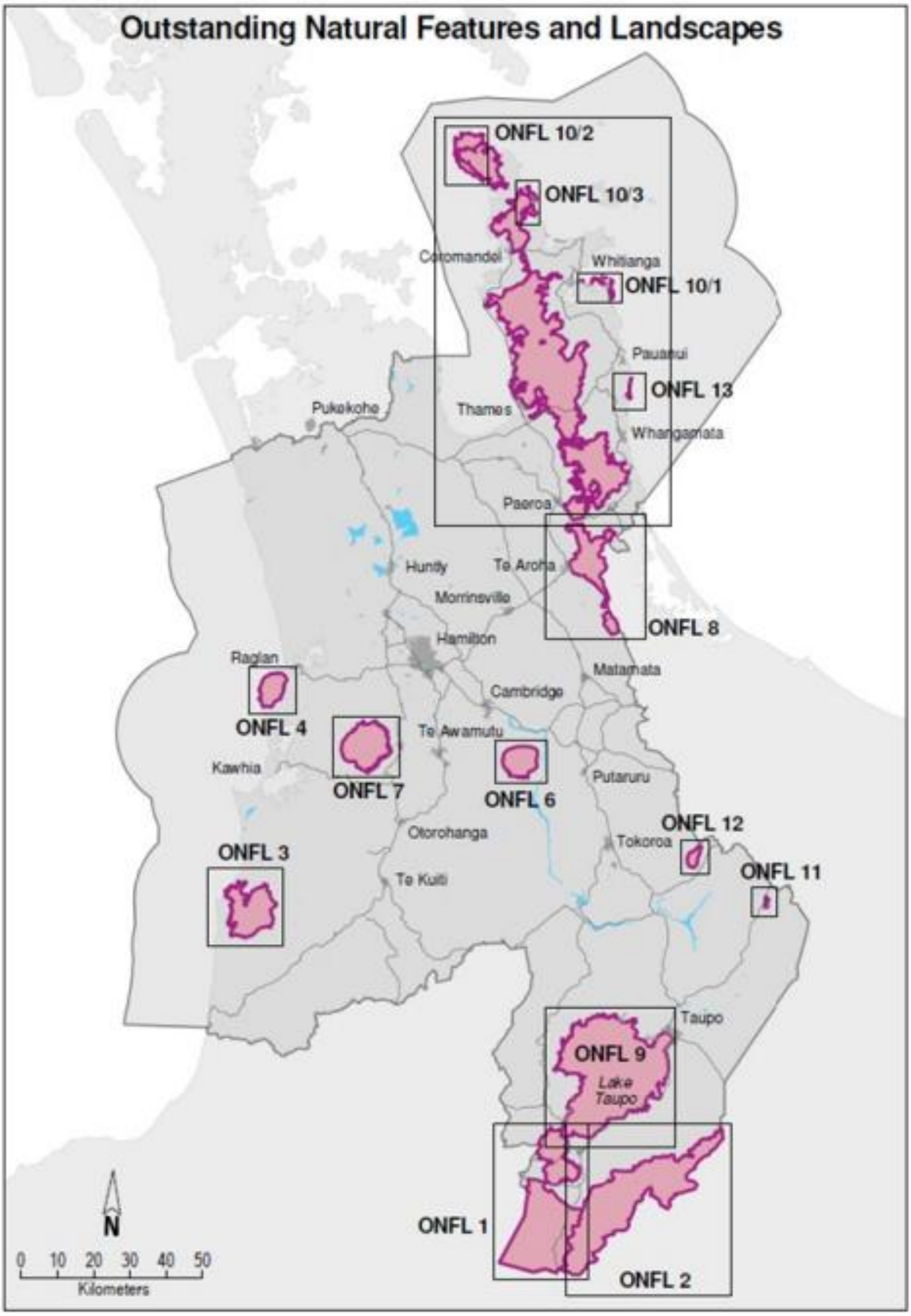
[110] Iwi management plans | Waikato Regional Council
[111] Waikato Regional Policy Statement | Waikato Regional Council
[112] Knowing our future by planning today – Future Proof

- Land use decisions to reduce demand.

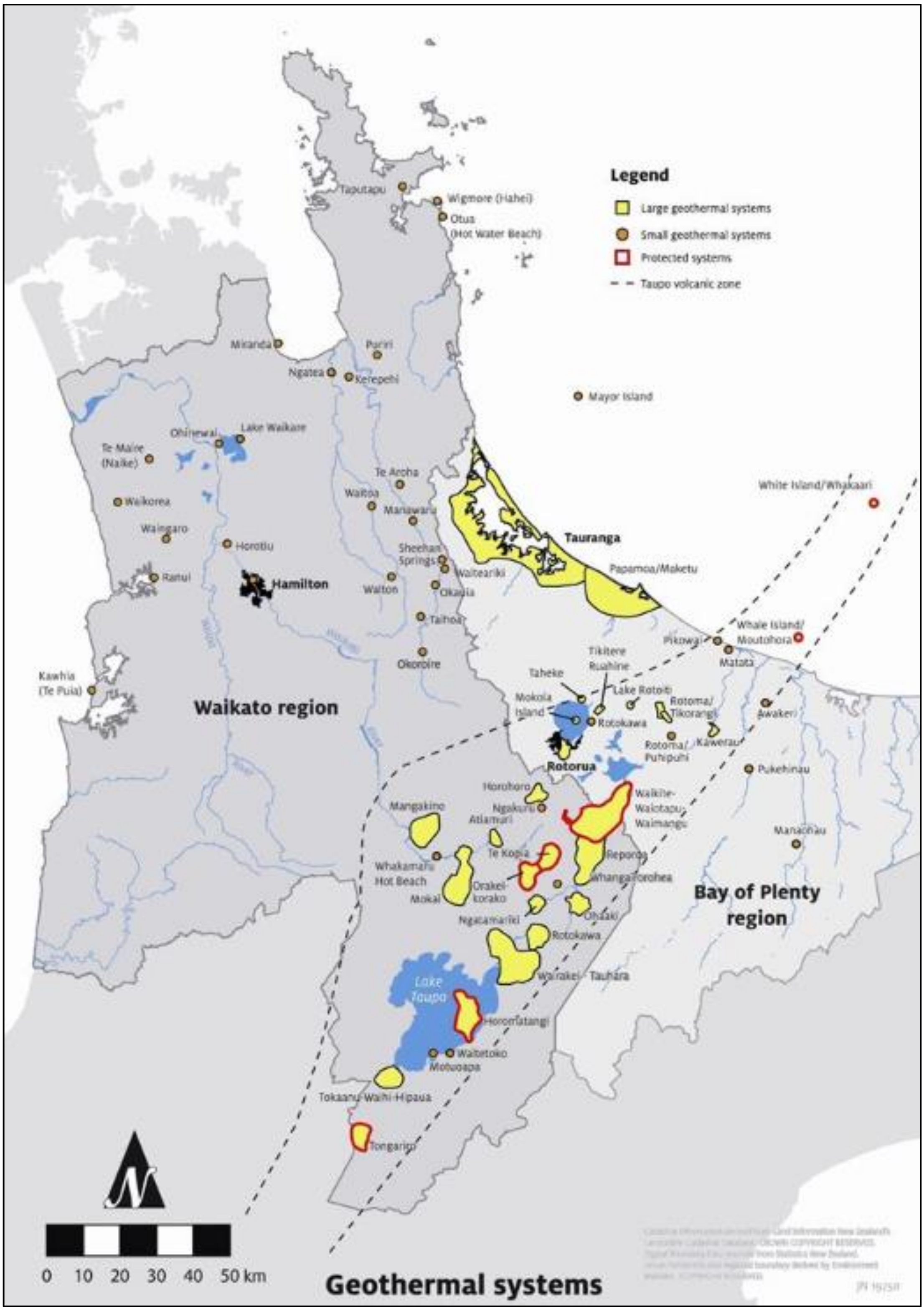
The infrastructure requirements for generation and transmission of new renewable electricity (both utility and distributed scale) and growing energy crops are primarily land use matters and the responsibility of the eleven territorial authorities which rely on the provisions of the regional policy statement for effect.

The Waikato Regional Policy Statement directs the regional plan to include policies and decision criteria for the continued operation of existing hydroelectric generation by recognising electricity generation as an existing value associated with waterbodies, and the use of the geothermal resource, including for electricity generation. Additionally, it directs both the regional and all district plans in the region to recognise the need to locate renewable electricity generation activities where the renewable energy resource is found, and the need for electricity transmission infrastructure to connect these generation sites to the national grid or to local distribution networks.

This is explicitly provided for in the natural features and landscapes chapter where regionally significant outstanding features and landscapes are spatially defined in maps with the policy expectation that new wind turbines and transmission infrastructure are located outside identified areas. This incorporated recommendation (7) from the Regional Energy Strategy, that revision of the operative regional policy statement should ensure that it includes criteria where wind energy generation should not occur, and that the regional policy statement makes provision for wind energy generation in remaining areas. This has been provided for in the identification of 16 regional scale Outstanding Natural Features and Landscapes as in the following map:



The Waikato Regional Policy Statement also spatially partitions the known geothermal resources into system types available for use and those that should be protected, as shown in the map below. It recognises that the special and valued biological, hydrological and edaphic surface features cannot be sustained once hydrological drivers within a defined geothermal system are disturbed through large scale extraction of fluids, steam and heat. Even with replacement of taken fluid by reinjection, the fluid driven features such as pools, sinter forming terraces and geysers are extinguished after large scale use.



There are 15 known large hot geothermal systems associated with the Taupō volcanic zone. No two systems are the same and therefore they are grouped into system types on the understanding of size, surface features and reservoir properties[113] and with the application of the precautionary principal. There are seven systems that have classified as development systems:

- Wairakei-Tauhara
- Ōhaaki
- Rotokawa
- Horohoro

[113] As at 2003.

- Mangakino
- Mokai
- Ngatamariki.

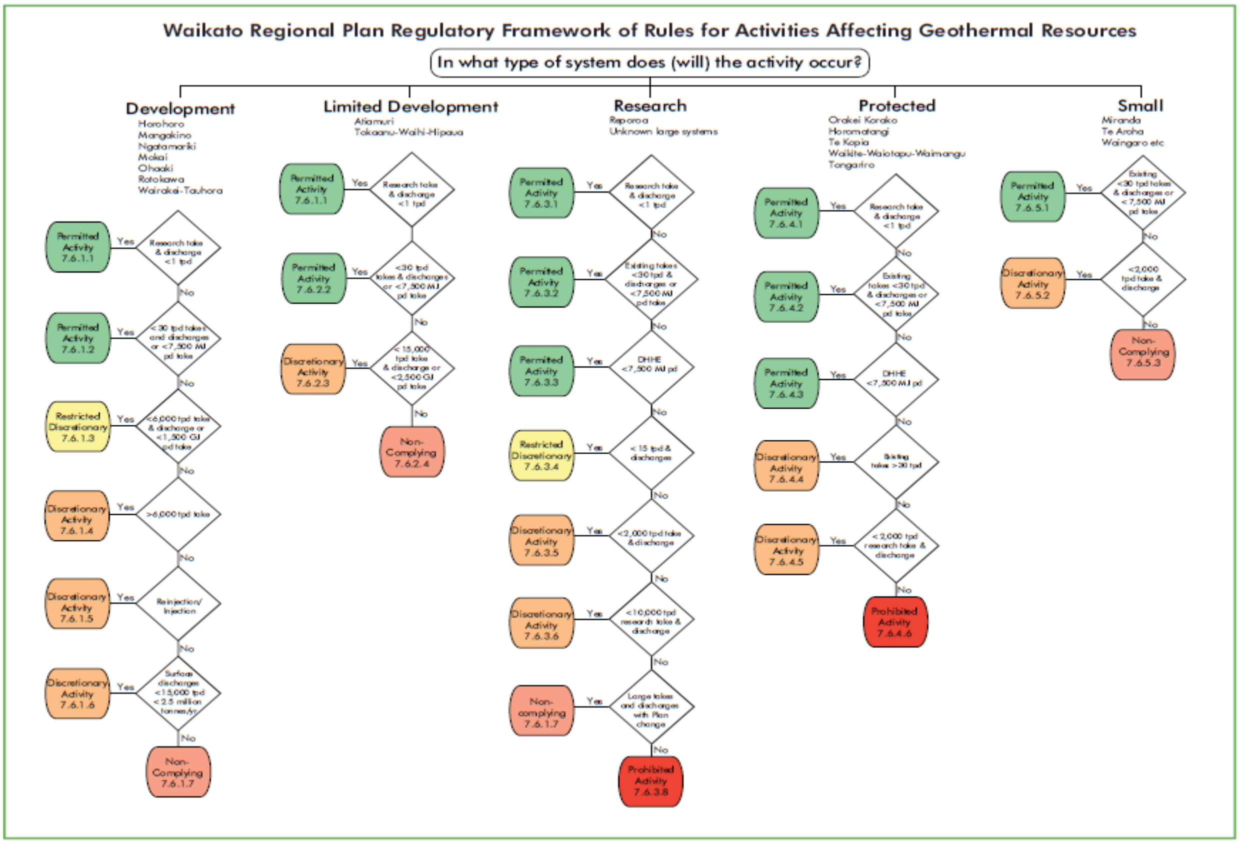
Five of these have geothermal power stations on them, while two (Horohoro and Mangakino) remain undeveloped.

Two geothermal systems have fluid features that have been assessed as being at risk of large-scale development and have restricted daily tonnages extraction. These are the Atiamuri and the Tokaanu-Waihi-Hipaua systems and have been classed for limited development. A further five systems are identified as protected systems with intact fluid supported surface features where even moderate takes of fluid is restricted and large scale is prohibited. Protected geothermal systems are:

- Horomatangi
- Tongariro
- Orakeikorako
- Te Kopia
- Waikite-Waiōtapu-Waimangu

Waikite-Waiōtapu-Waimangu extends inter-regionally to the Bay of Plenty region with the equivalent classification. Where large systems are discovered, or in the case of Reporoa are known but connections with previously protected systems unknown, a fourth 'holding' category of research system applies.

A specific consent application and decision-making pathway incorporating the precautionary approach applies to each type of geothermal system and is applied through the regional plan. This is graphically captured as a series of decision-trees in the following figure.



It is a regional council commitment to periodically review the boundaries and the status of geothermal systems, either on the provision of new information or on a regular basis. The system boundaries and connections are currently being investigated in three dimensions using modern magnetotelluric techniques and it is proposed that the system boundaries and classifications will either be confirmed or adjusted in the future. The over 35 small geothermal systems have their own consent pathway.

The Waikato Regional Policy Statement is silent on utility scale grid connected solar as at the time of review in 2010, the high cost of solar photovoltaic panels was considered to restrict this from becoming a mainstream option. The policy statement provides no direction to district plans on this matter.

9.9 Waikato Regional Plan and Regional Coastal Plan

The Operative Waikato Regional Plan[114] covers the key components of the environment for which the council has functions under section 30 of the Resource Management Act 1991, being water, river and lake beds, land and soil, air, and geothermal resources.

The plan contains objectives, policies, and implementation methods (including rules) of particular relevance to hydro and geothermal electricity generation, as well as methods of generation which produce air discharges. This includes rules for the take, damming and diversion of water, river and lake bed disturbances and structures, discharges to air and the take, use and discharge of geothermal water.

Chapter 3.6 of the plan is relevant to proposed hydroelectric dams within the region as it contains provisions relating to the damming and diverting of water, as well as any associated structures. This chapter identifies that the damming or diversion of water can lead to adverse effects including increased risk of flooding on neighbouring properties, increased risk of erosion of the bed and banks of lakes, rivers and streams, obstruction of fish passage and increased channelisation of river systems, leading to aquatic habitat loss. The objectives, policies and methods seek to address these adverse effects, in conjunction with other objectives and policies within the wider water module which relate to management of the region's water resources. Under Chapter 3.6, most new dams require resource consent as either a discretionary or non-complying activity.

Module 7 of the Waikato Regional Plan contains objectives, policies and rules addressing the taking, use, and associated discharge of geothermal water. The objectives and policies of this module seek to ensure that geothermal energy and water are used and managed efficiently, and significant adverse effects are avoided. The different resource consent pathways for geothermal management are addressed in the Waikato Regional Policy Statement section above.

The Operative Waikato Regional Coastal Plan (2011) contains little policy direction on renewable electricity generation, having been developed prior to relevant national direction. The Proposed Waikato Regional Coastal Plan (notified August 2023)[115] contains an energy and infrastructure chapter, which recognises the importance of renewable electricity generation and enables it in appropriate circumstances. Outside of outstanding and significant overlays, it is proposed that both renewable electricity generation and electricity transmission have consenting pathways commensurate with the effects of the activity.

9.10 District plans

One of the functions of territorial authorities under the Resource Management Act 1991 (RMA)[116] is to establish, implement, and review objectives, policies, and methods to achieve integrated management of the effects of the use, development, or protection of land and associated natural

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[114] Waikato Regional Plan | Waikato Regional Council

[115] Proposed Waikato Regional Coastal Plan | Waikato Regional Council

[116] Section 31(1)(a).

and physical resources of the district. This is primarily undertaken through preparing and implementing district plans.

District plans must, as a minimum, include the objectives and policies for the district, and rules to implement them. District plans are required to give effect to any national policy statement and any regional policy statement.[117]

The eleven territorial authorities within the Waikato region each have an operative district plan. At present, three territorial authorities (Waikato, Thames-Coromandel, and Waitomo District Councils) have proposed district plans at varying stages of development. Within these districts, both the operative and proposed district plans apply (to differing extents) to proposed activities. Many territorial authorities also have one or more plan changes in progress which propose to alter parts of their district plan.

Given their role in controlling land use and development, district plans have a significant impact on both the supply and demand sides of energy. On the supply side, district plans control the types of electricity generation activities that can occur within different areas of the district (based on zoning and policy overlays). As air pressure (wind) and sunlight are not consentable resources under the RMA, district plan rules for wind and solar farms (or the structures comprising them) are the key regulatory method for these forms of electricity generation under the RMA. District plans also provide rules relating to electricity and gas transmission and distribution lines and associated infrastructure, including rules for other activities in proximity to transmission lines, to protect continuing operation of the lines from reverse sensitivity effects.[118]

Appendix 4 provides a summary of key sections of each district plan in the region relevant to energy matters. All current district plans in the region contain objectives, policies and rules for electricity and gas transmission/distribution. Provisions relating to electricity generation activities are more varied throughout the region; in general, district plans prepared or changed more recently make specific provision for a greater variety of electricity generation methods than older district plans. The Waipā and Proposed Waitomo District Plans are examples of district plans that provide individual activity statuses for a wide range of different generation types. Most of the district plans within the region include enabling rules for small/community-scale renewable electricity generation, for example, via solar panels and small-scale wind turbines.

District plans affect energy use in many ways. This includes the pattern of zoning and policy overlays, as well as the associated objectives, policies and rules for subdivision and land use activities within each zone. These aspects interact to influence the spatial distribution of development within each district and of urban form.

Urban form/density, along with transportation provisions within district plans, affect the layout of the transport network and the viability of alternative transport modes, such as walking, cycling and public transport, ultimately impacting on energy demand and carbon emissions from transport. District plans may also contain provisions for energy-efficient building design, for example, rules relating to the orientation of buildings/living areas, or specific technologies, such as EV charging.

Most of the future opportunities for supply side renewable energy (wind, solar and biomass) and demand side efficiency, along with the interconnecting transmission infrastructure will require land use consents. The role of territorial authorities with district plans will therefore be critical to achieving the regional goal of transitioning to a low-emissions economy.

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[117] Section 75(3).

[118] Reverse sensitivity refers to the vulnerability of a lawfully established activity to a new activity or land use. It arises when a lawfully established activity causes potential, actual or perceived adverse environmental effects on the new activity, to a point where the new activity may seek to restrict the operation or require mitigation of the effects of the established activity.

This will require strong, high quality relationships with territorial authorities and a willingness to embrace a spatial approach to the future regional infrastructure needs both on energy supply and demand side use.

9.11 Future Proof Partnership

In addition to district plans, work related to aligning the regional regulatory roles associated with renewable electricity generation and transmission with energy efficiency, transport and urban form also needs to be integrated with work undertaken to further the wellbeing of regional communities under section 10 of the Local Government Act 2002.

Some territorial authorities within the region have growth strategies or plans prepared under the Local Government Act 2002, which sets out how each district/city will grow in the future, usually involving a spatial component of mapping planned growth areas.

Future Proof is a partnership between local and central government and iwi for the high growth sub-region of the Waikato, Waipā and Matamata-Piako districts and Hamilton city. The Future Proof partners prepare the Future Proof Strategy; a 30-year growth management and implementation plan for the sub-region.[119] The strategy is agreed by the partners and is given effect to by local government agencies by translation into regional and local planning instruments, including but not limited to:

- the Regional Policy Statement,
- the relevant district plans,
- the relevant land transport plans, and
- each partnering council's investment decisions delivered through relevant Long Term Plans.

While each of the districts and city have different growth due to their size, geographies and communities, the approach for the sub-region is underpinned by a compact and concentrated spatial pattern. This means that future development is focused on infill and intensification together with development of new growth areas in defined areas close to existing towns and cities.

The benefits of a compact and concentrated approach to growth and development include greater productivity and economic growth, better use of existing infrastructure, improved transport outcomes, enhanced environmental outcomes, greater social and cultural vitality, more opportunities for place-making and community connectedness, regeneration of existing urban areas, preservation of the natural environment and enablement of sustainable rural resource use. Through a more compact urban form, Future Proof also aims to work towards a sub-region of 30-minute communities, where people can meet most of their needs within a 30-minute walk, cycle, or public transport trip.

The focus within Future Proof on achieving a more compact urban form and shifting to active and public transport will contribute to efficiencies in energy demand as the sub-region continues to grow.

9.12 Summary of regulatory matters

At the national level, the Emissions Reduction Plan sets out the policies and strategies for meeting the relevant emissions budget. The first Emissions Reduction Plan Te Hau Mārohi ki Anamata requires the Ministry of Business, Innovation and Employment to prepare a National Energy Strategy. Engagement in the development of the national strategy is a key driver for the preparation of the Waikato Regional Energy Inventory.

[119] The Strategy – Future Proof.

At a regional level, the council prepares the Waikato Regional Policy Statement to achieve integrated management of natural and physical resources within the region. The Operative Waikato Regional Policy Statement recognises the important role of renewable energy, as well as the opportunity for efficient use of energy. The council also has the function of the strategic integration of infrastructure with land use through objectives, policies, and methods, which is fulfilled through the regional policy statement.

The council also has a regulatory role in relation to access to natural resources containing energy and the management of environmental effects from the generation of electricity and its transmission, through the regional plan and regional coastal plan. The regional plan is primarily relevant to hydro and geothermal electricity generation, while the Proposed Waikato Regional Coastal Plan contains provisions for electricity generation and transmission within the coastal marine area.

Most of the future opportunities for supply side renewable energy (wind, solar and biomass) and demand side efficiency, along with the interconnecting transmission infrastructure, will be regulated by district plans. The role of territorial authorities with district plans will therefore be critical to achieving the regional goal of transitioning to a low-emissions economy, as set out in the council’s strategic directions. This will require strong, collaborative relationships with territorial authorities and a willingness to embrace a spatial approach to the future regional infrastructure needs both on the energy supply side and the use demand side.

10. Market context

The electricity sector In New Zealand has been shaped by the Electricity Industry Reform Act 1998, which has resulted in the four major companies, Mercury, Genesis Energy, Contact Energy, and Meridian, which exert control over both generation and retail markets. The state-owned enterprise Transpower operates the national grid and is responsible for distributing electricity around the country and is a monopoly. Transpower is regulated by the Electrical Authority. The distribution subsector is comprised of 27 separate lines companies, with local networks that operate as monopolies over their respective areas. Each distributor is subject to price-quality regulation from the Commerce Commission.

The Waikato region is crucial in New Zealand's electricity production, given the large amount of renewable energy resources in the region, as well as the presence of the Huntly thermal power station. The region's strong transmission infrastructure and proximity to the Auckland market make it an attractive location for energy companies to invest in.

Appendix 5 provides an analysis of the New Zealand electricity sector, the findings of which are summarised below.

Generators sell electricity to retailers through a spot pricing mechanism, where prices are determined by real-time supply and demand conditions. Vertical integration allows the four major generators to sell electricity to their own retail arms first before offering the remaining supply to the wholesale market (the generators are known as 'gentailers' for this reason). This practice has sparked controversy, with smaller competitors accusing gentailers of setting higher prices for third parties than they charge their own retail arms.

The gentailers' pricing is driven by profit-maximisation objectives. While some of the gentailers are part-owned by the New Zealand government, they are driven by a legal obligation to be as profitable and efficient as non-Crown-owned businesses. Hence, while the government may have other objectives (such as maximising consumer surplus or decarbonisation of the economy) these are subsidiary to the gentailers' requirement to generate profits.

The electricity market in New Zealand has experienced steep price increases over the past two decades, with a 48 per cent rise in residential power prices since 2000. The dominance of the four major gentailers in an oligopoly limit competition and might be expected to lead to prices above marginal cost. Entry barriers in the electricity sector are high due to significant capital requirements, regulatory hurdles, and the present vertical integration of gentailers. The four large gentailers' use of vertical integration to self-hedge against spot price volatility hinders competition from smaller retailers and generators, and arguably impacts long-term infrastructure development.

The four main gentailers all have significant market shares, allowing them to exercise market power. Economic theory would suggest this creates the potential for anti-competitive behaviour and prices above marginal cost. Consumers lack an effective voice in the electricity sector, as electricity is considered a necessity with inelastic demand (i.e. demand does not change much when prices increase). Steady price increases over the last two decades, limited alternatives, and inelastic demand reduce consumer power. Changes in electricity prices have shown no significant effect on residential consumption, emphasising consumer vulnerability. Electricity, being a fundamental and essential service, has limited substitutes.

11. Demand side

11.1 Introduction

Demand management is an important policy lever for the integration of renewables into energy grids to reduce CO_2 emissions, reduce costs and maintain reliability of supply. Demand management refers to a range of policies and technologies designed to deliver greater efficiency and flexibility of use. Only some of the policy levers are available to the regional council, and indeed to the local government sector, requiring advocacy and behaviour-changing enabling measures.

Encouraging and enabling energy conservation and efficiency was the overriding highest priority outcome of the 2008 Waikato Energy Strategy. The strategy recognised the regional council's limited policy levers to achieve this, and that many of the opportunities fall to central government in market settings, import controls, and financial incentives. These are often referred to as 'demand management' and are analogous to the measures that have been successful for addressing water security.[120] In many situations the regional policy response will be engagement, advocacy and a range of suasion methods.

Various agencies[121] have previously referred to energy efficiency as the first fuel, or the hidden fuel – hiding in plain sight. In electricity circles it is referred to as:

"The cheapest kilowatt is the one you don't have to generate."

Many of the proposed solutions to meeting energy policy objectives come from the traditional approach of matching supply with demand. Proposed solutions to energy security issues in New Zealand include building new capacity and storage technologies.

Demand management reverses this thinking and focuses on how to reduce demand to meet supply constraints. Demand management aims to match demand with available supply as a cheaper alternative to investing in new generation capacity. A reduction in energy use can reduce CO_2 emissions and increase energy affordability, both key goals of the Electricity Industry Act 2010 as amended in 2022.

There is a role for policy support to increase the participation of the demand side as an economically efficient means of reducing total energy system expenditures and as an important complement to low carbon supply side solutions. International experience demonstrates that the success of demand management is determined by regulatory support and financial incentives for electricity generation companies.[122]

Demand management policy levers that can be used will need to be considered in both the review of the regional energy strategy and engagement with the national strategy, as many of the policy options are nationwide and would not be effective if implemented regionally. Examples are noted below:

- Smarter grid – AI enabled
- Smart metering (importance of in-home displays) allows the neg watts market to develop
- Energy labelling and product standards
- Time of use tariffs (e.g. creating incentives to use electricity at off peak times)
- Direct load control tariffs (utilities remotely turning off or turning down customers appliances during peak times) Allows passive participation of consumers in DM
- Reducing demand at peak times (active engagement of consumers in reducing their energy use)
- Shifting to off peak times

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[120] During the Australian, Millenniem drought, water efficiency measure saved more water at lower cost and greater speed than supply options: Managing Drought: Learning from Australia - Pacific Institute (pacinst.org)

[121]E.g., International Energy Agency, Word Economic Forum. The energy we don't use: How to realize the benefits of the greenest, most affordable energy | World Economic Forum (weforum.org), Energy Efficiency – Topics - IEA

[122] Warren Peter, 2014. A review of demand-side management policy in the UK, *Renewable and Sustainable Energy Reviews,* 29, 941-951.

- Import controls
- Minimum efficiency standards
- Distributed micro generation (reduces the cost of transmission) nega watts[123] market. New technology is making it possible for new parties including households to provide generation, storage and 'demand response services'?
- Flat fee payment for every unit of electricity saved. Requires the est of a baseline to determine how much electricity has been saved.
- Compulsory energy audits targeting the largest energy consumers (e.g. as recommended by the Task-force for Climate related Financial Disclosures)
- Supplier obligations and procurement policies.

There are two main opportunities to achieve a transition to a low emissions economy:

1. Change fuels from fossil sources to renewables, or
2. Use less energy services or using less fuel to achieve the same services (demand management).

The opportunity for demand management can be targeted to the greenhouse gas emissions (predominantly CO_2) from the transport and industrial sectors. Together these contribute 40 percent of the national (and regional) emissions profile.[124]

Options for the transition to low carbon, renewable energy for process heat is currently being researched by the government agency that is charged with mobilising New Zealanders to be world leaders in clean and clever energy use - the Energy Efficiency Conservation Authority[125].

The transport sector has the opportunity to not only change fuels and electrify road and rail transport but also to use less with mode shift to active transport and public transport. This is covered by the Government Policy Statement on Land Transport and is covered in the next section.

One of the biggest levers the regional council has for demand management using the regulatory policy lever, is through the development guidelines in the regional policy statement. This the local expression (in this example, through the Future Proof partnership) of giving effect to the national direction for urban development and the containment of urban sprawl around the Hamilton city area.

11.2 Transport

With 17 per cent of the national greenhouse gas emissions coming from the transport sector, and 16 per cent of the regional profile, reducing transport emissions will be key factor in the transition to a low emissions economy and will be a major consideration in the review of the regional energy strategy. This will be a combination of:

- Reduced need for transport (urban community design),
- Substituting fossil fuels with using renewable fuel sources (EVs), and
- Shifting the way we travel, including:
  - Mode shifts, from cars to active travel and public transport, and
  - Transferring freight from trucks to rail and coastal shipping.

Addressing transport via the above will form a major part of demand side management opportunities.

[123] A measure of power that is not used, Negawatt market - Wikipedia
[124] Climate-Roadmap.pdf (waikatoregion.govt.nz)
[125] Regional Energy Transition Accelerator | EECA

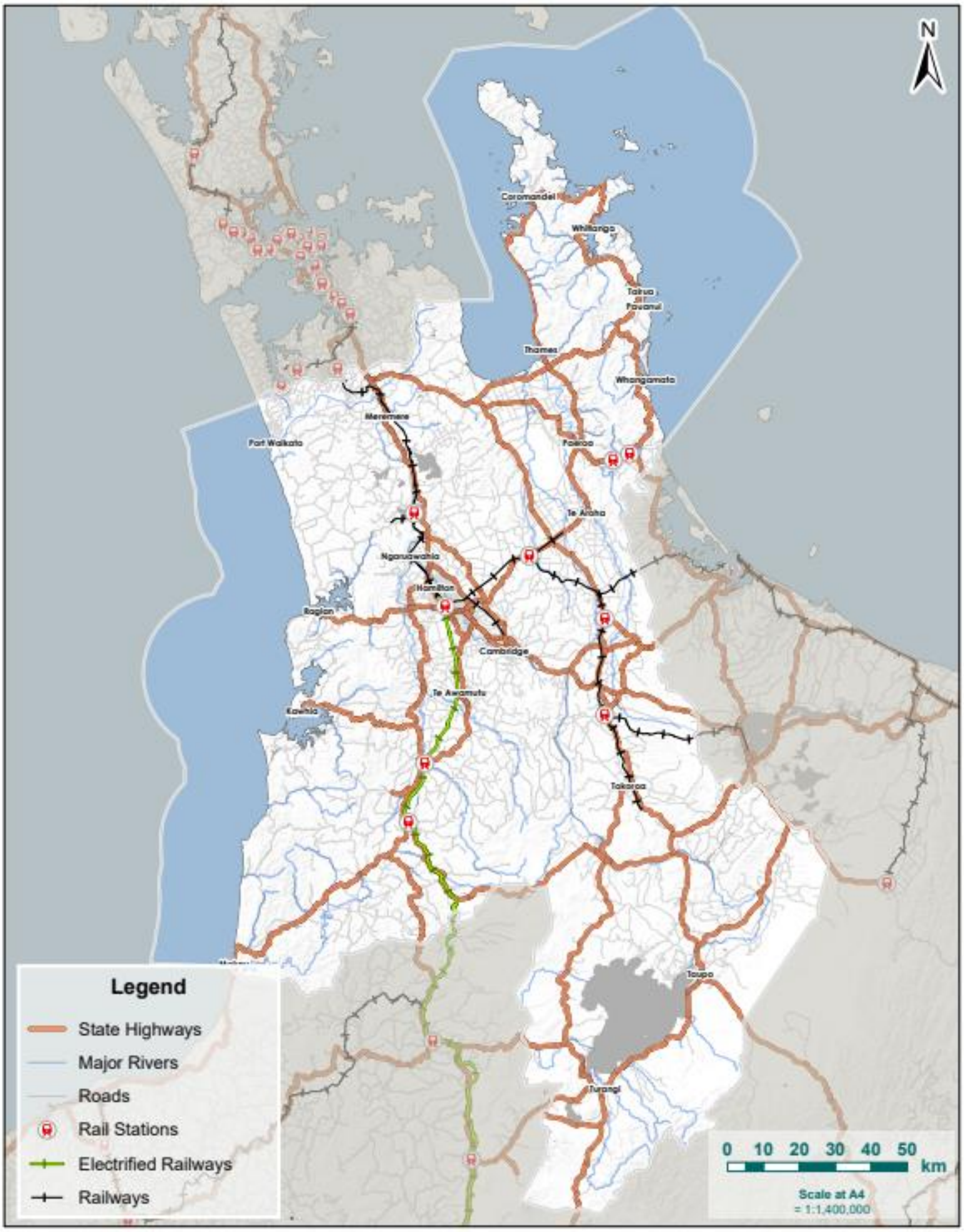
The Waikato region is a corridor region between Auckland and the rest of the country to the south. Additionally, it is also a corridor between the country and the rest of the world, connecting the country's major imports port (Auckland) and export port (Tauranga) to the rest of the country.[126] This is evidenced by the increasing use of Hamilton and surrounding centres as logistics hubs centred around road and rail infrastructure.

The importance of the transport sector to the national economy is recognised by central government which holds many of the policy levers able to advance this sector's role in the transition to a low-emissions economy. With the recent change in government bringing in policy designed to favour private vehicles and expand road use,[127] it would be unproductive to include previous policy settings in this inventory.

The reviewed regional energy strategy will need to work within and around the finalised ten-year national transport policy to progress toward a low-emissions economy.

The following map identifies the existing road and rail regional transport infrastructure. This will need to be augmented and upgraded to not only support a low emissions transport sector but also allow the decarbonisation of other sectors dependent upon transport logistics:

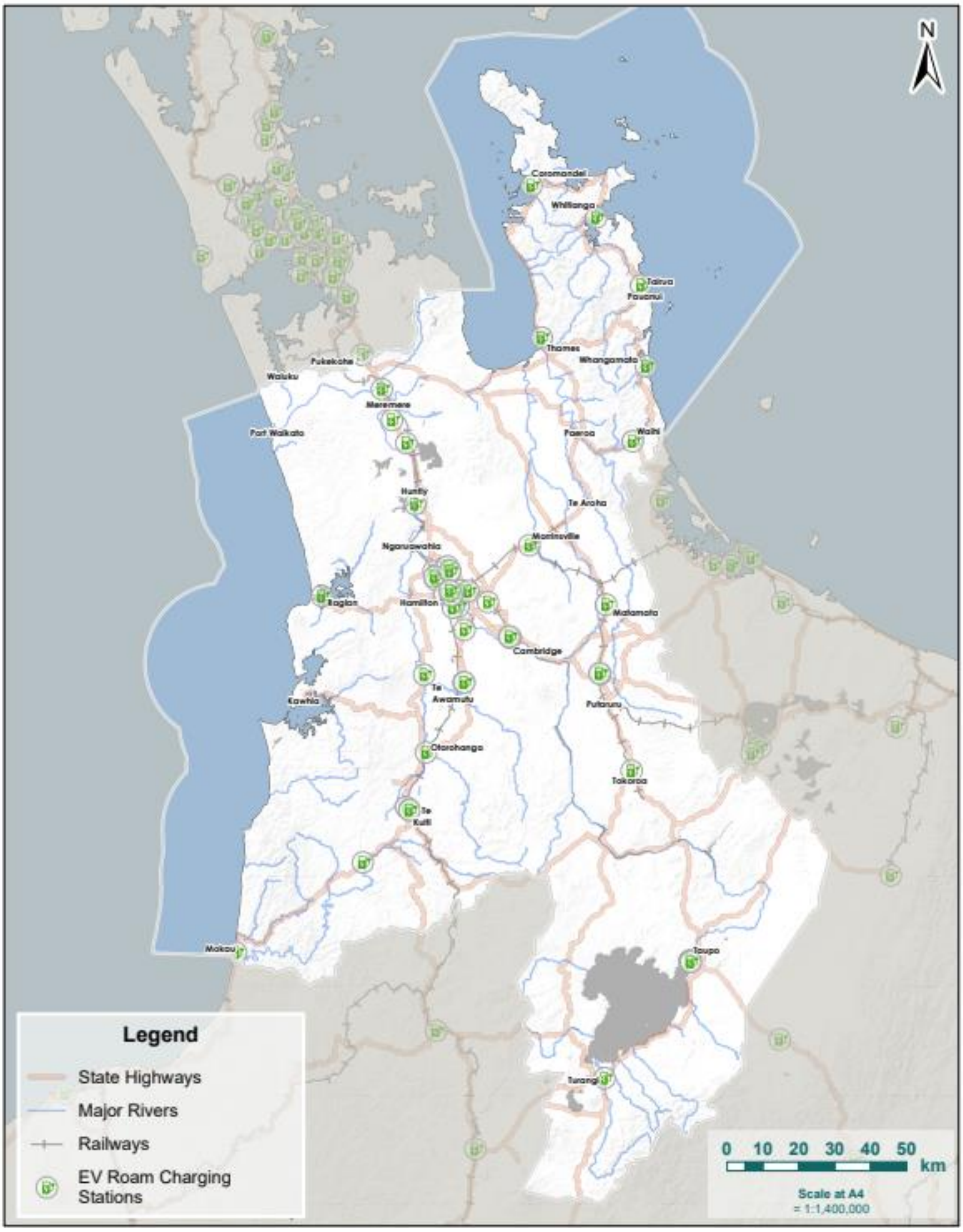
[126] Upper North Island Freight Story - Shared Evidence Base Document - Final Draft for UNISA CEs to PDF 2 (waikatoregion.govt.nz)
[127] GPS-on-land-transport-2024-Consultation-4-March-2023-.pdf



Using renewable energy to fuel road transport is supported by the government with a manifesto commitment to expand the national EV charging network with a commitment to invest $257 million to provide an additional 10,000 EV charging stations in the next four years (see Appendix 1).

While most EVs will be charged at home or work, there will always be a need to charge vehicles elsewhere. Drivers will need to use conveniently located public chargers. Currently, there are not enough public chargers to cater for the anticipated increase in EVs. There are 42 fast chargers and five ultrafast chargers across 36 locations in the region as per the map below:[128]

[128] Excludes Tesla chargers because Tesla chargers were not universally available to all EVs. Tesla chargers are now universal (since September 2023) New Zealand Public EV Charger Map | EECA



There are several gaps in the EV charging network across the region, particularly to the west in the Kawhia area, the central area bounded by Te Awamutu-Taumarunui-Taupō-Rotorua-Tokoroa, and in the northeast of the region across Hauraki and towards Thames and Coromandel Peninsula.

Electric vehicles have flexibility of travel to any place where there is a road, but this comes with the disadvantage of needing to carry heavy energy storage (via a battery), creating drag and requiring more energy to move. Where the travel is predictable as with freight between ports and logistics hubs, the option for just in time fuelling through rails and overhead wires becomes an option increasing the weight that can be carried for the power used. This efficiency can be achieved in urban rail situations as well as for freight.

The weight penalty is critical for the efficiency of freight with considerable interest in the best mode and fuel combination to achieve a low emission transport sector. Matters that will require information include not only the state of current technology but also the ability for this to be transferred and incorporated into the New Zealand context. Only then will the Waikato region be able to take advantage of new opportunities.

The reviewed regional energy strategy will need to identify not only the most energy efficient mode and fuel for passenger and freight transport but also to match that to the Waikato context and with the feasibility of achieving a transition to a low emissions economy with current and emerging national policy settings. The policy levers available to the region include access to renewable energy fuels, regulation of infrastructure, and amassing evidence to support advocacy to central government on policy settings. Matters for consideration in the review of the energy strategy will include:

- The need for upgrading the regional rail network to support renewable electricity generation and efficient freight logistics and inter-regional/local passenger transport. This may include:
    - Electrification of the rail system including the major logistics routes to Auckland and Tauranga.
    - High-volume, high-quality rail connectivity of the major logistic rail routes.
    - Potential expansion of rail lines to connect central north forestry (biomass) with processing hubs and existing thermal generation/process heat to the rest of the region and inter-regionally.
    - High quality inter-regional connection.
- Renewable fuel for freight transport, using electricity, or green molecules.

12. Key partners and stakeholders

12.1 Key messages from stakeholder and partner engagement

As part of this project, 26 individual meetings were held with representatives from a range of stakeholders and partners involved in energy across the Waikato region. These meetings consisted of semi-structured interviews/discussions which sought participants' views on the following matters:

- Relevant projects they are working on.
- Opportunities, barriers, and potential solutions they see in relation to energy in the Waikato region.
- Expectations for a future review of the Waikato Regional Energy Strategy.

A number of written responses were also received from stakeholders who were unable to attend a meeting. Appendix 6 includes a list of the stakeholders and partners who provided responses, either in meetings or via written responses.

The purpose of this engagement was confined to gathering information for the inventory; to contribute to the understanding of the current 'state of play' of energy in the Waikato region, including barriers/issues and opportunities. The number of individual stakeholders and partners contacted was kept reasonably targeted, recognising that more comprehensive engagement will be required as part of any future review of the Waikato Regional Energy Strategy.

Appendix 7 provides a list of suggested stakeholders and partners for a review of the Waikato Regional Energy Strategy. This is a working list that should be added to as part of any project planning for a strategy review.

The following sub-sections summarise the key messages received, aggregated by stakeholder/partner group. This is followed by a separate summary of stakeholder and partner expectations of a future Waikato Regional Energy Strategy.

<u>Energy users</u>

- Large energy users have plans to decarbonise and have commenced work on this. This is driven by aspirations to eliminate fossil fuels but also to reduce supply risks around natural gas and costs faced for carbon use.
- Security of gas supply is important to energy users, as natural gas is currently still required to keep boilers running. It is important that gas continues to remain available during the transition, at prices that are economic and affordable for end users.
- Having a well-developed plan for transitioning New Zealand's gas sector to a low emissions future is seen as critical to avoid price shocks and disruptions.
- The bioeconomy could play a significant role in assisting industry to decarbonise. However, a large amount of biomass would be required to replace natural gas use.
- Ensuring sufficient low-cost biomass for existing and emerging users will require the expansion of a high value domestic lumber industry and associated increase in the volume of by-product residual biomass material.
- Certainty of supply of biomass is needed to enable energy users to convert to biomass use.
- There is interest in investigating ways of extracting more biomass (in the form of wood), through research and technology improvements.
- Cost could be a barrier to extracting more forestry slash; further research is needed.
- As demand for biomass increases, strategic thinking is needed at the national level about how to make the best use of the trees grown and wood produced in New Zealand.
- Addressing electricity transmission and distribution constraints within the Waikato region will be a key to unlock decarbonisation – there is a need to provide capacity for industry, households, and transport.

- A significant amount of infrastructure will need to be planned ahead of time to support electrification of heavy transport (trucks and buses).
- Electrification and increases in EVs will increase demand for electricity.
- Technological solutions are being worked on to control at-home charging of EVs to reduce peak electricity demand. Education of users to encourage charging at off-peak times is also needed.
- There can be difficulties installing public EV chargers, as locations must have both land and power supply available. Other challenges include finding the right person to speak to at territorial authorities (as this often crosses the responsibilities of multiple departments) and community push-back on proposed charger locations.
- Ongoing changes to the Emissions Trading Scheme create uncertainty for energy users.
- Funding assistance is a catalyst for decarbonisation; there are concerns amongst industry about the Government Investment in Decarbonising Industry (GIDI) Fund ending.
- New Zealand is very reliant on imports as a country, therefore if there is high demand for a product (e.g. boilers) elsewhere in the word, this can create long lead times.

Electricity generators and retailers

- Generators and retailers know that major energy users are converting from fossil fuels but what is unclear is the timing for this.
- The Waikato region is considered to be strategically suited for increased electricity generation due to its proximity to demand centres (Auckland, Hamilton and Tauranga).
- Continued access to water, as well as operating flexibility, are challenges for hydroelectric generation.
- The future of the Tongariro diversions when the relevant resource consents come up for renewal in 2039, is a risk for the Waikato River hydro scheme.
- The importance of the Waikato and Tongariro hydroelectric generation schemes is recognised in the National Policy Statement for Freshwater Management 2020.
- How to meet peak demand is an increasingly important consideration.
- Renewable electricity generation can be intermittent due to weather dependency. Therefore, a challenge when trying to move away from use of fossil fuels is what to use to firm the grid in their place.
- The peaking role has previously been filled by gas and the Huntly Power Station, which is necessary to support and complement New Zealand's high penetration of renewable electricity generation.
- Battery storage will be required to respond to periods of peak electricity demand. However, batteries only last a short period of time, whereas there is potential that solar and wind farms may not generate for multiple days, depending on weather conditions. Preserving the existing flexibility in hydro would be one mechanism to assist with this.
- Use of hydro as a firming product would likely require more storage.
- Many countries are thinking about renewable energy not only for decarbonisation but for energy security. New Zealand currently imports a lot of liquid fuels. Utilising renewable energy resources within New Zealand, both to supply the electricity grid and for transport, would reduce exposure to geopolitical risks and volatile international commodity prices.
- Recent experiences with the consenting process for geothermal generation in the Waikato region have been positive.
- The Huntly Power Station relies on continued access to Waikato River flows for cooling purposes. Water availability and allocation are therefore key risks to the ongoing operation of the station.
- Solar farms have the benefit that the time to build and start delivering electricity is shorter than for other renewable generation types.
- The Waikato region is considered to be well-suited to solar generation, including due to the presence of large sites of flat land in single ownership.

- The policy direction within the National Policy Statement for Highly Productive Land 2022 has been a potential constraint for the consenting of solar farms.
- Securing access to land can be a constraint for new wind generation.
- For offshore wind proposals, there are also a lot of on-land considerations that could either form barriers or enablers.
- Offshore wind farms would require new skills and training to prepare people for relevant jobs.

Transmission and distribution companies

- Electricity is at the heart of regional growth and development; however, it is often an overlooked aspect as it is not as visible as housing, roads, or water.
- Waikato is both a strategic corridor for electricity transmission and a growth region.
- The Waikato region is complicated by having a number of local lines companies.
- Decarbonisation and electrification are having a significant impact on electricity demand.
- The number of grid connection enquiries for renewable generation has increased significantly since 2020.
- There has been a large number of new generators seeking to connect to the grid in recent years, for example, solar generators.
- There has also been significant demand load growth. This increase is due to demand from industrial process heat; for example, factories converting coal boilers to electricity.
- Lines companies face a lot of growth in their networks, but refurbishment and renewal of existing assets are also needed.
- It is important that lines companies have early warning regarding demand and supply changes. Having a level of certainty around when growth in electricity demand is coming is important for forward planning and enabling co-optimisation of network investment.
- Gaining more understanding around offshore wind proposals is important to transmission companies, including in relation to access and where they would connect to the grid.
- A challenge for lines companies is how to influence industry to locate where power supply is readily available, without requiring significant investment.
- Lines companies predominantly interact with councils in relation to placement of assets; this is primarily a territorial authority matter.
- It takes a long time to design, plan and build electricity transmission infrastructure.
- Consents and environmental approvals and land access for new assets can also be challenges for transmission.
- Resilience is an importance consideration for electricity transmission – the vulnerability of electricity infrastructure to natural hazards and the criticality of the infrastructure.
- Financial barriers are currently limiting uptake of rooftop solar panels.
- An increase in rooftop solar panels on homes will help consumers. However, the electricity generated would not be enough to avoid the need to invest in new electricity infrastructure to ensure there is enough electricity flowing around the region.
- Peak demand (in the evening) is not compatible with the time at which electricity is generated by solar panels (during the day). Storage options in homes will be needed to assist with this.
- New Zealand is a small country at the bottom of the world, competing with every country trying to decarbonise. However, being a small country also means New Zealand should be able to coordinate and act swiftly.

Economic development agencies

- Ensuring the grid is diverse is important.
- Many energy users are nervous about gas supply, as well as maintenance of ageing gas assets.
- There is some concern around the lack of competition in the current gentailer market model. This does not provide incentive for gentailers to go fully renewable. There are multiple layered aspects within the market that would need to change to address this.

- The large number of agencies responsible for regulation and policy making in regard to energy is also a challenge.
- There is an opportunity to locate energy users near generation within the Waikato region, for example, geothermal heat for use in industry/manufacturing.
- Attracting data centres is an opportunity for the Waikato region and New Zealand as a whole. The data centre industry needs to decarbonise and requires locations with abundant clean energy, that are also safe and geopolitically stable. However, this will require the country to think more about data sovereignty.
- There are potential costs and logistics barriers to use of biomass if this needs to be transported around the region. Lack of access to rail in parts of the region is also a barrier.

Territorial authority staff

- Territorial authorities are monitoring their carbon emissions and working on ways to reduce these, including through energy efficiency measures for council-owned assets. To date, this has primarily been the focus for territorial authorities, rather than working with communities on how they can reduce their emissions.
- Towns within the Waikato region are growing, through both residential and business/industrial development. Forward planning is therefore needed to ensure energy use is as sustainable and 'green' as possible.
- Territorial authorities need to balance electricity generation/decarbonising with the needs of their communities and the impacts electricity generation activities have on them.
- Solar farm proposals in the region have primarily been located on highly productive land. The National Policy Statement for Highly Productive Land 2022 (NPS-HPL) has therefore had an impact on consenting processes.
- However, regardless of the NPS-HPL, the protection of highly productive land is still an important policy issue for many districts within the region. There can also be community resistance to solar farms in rural areas.
- Many recent renewable electricity generation projects have been applied for via the fast-track consenting process; this means district councils are not the decision-makers.
- Increases in large-scale renewable electricity generation projects will put a strain on existing infrastructure.
- Tension can arise in planning processes between electricity transmission and impacts on private property rights.
- Careful planning is needed regarding the location of transmission corridors. The straightest line is not always the best option, for example, if this would cross a town centre or block a cultural viewshaft. The locations of proposed renewable electricity generation projects and transmission infrastructure should also avoid areas identified for future residential development in council-approved growth strategies.
- Road access to servicing towns will be an important consideration for offshore wind proposals, including the resilience of the roading network to natural hazards.
- Territorial authorities generally have a good understanding of forms of renewable electricity generation that are more mature in their districts (for example, hydro or geothermal generation), as well as of the interactions between electricity transmission infrastructure and other land uses. However, there is less understanding of the effects of other emerging forms of renewable generation, such as solar, small-scale wind and biomass.
- Consideration is needed around how to provide alternative transport mode choice for rural communities that is not petrol-driven.

Research and education institutes

- Prices in the New Zealand electricity market are abnormally high; electricity from renewable sources is essentially sold at coal power prices.

- As we move away from fossil fuels, it will be a lot more visible to people where energy is coming from. Harvesting more energy in New Zealand would provide the benefit of greater security against international disruptions, such as shipping disruptions, warfare, and currency fluctuations.
- The Waikato region is close to the demand centre of Auckland and contains a lot of energy resources; therefore, energy is a bigger issue for Waikato than it is for many regions.
- We are moving into a time when the harvesting of energy is more complex and requires more land and materials (for example, minerals).
- If devoting more land to different types of energy gathering, it is important to understand potential adverse impacts, for example, pressure on wetlands and effects on biodiversity (including of biomass crops).
- An increase in electricity generation also has impacts in terms of more transmission being required.
- Construction of infrastructure in New Zealand is expensive. Therefore, there is a risk that the cost of constructing connections to the grid could potentially lead to tensions between an optimal land use pattern and what is economically feasible, if project locations are driven by proximity to grid exit points.
- Overall, there is a significant spatial dimension to decarbonisation.
- A lot of the thinking about decarbonisation both in New Zealand and overseas is focused on the supply side; that more renewable generation is required, whereas the demand side is often overlooked.
- There are potential gains in being intelligent about how electricity is used, for example in domestic buildings and transport.
- A lot of the dry winter problem is correlated to higher demand for domestic heating (heating water and heating space). Efficient building design could assist with this, for example, proper insulation and double/triple glazing.
- The initial up-front cost of solar panels is being recognised as a barrier to rooftop solar.
- The relationship between urban form and transport is important from a demand perspective; can we minimise the number of situations where we are causing people to be involuntary commuters due to urban form?
- There are potential opportunities relating to small-scale community generation from waste (e.g. farm effluent).
- New energy industries will require new training and the ability for industry participants to upskill their teams.
- As well as the Energy Efficiency & Conservation Authority's (EECA) Regional Energy Transition Accelerator (RETA) Programme,[129] research being undertaken in the Ahuora Centre of Smart Energy Systems (University of Waikato)[130] relating to industrial process heat and renewable energy, will be a relevant resource for a review of the Waikato Regional Energy Strategy.
- Finding sufficient new energy storage is crucial to solving the dry year problem in New Zealand.
- There is an opportunity to investigate the potential of small-scale pumped hydro storage schemes in the Waikato region. This could provide an alternative to gas as a fast response to peaks in electricity demand as more intermittent renewable generation (wind and solar) is developed. There is however a risk of high construction costs being a disincentive to private industry.
- Another potential opportunity is to investigate the extent to which hydro spill losses can be reduced by imposing different operating rules on source hydro lakes. Having a narrower operating range on Lake Taupō could potentially reduce spill loss in the Waikato River power stations.

[129] Regional Energy Transition Accelerator | EECA
[130] Ahuora Centre for Smart Energy Systems - Ahuora - Centre for Smart Energy Systems: University of Waikato

- With reduced fossil fuel power generation, the resilience of North Island electricity supply needs to be considered, as it will become vulnerable to a worst-case scenario of an extended outage of the high-voltage direct current (HVDC) inter-island cable (for example, due to an earthquake on the Alpine Fault).
- In the rush to the electrified economy, it is important that environmental considerations are not lost in the need for more renewable generation.
- The future of the Whanganui diversions to the Tongariro Power Scheme requires consideration, in partnership with Whanganui River iwi.
- There is an under-utilised opportunity for direct use of geothermal energy.
- There is also a potential opportunity for direct use of low-temperature geothermal systems in the Waikato region.
- There are opportunities relating to the co-location of geothermal heat in the Taupō Volcanic Zone and the Central North Island forests.
- There are opportunities to reduce emissions through geothermal carbon dioxide capture and re-injection; this is already occurring at some geothermal power stations in the region.
- The potential use of supercritical geothermal resources is being investigated. However, there are financial and technological challenges associated with this.

<u>Community and commercial (incorporating community organisations and energy and planning consultants)</u>

- It is often difficult for potential electricity generation developers to find out where there is capacity in the grid.
- Solar farm proposals sometimes experience opposition from neighbours.
- A challenge/constraint is the lack of spatial planning for renewable energy projects (nationally and regionally). This was an issue previously when wind development began, which resulted in wind farms being pepper-potted along prominent ridgelines. The same issue is now arising as solar farm proposals become more common; there is no direction on where these should be located.
- There is an opportunity to get ahead of the curve with offshore wind proposals and determine how to best plan onshore components in advance.
- There are some potential challenges for offshore wind proposals, including infrastructure (e.g. ports) and supply chain issues, as well as the social license component.
- Early engagement with mana whenua will be crucial for any offshore wind proposals.
- There will need to be robust data collection regarding environment/ecological effects of offshore wind farm proposals. There is currently uncertainty around potential effects, for example on endangered migratory seabirds.
- Spatial planning for large renewable generation projects needs to embrace a collaborative approach. Traditionally New Zealand has been somewhat siloed in its approach to the planning and implementation of projects of this magnitude.
- Supporting mana whenua involvement in energy projects is crucial.
- There is currently a limited supply of biofuels/biomass for businesses looking to convert boilers.
- Better market mechanisms that allow the export of solar electricity across the network could make rooftop solar a more viable option for businesses.
- The very high cost of electricity is a national issue affecting both businesses and households.
- Energy conservation and efficiency are usually the cheapest sources of additional energy.
- Lots of opportunities exist in terms of community electricity generation projects. However, there are skills required in this space, including project management and organisational planning. Coordination is required to find the right people in the community who wish to contribute to such projects.
- Encouraging public transport use is an important aspect of reducing carbon emissions from transport, in addition to the electrification of buses.

- Electrification of railways and switching as much freight from road to rail as possible is an option to decarbonise transport.
- There are opportunities for residential energy savings by thinking about how to trap energy to achieve maximum benefit from it, for example, through energy efficient curtains in homes.
- Current commercial/industrial building designs are building in large demand for air conditioning into the future.
- After Cyclone Gabrielle, there was a limited number of lines company contractors available to repair damage to electricity infrastructure. With the increasing frequency of severe weather events, the availability of people/resources to look after this infrastructure will be an important consideration for the resilience of the network.

Iwi (Waikato-Tanui)

- Fossil gas in the electricity generation market will be required to continue to play an important peaking and firming role until alternative options are viable and available.
- However, in addition to the emissions, thermal electricity generation tends to be more expensive and often sets the marginal price. An accelerated build-out of lower-cost renewable generation (and storage if required and viable) is needed such that thermal generation is required less for back-up supply.
- Energy security and energy equity are vitally important to the health and wellbeing of hapū, whanau and wider communities.
- It is important to understand the impacts and benefits of proposed new renewable electricity generation projects, for example, offshore wind.
- Air, land, and waters must be protected in balance with enabling renewable electricity generation development.

12.2 Stakeholder and partner expectations of a Waikato regional energy strategy

The following sub-sections summarise responses from stakeholder and partner representatives about their expectations of a future Waikato Regional Energy Strategy.

Stakeholder/partner representatives provided these responses based on limited information about the potential scope and content of a regional strategy, and further expectations may be identified as part of any future engagement at the time of the strategy review.

Energy users

- A strategy should identify what is happening regarding energy supply and demand across the region and how different components fit together.
- A strategy should identify regionally significant industry and infrastructure, as well as renewable energy generators, and recognise locations that are of strategic significance for decarbonisation.
- The Waikato region is a gateway for a lot of transport movements. A strategy should raise awareness of the need for EV charging infrastrcture for longer journeys in the region, including for heavy vehicles.
- A strategy should plan ahead for infrastructure for electrification of heavy transport (trucks and buses).
- Consider enablers for public EV chargers.

Electricity generators and retailers

- Think about what physical resources within the Waikato region could provide flexibilty in an intermittent renewables world and how to make it attractive for market players to use them.
- A strategy should emphasise the importance of existing hydroelectric generation in the region, as well as the importance of flexibility and continued energy capacity as generation from intermittent renewable sources increases.

- A strategy should consider the importance of the Whanganui diversions to the Tongariro and Waikato River power schemes.
- Iwi aspirations should be an important part of the strategy.
- WRC could assist with coordination and the spatial component of renewable energy projects; ensuring that large-scale projects are not happening in silos.
- WRC could assist large-scale renewable electricity developers that are new to the region by providing a coordination role and advice about:
    - Who to speak to (including local authorities and iwi) to help with local stakeholder engagement.
    - Central government versus local government interests in these projects.
    - Planning processes and regional consenting requirements.
    - Large energy users in the region, to assist with project business case development.
- For offshore wind proposals, there is some support for identification of potential transmission routes in a spatial plan. Design of onshore transmission routes to limit impacts on local communities will be an important aspect of these projects.
- With an increase in renewable electricity generation, there is potential for regions to attract new electricity users. However, this requires coordination - planning for industrial land uses and associated infrastructure.

Transmission and distribution companies

- A strategy should assist with understanding where decarbonisation opportunities are. Having a regional view of carbon footprints would enable the formulation of a better strategy for where to focus efforts.
- The Waikato region is growing; the strategy should assist with understanding what this means for electricity infrastructure.
- Transmission companies need a level of comfort about whether growth is coming in order to make decisions. WRC could also assist with this by sharing information about relevant projects or approvals.
- A strategy needs to be collaborative and have a joined-up approach.
- There are many external drivers that affect whether proposed energy projects eventuate (e.g. government, regulatory settings) – thinking is required about how all stakeholders can coordinate and work together to make sure New Zealand is an attractive place to invest.

Central government (EECA)

- Consider how to encourage and support new businesses in the region to use low-carbon options (renewable energy) from the outset, rather than using gas.
- A strategy should identify and increase awareness of other agencies' responsibilities in relation to energy, and reference and direct readers to existing published reports.
- If the strategy results in regulatory implementation mechanisms, would like to see consistency between regions.

Economic development agencies

- A strategy should provide clear certainty to enable investment for growth.
- A strategy could assist by providing alignment of all relevant policy levers and identification of implementation mechanisms.
- Rather than existing in silos, a strategy should bring together everything that is happening of relevance to energy in the region. It should identify risk areas, opportunities and how these will be addressed, and provide a regional position.
- Include iwi/Māori perspectives, as iwi have significant interest in energy projects.

- The strategy should bring in the results of EECA's RETA work.
- A strategy should consider the logistics aspect (e.g., of transporting biomass around the region).

Territorial authority staff

- A strategy should include a problem defintion; it is agreed that we want to reduce emissions, how do we reach goals from where we are now? Identify where the Waikato region wants to go regarding energy.
- A strategy should take into account all relevant national direction and consider how to resolve tension between competing direction.
- Consider how to deal with competing interests, for example between electricity generation and outstanding natural landscapes.
- Appropriately consider the potential adverse effects of electricity generation on local communities.
- With the Waikato region's role as a transmission corridor for electricity, the strategy should consider what communities within the region can gain from this.
- The strategy should also consider the distribution of economic benefits within the region and the potential for generation projects to strengthen the local community where they are based, rather than benefits (e.g. employment opportunities) being concentrated outside of the relevant district.
- There is support amongst territorial authority staff for the use of spatial planning in relation to renewable energy in the region, despite the repeal of the Spatial Planning Act 2023.
- An understanding of the potential locations of different forms of electricity generation would be helpful for territorial authorities; for example, understanding where different energy resources are located and the proximity to the grid.
- If a strategy was to identify transmission corridors, this should be high-level and corridors would need to be considered holistically, taking into account features that require protection.
- Relevant partners should be involved in the development of a strategy (including territorial authorities, iwi, and Economic Development Agencies).
- The strategy should consider different scales; it should pick up on smaller-scale, locally distributed generation (including domestic solar and community sharing projects), as well as large-scale electricity generation projects. Small-scale projects have potential to add up to resilience within individual districts and the region.
- Address the demand side as well as the supply side of energy. Consider how communities can be set up to make more efficient use of energy, to limit the need to construct new power stations.
- The strategy needs to integrate with the work done through the Future Proof Strategy in relation to land use, transport and three waters planning.
- A strategy could promote energy efficiency requirements for buildings.
- A strategy should consider climate change adaptation requirements and the impacts of a changing climate on land uses in the region.
- It would be helpful if some educational materials could be produced as part of the project, providing balanced information about both the supply side (different forms electricity generation) and demand side of energy.
- WRC could assist territorial authorities with understanding best-practice management of different forms of electricity generation, particularly those that are newer to the region, or parts of the region.

Research and education institutes

- There are opportunities for a strategy to fit in with the National Emissions Reduction Plan; the strategy should provide an account of how it does this.
- The strategy must address the demand side as well the supply side of energy.
- Demand side aspects should include efficient building design and improvement of cycling options.
- The strategy could be a vehicle to promote information sharing; for example, if electricity companies made information about geothermal resources available for use in research.
- Researchers sometimes receive enquiries from electricity generation developers investigating potential projects. It would be helpful if there was a map of the region showing the locations of different energy resources (both on and offshore) and a resource assessment; a spatially interrogable resource inventory.
- WRC could also assist with directing developers to relevant people within local authorities to speak to about proposed projects.
- It is important that geothermal energy is not overlooked in the strategy, particularly given the prevalence of geothermal resources in the Waikato region.
- It would be helpful to create some energy education resources as part of a strategy development project.
- Creating new educational courses takes time, therefore it would be helpful for energy training providers to be included in conversations about the regional direction for energy and future skill requirements early on.

<u>Community and commercial (incorporating community organisations and energy and planning consultants)</u>

- A strategy should do the thinking at a regional level about what transmission corridors are required and whether there are areas of land that should be considered for renewable electricity generation.
- Spatial planning for energy needs to start with higher-order planning documents and cascade down.
- Address the demand side; how to reduce energy use/increase efficiency. This should include a focus on low-energy building design.
- A strategy should think about what we, as a region, need to improve upon that will be future fit in 10-15 years' time.
- The strategy could set targets for distributed generation. This would increase community resilience.
- A strategy should consider the merits of energy hubs for resilience purposes; whether there should be local generation centres near communities that can be safely and easily used if a natural hazard or other event takes out power.
- At a community level, it would be useful to identify what the bottlenecks are that might be preventing people from being able to act to reduce their household emissions.
- Consider strategies for promoting and increasing public transport use.

<u>Iwi (Waikato-Tainui)</u>

- It is important that the strategy considers energy in the context of climate change mitigation.
- Consider Te Ture Whaimana o Te Awa o Waikato - Vision and Strategy for the Waikato River.

12.3 Themes

Security of supply	Transition
Renewable energy	Address demand too
Collaboration	Resilience of network
Spatial planning	Decarbonisation

The following high-level themes were identified across the stakeholder and partner key messages and expectations of a review of the Waikato Regional Energy Strategy:

- Finding renewable options for firming the grid (security of energy supply) are an important issue with increasing electricity demand and generation from intermittent renewable sources.
- Careful planning is required for the transition of the gas sector.
- Electricity affordability is an important issue for large energy users and households/communities. This is affected by market barriers.
- Coordination and information sharing is important for all parties involved in the energy/electricity sector, to assist with forward-planning.
- There are many spatial elements to decarbonisation.
- Support for spatial planning for transmission corridors and potential areas to consider for renewable electricity generation.
- Consider methods to reduce electricity demand/increase efficiency (including transport, urban form and building design), as well as the supply side of energy.
- The need to plan to reduce carbon emissions from transport – including EV charging, switching freight from road to rail, electrification of rail, increasing public transport use, improving cycling options.
- Include iwi aspirations.
- Support for a collaborative approach to strategy development, bringing together relevant stakeholders and partners.
- The need to balance renewable electricity generation with effects on communities and the natural environment.
- Include and promote smaller/community-scale electricity generation, in addition to large-scale projects.
- Consider resilience aspects - at a regional and local scale, and of both electricity supply and supporting infrastructure (e.g. road access).
- New skills and training will be required for the development of new energy industries/forms of electricity generation.

13. Information and policy gaps

13.1 Information needed for the Waikato Regional Energy Strategy

The following information gaps have been identified during the inventory process, which will need to be understood for a review of the Waikato Regional Energy Strategy:

- The energy profile of the region; understanding the flows of energy within the regional economy; where energy comes from, how much is used within the region and how much is transformed for storage and transport (either within the region or exported).
- An understanding of demand, who uses energy and electricity in the region and how much. This would be assisted by speaking to all of the electricity distribution companies in the region.
- The opportunities for reducing greenhouse gases emissions from existing industrial process heat users that currently rely on fossil fuels, either via electrification or use of biomass. This is currently the subject of contemporaneous and complementary work by the Energy Efficiency and Conservation Authority (the Regional Energy Transition Accelerator report for the Waikato region), which will be completed in time for review of the Waikato Regional Energy Strategy.[131]
- Fine-scale analysis of biomass availability in the region.
- Detailed analysis of pumped hydro opportunities in the region.
- Need for upgrading the regional rail network to support renewable electricity generation and efficient freight logistics and inter-regional / local passenger transport. This may include:
    - Electrification of the rail system including the major logistics routes to Auckland and Tauranga.
    - High-volume, high-quality rail connectivity of the major logistic rail routes.
    - Potential expansion of rail lines to connect central north forestry (biomass) with processing hubs and existing thermal generation / process heat to the rest of the region and inter-regionally.
    - High quality inter-regional connection.
- Renewable fuel for freight transport, electricity, or green molecules.
- Apply the United Nations Framework Classification (UNFC) for resources to potential energy solutions in the strategy to help the community, iwi, investors, and other stakeholders compare different energy related project proposals (see Appendix 8).

[131] Regional Energy Transition Accelerator | EECA

14. Recommendations

It is recommended that the contents of the Waikato Regional Energy Inventory are used to inform the council's engagement with the National Energy Strategy and the review of the Waikato Regional Energy Strategy.

It is recommended that the suggested partners and stakeholders identified in Appendix 7 are engaged with as part of the Waikato Regional Energy Strategy review. The Waikato Regional Council Regional Transport Connections Directorate and Social and Economic Science Section should also be involved in the strategy review.

15. List of Appendices

1. Government's energy policy commitments
2. Waikato Regional Climate Effects Report Applying CMIP6 Data
3. Regional Climate Action Roadmap - energy and Industry commitments
4. Key district plan provisions relating to energy
5. Analysis of the New Zealand Electricity Sector
6. Record of partner and stakeholder engagement for the Regional Energy Inventory
7. Suggested partners and stakeholders for a review of the Waikato Regional Energy Strategy
8. United Nations Framework Classification for Resources (UNFC)

Addendum to: Waikato Regional Energy Inventory (March 2024) Updated February 2025

Appendix 1 Government's energy policy commitments

All three coalition parties have defined primary energy policies and, as energy drives the economy, other policies that have a vicarious influence on energy decisions and choices. The energy policies of the government are those of the National Party (default) modified by the respective agreements with New Zealand First and ACT party. The agreement between the National party and ACT states that ACT agrees to progress the National Party priorities this term as set out in the "National Policy Programme" (clause 10). A similar undertaking is found in the coalition agreement between the National Party and the New Zealand First Party, referring to National Party's Fiscal plan, Tax Plan, 100 day plan and 100 point plan, except for specific exemptions in the agreement (clause 10).

National's policy programme

National's programme as part of its plan to "get our country back on track"[132] contains 22 separate policy areas with three directly relating to energy. These are, on the supply side:

- Electrify NZ,
- Electrify NZ – Offshore wind,

and on the demand side:

- Supercharging EV Infrastructure.

A further two policy areas are related to the transition to a low emissions economy. These are:

- Infrastructure for the future, and
- Forests for a strong economy.

Each energy manifesto document introduces the topic, creates a point of differentiation from the previous Labour government's policy and identifies a series of commitments that the coalition government will action. The commitments are itemised without editing in the following sections.

Electrify NZ[133]

National will:

- Turbo-charge new renewable power projects including solar, wind and geothermal by requiring decisions on resource consents to be issued in one year and consents to last for 35 years.
- Unleash investment in transmission and local lines by eliminating consents for upgrades to existing infrastructure and most new infrastructure.
- Require decisions on resource consents for non-hydro renewable generation within one year of application.
- Issue a new National Policy Statement for Renewable Electricity Generation (NPS-REG) within a year of National taking office. A consultation draft will be available within six months. The new NPS-REG will be strongly directive about enabling renewable generation. The new NPS-REG will make solar, wind, geothermal and biomass a controlled activity under the Resource Management Act, requiring councils to update their plans to make consents for these generation types near-automatic. The NPS-REG will outline the conditions that may be attached to new consents. Provided the conditions are met, consents cannot be declined.
- Create nationally consistent rules for each type of renewable generation so requirements are clear.
- Consents for most types of renewable generation will be near-automatic provided national rules are met.
- Increase the minimum duration of consents for all renewables, including hydro, to 35 years to increase investment certainty. There will be regular reviews to address effects.

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[132] National's plan to get our country back on track
[133] Electrify_NZ.pdf (nationbuilder.com)

- Introduce new National Environment Standards for each generation type to provide consistency and certainty.
- Restore "remedy and mitigate" as options to manage adverse effects from renewable generation as well as transmission and local lines. The emphasis should be on addressing adverse effects rather than avoiding them.
- Set minimum lapse times on resource consents for all renewable generation to 10 years to provide certainty. Consents generally lapse after five years if they are not used, adding risks for projects with long lead times.
- Establish a one year limit to re-consent existing generation assets, including hydro.
- Introduce a National Policy Statement – Hydrogen to provide certainty for investment in hydrogen production and distribution.
- Introduce a National Policy Statement – Distribution to make it easier to build infrastructure, including poles, lines, transformers and substations.
- Eliminate consents for upgrades to existing transmission and local lines infrastructure, within limits.
- Require consents for transmission and local lines to be issued in one year, increase durations to 35 years, and set minimum lapse times to 10 years.
- Update the Commerce Act and associated regulations to provide greater certainty around cost recovery for regulated infrastructure.
- Introduce options to manage first mover disadvantage for new connections to local lines, including claw back rules to allow first movers (such as new EV charging stations that pay 100% of the upfront cost of lines upgrades) to recover a share of those costs from future connections to that infrastructure.
- Change cost recovery rules to allow a share of new connection costs to enter the Regulated Asset Base, meaning greater sharing of connection costs for specified activities such as EV charging stations.
- Introduce an information disclosure regime under the Commerce Commission to monitor connection costs for local lines. The purpose is to ensure costs are reasonable and avoid gold plating.

Electrify NZ – Offshore wind[134]

In addition to the commitments in Electrify NZ, National will:

- Fast track the introduction of offshore wind permits so feasibility studies for offshore wind sites can get underway as soon as possible.
- Complete the commercial permits process within one year to clear the way for investment as feasibility studies are completed.
- Require resource consents for offshore wind generation to be issued within two years of an application by updating the National Policy Statement for Renewable Energy, with this timeframe to be reviewed as offshore wind becomes embedded.
- Require consents for new transmission lines to be issued within one year and eliminate consents for upgrades to existing transmission lines within limits, with transmission funding rules to be updated to support investment.
- Work with NIWA and GNS Science to publish weather and geology data to support feasibility studies

Supercharging EV Infrastructure[135]

National will:

- Invest $257 million over four years to deliver a network of 10,000 public EV chargers by 2030, nearly ten times more than the current number of public EV chargers.
- Revive the highly successful Ultra-Fast Broadband (UFB) funding model to ensure EV chargers are built where drivers need them including underserved areas.

[134] Offshore_Wind.pdf (nationbuilder.com)
[135] Supercharging_EV_Infrastructure.pdf (nationbuilder.com)

- Cut the red tape holding back EV infrastructure investment by eliminating the need for resource consent for EV charging points to reduce up-front costs.
- End the "ute tax" and clean car discount schemes which Labour said would be fiscally neutral but which are unnecessary, expensive and fiscally unsustainable.

National will cut the red tape that's holding back investment in EV chargers by:
- Making the installation of EV chargers a permitted activity under the RMA.
- Setting default safety and design standards to reduce the cost of delivering EV chargers across the country.
- Requiring distribution companies to provide relevant geographical information system (GIS) data on potential charging point locations to providers free of charge.

Infrastructure for the Future[136]

National will:

- Create a 30-year infrastructure plan for New Zealand covering all infrastructure sectors.
- Further streamline consenting rules by shifting to a standards-based regime for priority consents over time. Standards will cover all forms of infrastructure and set at a level that protects the environment.
- introduce a new class of projects for consenting purposes known as Major Infrastructure Priorities
- (MIPs). These will be for large, complex projects which under the current RMA would require public notification and public hearings
- Legislate to give the Minister for Infrastructure the power to classify particular projects as Major Infrastructure Priorities, in certain circumstances. Classification as a Major Infrastructure Priority will mean a decision on the project must be issued within one year.
- Require government agencies to develop and publish capital investment plans for a minimum period of 10 years, as recommended by the Infrastructure Commission.
- Require regular reporting of how major infrastructure projects are progressing, to monitor progress, and to make sure insights are shared across government. These reports will go directly to the Cabinet Committee considering Infrastructure and related matters
- Investigate how central government can support the development of a National Underground Asset Register (NUAR) – a "single source of truth" as to what is under the ground.
- Explore whether there is merit in standardising the methodology that local authorities can use when charging development contributions.

Forests for a Strong Economy[137]

Policy commitments cover a range of activities and those that specifically relate to emissions reductions and the use of the Emissions Trading Scheme to decarbonise the economy are included below.

National will:

- Boost wood processing by introducing one-year consents to establish new wood processing facilities, streamlining re-consents, and investigating Emissions Trading Scheme credits for wood processors for embedded carbon in their products.
- Build confidence in forestry by restoring the stability of Emissions Trading Scheme revenues for the sector

136 Infrastructure_for_the_Future.pdf (nationbuilder.com)
137 Forests_for_a_Strong_Economy.pdf (nationbuilder.com)

- Investigate phasing-in of ETS credits for wood processors based on the embedded carbon captured in longer-life timber products. This would support further investment in valued-added processing and contribute to New Zealand's climate change goals.
- Restore stability and confidence in the ETS and a gradually increasing ETS price by committing to no major ETS reforms, including Labour's irresponsible proposals to restrict how participants meet surrender obligations, introduce separate treatment for gross reductions and forestry, and expiry dates on ETS units ("vintaging").

Coalition Agreement between NZ National party and ACT New Zaland

The agreement clearly states that the ACT Party agrees to progress the National Party priorities, thereby defining the above commitments relating to energy matters as the default programme.[138] The agreement makes additions and modifications to the 'National Policy Programme' in the following ways and to the following extent. Energy references to general provisions are highlighted for clarity in this document but not in the original.

The Parties will:

- National's commitment to supercharge electric vehicle infrastructure with a comprehensive, nationwide network of 10,000 public EV chargers by 2030 will specifically take into account ACT's concern that there be robust cost benefit analysis to ensure maximum benefit for government investment.
- Repeal the Clean car Discount
- Amend the Resource Management Act 1991 to make it easier to consent new infrastructure including renewable energy, allow farmers to farm, get more houses built, and enable aquaculture and other primary industries.
- Work to replace fuel excise taxes with electronic road user charging for all vehicles, starting with electric vehicles.
- Repeal the ban on offshore oil and gas exploration.
- Immediately issue stop-work notices on several workstreams, including (among other things):
    - Lake Onslow Pumped Hydro.

Coalition Agreement between the National Party and New Zealand First

The agreement clearly states that the New Zealand First Party agrees to progress the National Party priorities as set out in the Fiscal Plan, Tax Plan, 100 day plan and 100 point economic plan, except for the specific exemptions which have been agreed between the parties and set out in the Coalition Agreement.[139] In a similar way to the agreement between National Party and the ACT Party, the energy policy commitments of the National Party form the default position. The agreement adds to or modifies these. Energy references to general provisions are highlighted for clarity in this document but not in the original.

The Parties will:

- Support seniors by maintaining the Winter Energy Payment, increasing Super every year and boosting it with our tax relief plan, which will see a superannuitant couple get over $600 extra each year.
- Deliver Net Zero by 2050 including by doubling New Zealand's renewable electricity and supporting new technology to reduce agricultural emissions.
- Assess and respond to the impact that energy prices have on inflation including consumer led institutional improvements.
- Amend the Resource Management Act 1991 to (among other things):
    - Make it easier to consent new infrastructure including renewable energy, allow farmers to farm, get more houses built, and enhance primary sector including fish and aquaculture, forestry, pastoral, horticulture and mining.

[138] See Clause 10.
[139] See Clause 10.

- Investigate the threshold at which local lines companies can invest in generation assets.
- Commission a study into New Zealand's fuel security requirements.
- Investigate the reopening of Marsden Point Refinery. This includes establishing a Fuel Security Plan to safeguard our transport and logistics systems and emergency services from any international or domestic disruption.
- Progress further work examining connecting the railway to Marsden Point and Northport from the Northern Main Truck Line.
- Require the electricity regulator to implement regulations such that there is sufficient electricity infrastructure to ensure security of supply and avoid excessive prices.
- Examine transmission and connection pricing to facilitate cost effective connection of new renewable generation resources, both on-shore and off-shore.
- Plan for transitional low carbon fuels, including the infrastructure needed to increase the use of methanol and hydrogen to achieve sovereign fuel resilience.
- Future-proof the natural gas industry by restarting offshore exploration and supporting development of hydrogen technology to produce hydrogen from natural gas without co-production of CO2.
- Ensure that climate change policies are aligned and do not undermine national energy security.
- Ensure the government's energy settings allow for the exploration of natural geological hydrogen in New Zealand, to maximise future energy resilience.
- Stop the current review of the ETS system to restore confidence and certainty to the carbon trading market.

Appendix 2 Waikato Regional Climate Effects Report Applying CMIP6 Data

Dr Yinpeng Li, Dr Peter Urich, Johnny Yu and Hannah Rogers of ClimSystems

26 November 2021

Executive Summary

(1) This report investigates nine essential climate and two socioeconomic variables for the Waikato Region, using historical and CMIP6 GCM SSP2-4.5 and SSP5-8.5 scenario data. Trends in average seasonal and annual mean, maximum and minimum temperature are explored. Patterns in average seasonal and annual precipitation, runoff, wind speed, daily extreme precipitation, daily extreme wind speed, and annual potential evapotranspiration deficit are also analysed. And in terms of socio-economic variables, historical water take statistics are examined.

(2) Historical annual mean temperature changes indicate a warming trend in the Waikato region. The average annual mean temperature of the Waikato Region is expected to rise over the examined time slices of 2050, 2070 and 2090, increasing 3.2°C in 2090 applying the SSP5-8.5 50th percentile scenario compared to the baseline (2005 is the central year of 1985-2014 set in the IPCC AR6 report). Seasonally, the average temperature of the summer months is predicted to increase more rapidly than other seasons.

(3) Under both scenarios, the maximum temperature of the Waikato Region, relative to the baseline, is shown to increase out to 2090. Again, the data suggests that the summer months (DJF) will experience the most significant temperature rise, with 3.4°C increase by 2090 under SSP5-8.5. The greatest temperature increases occur in southeast districts (such as Taupō), decreasing towards the northwest corner.

(4) The minimum temperature analysis predicts an annual increase across both SSP2-4.5 (1.53°C) and SSP5-8.5 (3.06°C) scenarios by 2090. Seasonally, the summer months show the greatest increase in temperatures, followed by autumn. As with the maximum temperature analysis, the changes in minimum temperature are most noticeable in the south-eastern corner of the region and lowest in the north, including the Coromandel and Waikato districts.

(5) Based on the precipitation data from 1972 to 2020, the annual mean precipitation in Waikato region shows a declining linear trend, at a rate of around 20 mm per decade. The interannual variabilities need to be considered, especially in recent years, as precipitation has experienced historical lows in parts of the Waikato region. The annual mean? Precipitation of the Waikato Region could continue the historical trends under both scenarios out to 2090. However, these changes are predicted to be relatively minor (0.5% reduction). While autumn and spring months exhibit a declining trend, the summer and winter months show a small increase in precipitation (X%). The districts with the greatest predicted increase in precipitation are around the southern edges of the region, notably the Waitomo and Taupō Districts. In the northeast, predictions suggest a decline in precipitation in the Hauraki, Coromandel and Waikato Districts, at least for later periods of the analysis.

(6) Annual runoff is expected to decline in 2050 and then gradually increase out to 2090 under SSP2-4.5. For the SSP5-8.5 scenario, runoff is likely to increase out to 2090. Concerning the seasons for both scenarios, runoff most distinctly declines in the spring months. Generally, the region’s north-western area is expected to receive the greatest increase in runoff, while the eastern edge may experience minor changes. Interestingly, the baseline runoff map displays an irregularly high runoff value over Hamilton City. This elevation is likely the result of the

anthropogenic effect of a densely populated district, and associated impervious areas, on the runoff.

(7) The historical annual mean wind speed in Waikato region is 3.23 m/sec, it is 11.62 km/hr, and the seasonal variations are not significant. Higher wind speeds occur in Coromandel and West Coast areas. Based on the VCSN data 1997-2020, the average wind speed shows a weak decreasing trend, 0.093m/sec (0.335 kph) per decade. The average annual wind speed of the Waikato Region decreases across both scenarios into 2090, compared to the baseline. Seasonally, while the wind speed declines for the summer and autumn months, it could increase slightly over the winter and spring months for both SSP scenarios. The districts predicted to experience the most significant increases in wind speed are primarily the Waitomo and Taupō Districts.

(8) The historical daily extreme precipitation data is obtained from HIRDSv4. Average Return Intervals (ARI) of 10-, 20-, 50-, 100-, and 250-year data was analysed for the historical period. The highest extreme precipitation occurs in the Coromandel area, where events can reach more than 600mm for a 1 in 250-year return event. The areal average of 100-year return daily extreme precipitation is 197 mm. Daily extreme precipitation is predicted to increase out to 2090 across all ARIs and for both SSP scenarios for the Waikato Region. The rate of change increases over time between 2050, 2070, and 2090. The most extreme precipitation intensity tends to occur in the Coromandel District.

(9) Station specific analysis was applied for the 31 stations which have relatively long records of hourly wind speed data. Extreme wind speed generally increases out to 2090 across most districts of the Waikato region. Some of the districts which may experience the greatest increase in extreme wind speed include Waitomo and Taupō districts which could increase by 4.9% in 2090, compared to their baseline. It should be noted that South Waikato does not have adequate data for the extreme wind speed analysis.

(10) PED increases into 2090 for both SSP2-4.5 and SSP5-8.5 scenarios. As expected, the additional area where the PED exceeds 200 mm is far greater than that exceeding 400 mm. Districts with the highest area with a PED larger than 200 mm and 400 mm include the Hauraki and Waikato districts.

(11) Based on data provided by WRC, almost 600 million m^3 of water is taken per annum under consent in the Waikato region. Of this volume, 479 million m^3 comes from surface water, and 119 million m^3 from groundwater. Across the whole region, municipal supply is the largest proportion, taking more than 310 million m^3 or 51% of the total volume. In contrast, industrial activities consume just less than a quarter of the volume. Despite only utilising 7% of the total volume of water, stock water takes required almost 2500 consents, whereas municipal supply takes only resulted in 196 consents. While surface water take was also predominantly utilised by town supply activities, groundwater was predominantly used for industrial activities (35%).

(12) The economic index analysis for the Waikato Region suggests that the modified employment count (MEC) is likely to increase into 2090 for industrial, 'town supply' and the 'other' sectors. Furthermore, while agriculture experienced a decline in MEC between 2018 and 2020 of 1.2%, it is likely to recover by 2030 and continues to increase by more than 10% by 2060. The value-added statistics demonstrate the same trends as the MECs.

(13)Finally, from a population of about 475,600 in 2018, the Waikato Region grew by 3.56% in 2020. The population will likely grow by more than 20% by 2040 and more than 35% in 2060, relative to the baseline. More details regarding water supply and demand trends and projections can be found in the accompanying "Climate Change Impacts on Water Resources and Water Demand Trends in the Waikato Region Report.

(14)The water availability and demand issues across the Waikato region was investigated using historical and CMIP6 GCM scenario data. In addition, statistical results of potential changes in precipitation and PET were analysed for the integrated water management zones and aquifers as identified by WRC.

(15)Historical variability and changes in the trend of precipitation were analysed over the Waikato region. Recent low precipitation years have raised general awareness of water supply and demand issues. However, there is no clear signal of annual precipitation decrease at the historical decadal scale.

(16)Precipitation changes in CMIP6 model data have indicated a median model annual ensemble signal of less than a possible 1.0 % decrease in annual precipitation. However, sub-annually the median model ensemble signaled a potential 5.0 % decrease over the spring and summer seasons by 2090. This signal was not in CMIP5 GCM ensemble median ensemble projections. Notably, the intermodal variability range across the ensemble of 45 CMIP6 models, in reference to the CMIP5 models, depicts greater decreases and increases, and underscores the uncertainties across the projections.

(17)Notably, historical PET has increased significantly at approximately 100 mm over recent decades across many of the region's territorial authorities. Under the modelled scenarios, the continued increase in temperature under CMIP6 modeling could increase PET, from 4% to 5% under SSP2-4.5 2050, and up to 12 to 15% under SSP5-8.5 in 2090 in ensemble median. However, the median increase may be conservative, given observed PET increases of about 10% over the last few decades.

(18)Historical runoff data were investigated using NOAA reanalysis data. Runoff changes show a similar yet stronger decreasing signal in the spring and summer seasons. Therefore, the future runoff is projected to decrease in both SSP scenarios applied. The decrease of precipitation and runoff and the increase of PET will likely lead to a reduction in surface water and groundwater resources, plus lead to drier soil conditions, especially during late spring and summer, particularly for the northern part of the Waikato region.

(19)Historical surface water variabilities were investigated using streamflow data from 29 gauges across the Waikato region. Q5 low flow, defined as the threshold of allocable surface water, was calculated for each decade. In recent decades many of the stations have shown a decline in Q5 flow. Thus, the allocable surface water resources are diminishing.

(20)The allocable amount of surface water has been either fully or over-allocated in several catchments. A total of 53% of surface water has been allocated across the Waikato region. At the same time, 6% of the groundwater of the mapped reserves of the Waikato region is allocated.

(21)Groundwater availability was investigated using 28 aquifer areas. The WRC's documented precipitation recharge fraction approaches were applied. Thus, groundwater recharge represents a relatively small proportion of the annual mean precipitation.

(22)Future water demand was projected for population and economic activities applying the WISE (2018 baseline) projections. By 2050 the medium projection of regional population could increase by 28.5% (with a modelled range of between 13.3% and 43.8%) and 35.5% (between 14.4% and 56.77%) in 2060. These changes are in part driven by higher population increases in Hamilton City and the Waikato District rather than evenly across the other Districts.

(23)The increase in population and economic activities, barring technological changes, will likely increase the region-wide demand for water. With water demand in proportion to population, all the allocable surface water could be allocated between 2050 and 2060 under the high population projection.

(24) Currently, low stream flows occur widely in March and April. For example, the lower Waikato River is on average only 50% of the high flow that has been historically reached in August. The seasonal variabilities of streamflow are already resulting in noticeable water allocation tensions. Under both modelled climate change scenarios, stream flows during the drier spring and summer seasons are projected to decrease due to increasing temperatures and evapotranspiration and the concomitant potential for a decrease in annual and more pronounced seasonal precipitation.

Appendix 3 Regional Climate Action Roadmap - energy and industry commitments

Goals for success from the council's strategic direction:

- Work with iwi partners and stakeholders to agree options and equitable pathways to help guide industries and communities to reduce use of fossil fuels and increase energy efficiency in our transition to a resilient, low emissions economy.
- Deliver an updated regional energy strategy and facilitate an increase in access to and use of renewable energy.
- Achieve year on year progress toward reducing the council's own corporate emissions, including through our supply chain, consistent with New Zealand's target for net zero greenhouse gas emissions by 2050.

5.1 Understand how our region is likely to change (land use, economy, industries, energy profile) as we reduce reliance on fossil fuels and transition to a low-emissions economy and ensure that appropriate regional policy statement and regional plan settings are in place to enable regional opportunities to achieve this transition.

5.2 Review policies and rules in regulatory plans to:

- include promotion of energy efficient developments and associated supporting infrastructure
- facilitate access to energy rich natural resources as a substitute for use of fossil fuels
- ensure present regional policy statement settings for outstanding natural features and landscapes are compatible with the land use changes associated with grid-scale solar PV sites.

5.3 Actively engage in the development of offshore renewable energy to ensure regulatory settings are in place and fit for provision of appropriate transmission infrastructure to connect ocean-based developments off the region's west coast.

5.4 Advocate to electricity generators and retailers, distribution network operators and central government to remove commercial barriers to property scale (distributed) PV generation of electricity.

5.5 Work with relevant stakeholders, including network operators, Transpower, territorial authorities and iwi, to ensure existing electricity transmission infrastructure and new elements (generation and transmission) are designed and located to futureproof for a changed climate.

5.6 Advocate for increased Māori involvement in renewable electricity generation and ensure that Māori values are integrated into any decision-making processes.

5.7 Understand the benefits of and drawbacks to innovative energy technologies, such as waste to energy.

5.8 Consider consents for GHG air discharges and make changes to regional plan and relevant policy statements to be consistent with national direction.

5.9 Work collaboratively with territorial authorities to develop a consistent approach when considering the use of council property to support community renewable electricity generation and battery storage initiatives.

Appendix 4 Key district plan provisions relating to energy

This appendix identifies key sections relevant to energy matters in the district plans within the region. This predominantly focuses on the supply side of energy, including the activity statuses for new renewable electricity generation activities.[140]

Some key sections of district plans relevant to the demand side of energy are also identified below, however, as discussed in Section 9.10 of the inventory, demand-side aspects are affected by the many interacting elements within district plans. Therefore, it is recommended that the provisions of each district plan be read in conjunction with relevant planning maps to understand the impacts on energy demand within each district.

Waikato district

Two district plans currently apply in the Waikato district: the Operative Waikato District Plan – Franklin Section (2000) and Waikato Section (2013)[141] and the Proposed Waikato District Plan – Appeals Version.[142]

The key sections of the Proposed Waikato District Plan – Appeals Version relevant to energy are:[143]

- **UFD – Urban form and development chapter**
    - The objective of this chapter is a compact urban form that provides for connected, liveable communities.
- **AINF – All infrastructure chapter**
    - Contains objectives and policies relating to the National Grid, energy efficiency, increasing renewable electricity generation, recognising non-renewable energy resources and electricity generation within the district, the land transport network and improving the resilience of infrastructure.
    - Provides general rules for infrastructure.
- **EIT – Infrastructure, energy and transport section** - contains the below chapters of particular relevance.
- **EDIS – Electrical distribution chapter**
    - Provides rules for electricity distribution lines and associated infrastructure.

- **EGEN – Electricity generation chapter**
    - Contains rules for electricity generation activities, including small and community-scale electricity generation, research and exploratory-scale investigations for

[140] The following categories of activity exist under the Resource Management Act 1991:

- Permitted - can be carried out without resource consent if it complies with all relevant rules in the district/regional plan.
- Controlled - requires resource consent but the application must be granted by the council. The council can impose conditions relating to specified matters over which it has reserved control.
- Restricted Discretionary - requires resource consent and the council exercises its discretion in deciding whether to grant or decline consent. The council's discretion to grant or decline the consent and impose conditions is restricted to the matters listed in the district/regional plan.
- Discretionary - requires resource consent and the council may exercise its full discretion when deciding whether to grant or decline consent and on any conditions it imposes.
- Non-Complying - requires resource consent and will only be granted if it can be shown that the activity is not contrary to the objectives and policies of the plan or that the adverse effects on the environment are minor.
- Prohibited - cannot be carried out; resource consent cannot be applied for or granted.

[141] Operative District Plan (waikatodistrict.govt.nz)
[142] Proposed Waikato District Plan - Appeals Version
[143] Many of the relevant provisions within the Proposed Waikato District Plan – Appeals version are under appeal and are therefore subject to potential change.

renewable electricity generation, large-scale wind farms and electricity generation within the Huntly Power Station site.

Activity statuses for new renewable electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
Small-scale electricity generation and community-scale electricity generation.[144] Includes freestanding and roof-mounted wind turbines (subject to standards relating to location, maximum number per site and size and noise limits) and rooftop solar panels (subject to height limits).	Permitted - all zones. Restricted Discretionary where compliance not achieved.
Large-scale wind farms.	Discretionary - General rural zone, if not within an Identified Area. Non-Complying - all other zones and within Identified Areas in the General rural zone.

- **LFG – Liquid fuels and gas chapter**
  - Provides rules for liquid fuel and gas pipelines, storage facilities and pump stations operated by a network utility provider.
- **GRID – National Grid chapter**
  - Provides rules for electricity transmission lines and associated infrastructure, as well as other activities in proximity to the National Grid.

Waipā district

Operative Waipā District Plan (2017)[145] - key sections relevant to energy:

- **Section 1 – Strategic Policy Framework**
  - Contains objectives and policies relating to a consolidated settlement pattern and energy and resource efficiency.
- **Zone Sections**
  - Contain objectives and policies relating to the operation, maintenance and development of the National Grid and rules for activities in proximity to the National Grid.
- **Section 12 – Karāpiro and Arapuni Hydro Power Zone**
  - Provides for the development, operation, maintenance and upgrading of existing and new hydroelectric power generation infrastructure and activities in a manner that avoids, remedies or mitigates any significant adverse effects on the environment and the health and well-being of the Waikato River.
- **Section 15 – Infrastructure, Hazards, Development and Subdivision**
  - Contains objectives and policies relating to sustainable design, urban consolidation, and the National Grid.
  - Contains rules for subdivision in proximity to the National Grid.
- **Section 16 – Transportation**
  - Contains objectives and policies relating to sustainable multi-modal land transport systems, and associated rules.
- **Section 17 – Works and Utilities**

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[144] "Small-scale electricity generation" and "community-scale electricity generation" are defined in the Interpretations chapter.

[145] Waipā District Plan - Waipa District Council (waipadc.govt.nz)

- Contains objectives, policies and rules relating to electricity transmission and distribution, hydroelectricity generation and individual and small-scale renewable electricity generation.
- Provides rules for electricity transmission and distribution, gas pipelines and methods of electricity generation, including wind turbines, rooftop solar panels, solar power generation plants, bio gas, co-generation plants and coal fired generation.

Activity statuses for new electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
One wind turbine per site, subject to rules relating to maximum size/height and noise.	Permitted - Residential, Large Lot Residential, Rural and Deferred Zones. Discretionary - other zones and within specified areas (e.g. Outstanding Natural Features and Landscapes, Significant Natural Areas, and character areas).
More than one wind turbine.	Discretionary - Residential, Large Lot Residential, Commercial, Industrial, Rural and Deferred Zones. Non-Complying - all other zones and within specified areas.
Solar power generation plants.	Discretionary - all zones, except special purpose zones (Chapters 8-11 and 13) (Non-Complying).
Solar power generation collector panels up to 6m^2 on buildings.	Permitted - all zones.
Solar power generation collector panels greater than 6m^2 on buildings. [146]	Permitted - all zones, except within an Outstanding Natural Feature and Landscape, identified character precent area, character cluster or character street (Restricted Discretionary).
Bio gas produced by anaerobic fermentation of waste not exceeding 4m^2 per day.	Permitted - Commercial, Industrial, Rural and Deferred Zones. Non-Complying - all other zones.
Bio gas produced by anaerobic fermentation of waste exceeding 4m^2 per day.	Discretionary - Commercial, Industrial, Rural and Deferred Zones. Non-Complying - all other zones.
Co-generation plants, natural gas, and biomass generators of electricity.	Discretionary - Industrial Zone. Non-Complying - all other zones.

Hamilton city

[146] Draft Plan Change 30 – Minor Technical Amendments is proposed to include changes to Chapter 17, including to the size limit for solar power generation collector panels attached to buildings and to mitigate effects in protected landscapes, the inclusion of standards pertaining to glare and projection from the roof. [Draft Plan Change 30 – Minor Technical Amendments - Waipa District Council (waipadc.govt.nz)]

Operative Hamilton City District Plan (2017)[147] - key sections relevant to energy:

- **Chapter 2 – Strategic Framework**
  - Contains objectives and policies relating to sustainable urban form, efficient use of land, resources and infrastructure, and minimising energy use.
- **Zone chapters**
  - Contain objectives and policies relating to efficient use of land and infrastructure and use of energy-efficient and sustainable design technologies.
- **Chapter 25.7 – Network Utilities and the Electricity National Grid Corridor**
  - Contains objectives and policies relating to network utilities, the electricity transmission network and increasing use and development of renewable energy resources, including encouraging small and community-scale distributed generation.
  - Provides rules for electricity transmission and associated structures, electricity distribution, gas transmission pipelines, electricity generation (including wind energy facilities, small and community-scale distributed generation and solar panels) and activities in proximity to the National Grid.

  Activity statuses for new renewable electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
Wind energy facility and windpower generators for bulk power supply.	Discretionary - all zones.
Small scale distributed renewable energy generation.	Permitted - all zones.
Community scale distributed renewable energy generation.	Discretionary - all zones.
Solar panels and solar heating systems for the purposes of serving the site on which they are located.	Permitted - all zones.
Solar panels and solar heating systems for the purpo ses of serving more than one site.	Restricted Discretionary - all zones.

  *All subject to standards relating to height, size and building setbacks.

- **Chapter 25.14 – Transportation**
  - Contains objectives and policies relating to an integrated, multi-modal transport network, including promotion of energy efficiency and conservation, and associated rules.
- **Chapter 25.15 – Urban Design**
  - Contains objectives and policies relating to subdivision and development that promotes sustainable energy use and connected and sustainable transport networks.

Thames-Coromandel district

Two district plans currently apply in the Thames-Coromandel district, the Operative Thames-Coromandel District Plan (2010)[148] and the Proposed Thames-Coromandel District Plan – Appeals Version (December 2023)[149].

[147] Home - Hamilton City Operative District Plan (isoplan.co.nz)
[148] TCDC_ODP2010_External
[149] TCDC_Appeals2016_External

The key sections of the Proposed District Plan – Appeals Version relevant to energy are:[150]

- **Section 15 – Development and Growth**
    - Contains objectives and policies relating to the coordination of growth and infrastructure, including encouraging intensification, increasing energy efficiency and protection of the national grid.
- **Section 18 – Transport**
    - Contains objectives and policies relating to integrated and efficient transport networks, including being energy efficient.
- **Section 19 – Utilities**
    - Contains objectives and policies relating to network utilities and renewable electricity generation.
- **Section 30 – National Grid Overlay**
    - Provides rules for activities in proximity to the National Gird.
- **Section 37A – Electricity and Telecommunications Distribution, Transmission and Generation**
    - Contains rules for electricity lines, solar panels, and wind turbines.

Activity statuses for new renewable electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
Solar panels.	Permitted - all zones (subject to compliance with size and zone performance standards within Residential Areas). Restricted Discretionary where compliance not achieved.
Wind turbines.	Permitted - Airfield Zone, Conservation Zone, Industrial Zone and the Rural Area (subject to compliance with rules relating to size, height and maximum number of turbines). A wind turbine that is not a Permitted activity is a Restricted Discretionary activity.

Hauraki district

Operative Hauraki District Plan – Hauraki Section (2014)[151] - key sections relevant to energy:

- **Section 3.9 – Significant Resource Management Issues – Energy**
    - Identifies energy as one of the significant resource management issues for the Hauraki district and describes the role of the District Plan in relation to energy (including transport, generation facilities and energy efficiencies in subdivision and development design).
- **Section 7.4 – Provosion for Network Utilities and Energy Generation**
    - Contains objectives and policies relating to the development, maintenance and upgrading of network utilities and the sustainable utilisation and management of the district's natural and physical resources for electricity generation and associated infrastructure.
    - Contains rules for electricity generation activities, including electricity generation for on-site domestic use and other renewable electricity generation activities.

Activity statuses for new renewable electricity generation activities

Activity	**Activity status**

[150] Some provisions within the Proposed Thames-Coromandel District Plan – Appeals version are under appeal and are therefore subject to potential change.
[151] District Plan Text - Hauraki Section - Hauraki District Council (hauraki-dc.govt.nz)

	(subject to compliance with all other relevant district plan rules)
Electricity generation facilities/plants/schemes for on-site domestic use.	Permitted - all zones (subject to compliance with the relevant zone development standards).
Other renewable electricity generation activities.	Discretionary - Rural Zone.
Any other electricity generating activity not provided for above.	Non-Complying - all zones.

- **Section 8.2A - Buildings, Structures, Subdivision and Earthworks within a High Voltage Transmission Corridor**
  - Provides rules for activities in proximity to high voltage transmission lines.

Operative Hauraki District Plan – Franklin Section (2000)[152] - key sections of relevance to energy:

- **Part 3B –Sustainable Management and Enhancement of the Natural Environment**
  - Identifies renewable energy as a key resource management issue for the district.
- **Part 15.1 – Network and other utilities and essential services**
  - Provides objectives, policies, and rules relating to the development, operation, and maintenance of network utilities (which includes gas pipelines and electricity transmission and distribution lines) and electricity generation.

Activity statuses for new renewable electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
Generation of less than 1MVA of output of electricity from wind or solar sources.	Permitted - all zones (subject to compliance with the performance standards for the relevant zone).
Other electricity generation.	Discretionary – all zones.

Matamata-Piako district

Operative Matamata-Piako District Plan (2015)[153] - key sections relevant to energy:

- **Section 2.3 – Significant resources management issues**
  - Identifies renewable electricity generation as a significant resource management issue for the Matamata-Piako district and discusses the importance of, and ways to achieve, energy efficiency.
- **Section 2.4 - Sustainable management strategy**
  - Contains objectives and policies relating to energy efficiency and renewable electricity generation.
- **Section 3.7 – Works and network utilities**
  - Provides objectives and policies relating to provision of network utilities (including electricity distribution lines).
- **Section 8.2 – Electricity transmission and distribution activities**
  - Provides rules for electricity transmission and distribution facilities.
- **Section 8.3 – Renewable energy generation activities**
  - Provides rules for electricity generation activities, including small-scale and community-scale electricity generation, large-scale wind farms and other renewable electricity generating activities.

[152] District Plan Text - Franklin Section - Hauraki District Council (hauraki-dc.govt.nz)
[153] District Plan (mpdc.govt.nz)

Activity statuses for new renewable electricity generation activities

Activity	Activity status (subject to compliance with all other relevant district plan rules)
Small-scale renewable energy generation (subject to compliance with height, size, and noise limits).[154]	Permitted - all zones. Restricted Discretionary where compliance not achieved.
Community-scale renewable energy generation (subject to compliance with height, size, and noise limits).[155]	Permitted - Business, Industrial and Rural Zones. Restricted Discretionary - Kaitiaki (Conservation), Identified Significant Features, Residential, Medium Density Residential and Rural Residential Zones, Settlement Zone (Residential Precincts) and Public Reserves.
Large-scale wind farms.	Restricted Discretionary - Business, Industrial and Rural Zones. Discretionary - Kaitiaki (Conservation) Zone and Identified Significant Features. Non-Complying - all other zones.
Other renewable energy generating facilities.	Discretionary - Business, Industrial and Rural Zones. Non-Complying - all other zones.

- **Section 8.4 – Liquid fuels and gas transmission and distribution**
  - Provides rules for gas distribution pipelines and other associated infrastructure.

South Waikato district

Operative South Waikato District Plan (2015)[156] - key sections relevant to energy:

- **Chapter 6.2 – Managing and Providing for Infrastructure, Communications and Major Industrial Sites**
  - Identifies managing and providing for infrastructure, communications, and major industrial sites as a significant resource management issue for the South Waikato district. This includes discussion of the Waikato Hydro Scheme, sustainable development of other renewable energy sources, the electricity transmission network and gas transmission.
- **Chapter 7.1 – ENGY Energy**
  - Provides objectives and policies for energy, including improving energy efficiency, enabling production of energy from renewable sources in a sustainable manner and encouraging adaptability to climate change.
  - Contains rules for network utilities and electricity generation.

Activity statuses for new renewable electricity generation activities

Activity	Activity status (subject to compliance with all other relevant district plan rules)

[154] "Small-scale energy generation" is defined in Section 15 – Definitions.
[155] "Community-scale energy generation" is defined in Section 15 – Definitions.
[156] District Plan - South Waikato District Council

Domestic scale renewable energy devices (provided they do not involve water storage and subject to rules relating to aquatic effects and height).[157]	Permitted - all zones. Where compliance with relevant standards is not achieved – Restricted Discretionary.
Community scale renewable energy development except for hydro-electric generation (provided it is not located within an Outstanding Natural Landscape or Feature and subject to rules regarding area and height).[158]	Permitted - all zones. Where compliance with relevant standards is not achieved – Restricted Discretionary.
Community scale renewable energy development using hydro-electric generation.	Restricted Discretionary - all zones.
Other *network utilities and infrastructure* for electricity generation and gas.	Discretionary – all zones.

- **Chapter 7.3 – TRAN Transport**
  - Contains objectives and policies relating to an integrated transport network and provision for alternative transport modes (particularly walking and cycling).
- **Chapter 14.2 – SPZ-ELG Electricity Generation**
  - Recognises that that five hydroelectric power generating facilities are located on the Waikato River within the South Waikato district.
  - Provides objectives and policies relating to renewable electricity generation.
  - Provides objectives, policies and rules relating to the development, operation, and maintenance of the components of the Waikato hydro scheme.

Ōtorohanga district

Operative Ōtorohanga District Plan (2014)[159] - key sections relevant to energy:

- **Renewable Electricity Generation Policy Area**
  - An area identified on the planning maps to recognise and provide for the activities, operations and infrastructure associated with electricity generation at the Waipapa Core Site as well as the larger Waikato Hydro Scheme.
- **Issue 3 – Rural Character and Issue 5 – Neighbourhood Character**
  - Contain a policy promoting the use of energy efficient design, orientation, and layout, in subdivision, building and development, where approriate.
- **Issue 6 – Subdivision of land**
  - Contains objectives and policies relating to controlling adverse effects of subdivision in proximity to high voltage electricity transmission lines and gas lines.
- **Issue 11 – Network Utility Operations and Electricity Generation**
  - Provides objectives and policies to recognise and provide for the operation, maintenance, upgrading and development of the high voltage electricity transmission network and renewable energy activities.
- **Land Use Chapter - Section 1 – District Wide Rules**
  - Contains rules for electricity and gas infrastructure, and electricity generation infrastructure and activities within the Renewable Electricity Generation Policy Area (the Waipapa Core Site).

[157] "Domestic scale renewable energy devices" is defined in Chapter 3.1 – Definitions.
[158] "Community scale renewable energy development" is defined in Chapter 3.1 – Definitions.
[159] District Plan - Ōtorohanga District Council (otodc.govt.nz)

Waitomo district

Two district plans currently apply in the Waitomo district, the Operative Waitomo District Plan (2009)[160] and the Proposed Waitomo District Plan – Notified Version (2022)[161].

The key section of the Operative District Plan of relevance to energy is:

- **Section 15 – Network Utilities**
    - Provides objectives, policies, and rules for network utilities, including gas transmission and distribution pipelines, and electricity transmission and distribution lines.

The key sections of the Proposed District Plan – Notified Version relevant to energy are:[162]

- **Chapter 16 – Strategic direction, urban form and development**
    - Contains objectives relating to increased use of renewable energy sources, greater energy conservation and encouraging urban development that supports reductions in greenhouse gas emissions and minimises energy demand.
- **Chapter 17 – Energy**
    - Provides objectives and policies relating to energy, including increasing community resilience through renewable electricity generation, recognising the national significance of renewable electricity generation activities, and encouraging the efficient use of energy.
    - Contains rules relating to solar panels, hydroelectricity generation, wind turbines, biogas, co-generation plants and coal fired electricity generation.

Activity statuses for new electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
Solar panels attached to an existing building.	Permitted - all zones, except if attached to heritage buildings or structures (Restricted Discretionary).
Freestanding solar panels up to and including $6m^2$ per site.	Permitted - all zones, except outstanding natural landscapes, outstanding natural features, outstanding natural character, heritage buildings and structures, sites or areas of significance to Māori and significant archaeological sites (Restricted Discretionary).
Freestanding solar panels greater than $6m^2$ and up to $25m^2$ in area per site (subject to compliance with setback rules for the relevant zone).	Permitted - Industrial, General Rural and Rural Production Zones. Restricted Discretionary - all other zones.
Hydroelectricity generation of up to and including 5kW of electricity per site (maximum total gross floor area of all structures must not exceed $2m^2$).	Permitted - all zones, except outstanding natural features, sites and areas of significance to Māori, significant archaeological sites, outstanding natural character (Restricted Discretionary).

[160] Operative Waitomo District Plan - Waitomo District Council
[161] Proposed Waitomo District Plan - Waitomo District Council
[162] Most rules within the Proposed Waitomo District Plan will not apply until decisions on submissions have been issued. Currently, only those rules with immediate legal effect in accordance with section 86B of the Resource Management Act 1991 apply.

Hydroelectricity generation activities with an output of more than 5kW and up to 20kW of electricity per site.	Restricted Discretionary - all zones, except heritage buildings and structures, sites and areas of significance to Māori, significant archaeological sites, outstanding natural character (Discretionary) and outstanding natural features (Non-Complying).
One wind turbine with a rated capacity of up to and including 5kW per site, except for the Industrial, General Rural, Rural Production Zones & PREC3 where the maximum is two wind turbines with a rated capacity of up to and including 5kW each per holding (subject to compliance with height, size, boundary setback and noise rules).	Permitted - all zones, except heritage buildings and structures, sites and areas of significance to Māori, significant archaeological sites, outstanding natural character (Discretionary) and outstanding natural features (Prohibited).
New renewable electricity generation activities including community scale renewable electricity activities not otherwise provided for.	Discretionary - all zones, except outstanding natural landscapes, outstanding natural features, heritage buildings and structures, sites or areas of significance to Māori, significant archaeological sites (Non-Complying) and outstanding natural features, outstanding natural character (Prohibited).
Biogas produced by anaerobic fermentation of waste (not exceeding 4m^3 per day and subject to boundary setback standards).	Permitted - outstanding natural landscapes, General Rural, Rural Production and Industrial Zones, coastal environment, karst overlay, high/very high natural character, landscapes of high amenity value. Non-Complying - all other zones.
Co-generation plants and waste to energy plants.	Discretionary - General Rural, Rural Production and Industrial Zones. Non-Complying - all other zones.

- **Chapter 18 – National Electricity and Gas Transmission**
  - Provides objectives, policies and rules relating to protection of the National Grid and gas transmission lines.
- **Chapter 19 – Network Utilities**
  - Contains objectives, policies and rules relating to effective, resilient, efficient, and safe network utilities.
- **Chapter 20 – Transport**
  - Contains objectives and policies relating to a well-connected, integrated, and accessible transport system, including promoting walking and cycling and reducing dependency on private motor vehicles.
  - Contains rules relating to transport, including a rule for electric vehicle charging stations.

Rotorua Lakes district

Operative Rotorua District Plan (2016)[163] - key sections relevant to energy:

[163] District Plan - Rotorua Lakes Council

- **EIT – Energy, Infrastructure and Transport**
  - Contains objectives and policies relating to high voltage electricity transmission, the transport network and sustainable utilisation of the district's natural and physical resources for electricity generation.
  - Contains rules for electricity lines, gas transmission pipelines, electricity generation infrastructure (including for hydro, geothermal, wind and solar electricity generation faculties) and activities in proximity to the National Grid.

    Activity statuses for new renewable electricity generation activities

Activity	**Activity status** (subject to compliance with all other relevant district plan rules)
New hydroelectricity generation facilities.	Controlled - Industrial 2 Zones. Discretionary – all other zones.
New geothermal electricity generation facilities on a geothermal field shown for development on the planning maps.	Controlled - Industrial 2 Zones. Discretionary – all other zones.
Large scale wind turbines or solar electricity generation facilities.	Discretionary - Rural Zone.

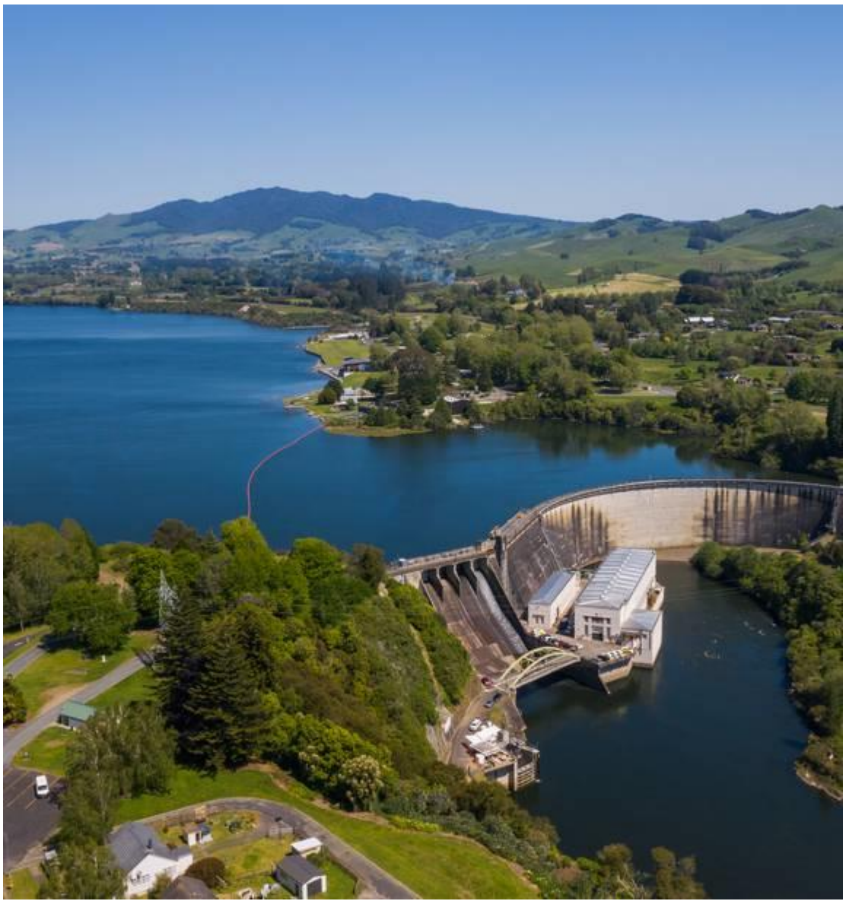
- **SDRE – Renewable Energy and Emission Reduction**
  - Provides an objective and policies relating to sustainable and efficient use, development, operation, maintenance and upgrading of renewable electricity generation resources.

Taupō district

Operative Taupō District Plan (2007)[164] - key sections relevant to energy:

- **Chapter 3b – Rural Environment**
  - Contains policies relating to management of subdivision of rural land overlying Geothermal Areas to avoid conflict with geothermal electricity generation on identified Development and Limited Development Geothermal Systems and providing for the continued operation and associated development of existing electricity generation facilities and network utilities in the rural environment.
- **Chapter 3f – Traffic and Transport**
  - Contains objectives and policies relating to operation of the transport network, including encouraging use of alternative modes of transport.
- **Chapter 3n – Network Utilities**
  - Contains objectives and policies relating to the operation, maintenance, and provision of network utilities.
- **Chapter 3o – Geothermal Activity**
  - Contains objectives and policies relating to geothermal resource use and development.
  - Provides maps of Geothermal Development and Limited Development Systems within the Taupō district.
- **Chapter 4b – Rural Environment**
  - Provides that any activity involving continued operation, maintenance, and minor upgrading of existing electricity generation core sites, geothermal steamfields and associated structures is a Permitted activity.
- **Chapter 4e.14 – Network Utilities**
  - Contains rules for network utilities and associated structures, including electricity lines.

[164] District Plan - Taupō District Council (taupodc.govt.nz)



ANALYSIS OF THE NEW ZEALAND ELECTRICITY SECTOR

ABSTRACT
This report aims to provide an unbiased analysis of the New Zealand electricity sector. The report has been written, primarily to be used as a reference in the Waikato Regional Energy Inventory.

Written by Aidan Nelson

Waikato Regional Council
Te Kaunihera ā Rohe o Waikato

Executive Summary

This report outlines the New Zealand electricity sector, including the generation, transmission, distribution, and retail components.

The sector has been shaped by the Electricity Industry Reform Act 1998, which has resulted in the four major companies, Mercury, Genesis Energy, Contact Energy, and Meridian, which have an oligopoly over both generation and the retail market. The state-owned enterprise Transpower operates the national grid and is responsible for distributing electricity around the country as a monopoly. Transpower is regulated by the Electrical Authority. The distribution subsector is comprised of 27 separate lines companies, with local networks that operate as monopolies over their respective region of New Zealand. Each distributor is subject to price-quality regulation from the Commerce Commission.

The Waikato region is crucial in New Zealand's energy production. It has a large amounts of renewable energy resources like geothermal, hydro, and wind, as well as the Huntly thermal power station. The region's strong transmission infrastructure and proximity to the Auckland market make it an attractive location for energy companies to invest in.

The generators sell electricity to retailers through a spot pricing mechanism, where prices are determined by real-time supply and demand conditions. Vertical integration allows the four major generators to sell electricity to their own retail arms first before offering the remaining supply to the wholesale market (the generators are often called 'gentailers' for this reason). This practice has sparked controversy, with smaller competitors accusing gentailers of setting higher prices for third parties than they charge their own retail arms.

The gentailers' pricing is driven by profit-maximisation objectives. While some of the gentailers are part-owned by the New Zealand government, they are driven by a legal obligation to be as profitable and efficient as non-Crown-owned businesses. Hence, while the government may have other objectives (such as maximising consumer surplus or decarbonisation of the economy) these are subsidiary to the gentailers' requirement to generate profits.

The electricity market in New Zealand has experienced steep price increases over the past two decades, with a 48 per cent rise in residential power prices since 2000. The dominance of the four major gentailers in an oligopoly limit competition and might be expected to lead to prices above marginal cost. Entry barriers in the electricity sector are high due to significant capital requirements, regulatory hurdles, and vertical integration of gentailers. The four large gentailers' use of vertical integration to self-hedge against spot price volatility hinders competition from smaller retailers and generators, and arguably impacts long-term infrastructure development.

The four main gentailers all have significant market shares, allowing them to exercise market power. Economic theory would suggest this creates the potential for anti-competitive behaviour and prices above marginal cost. Consumers lack an effective voice in the electricity sector, as electricity is considered a necessity with inelastic demand (i.e. demand does not change much when prices increase). Steady price increases over the last two decades, limited alternatives, and inelastic demand reduce consumer power. Changes in electricity prices have shown no significant effect on residential consumption, emphasising consumer vulnerability. Electricity, being a fundamental and essential service, has limited substitutes. While decentralised renewable sources like solar panels may provide an alternative, high costs currently limit widespread adoption.

The sector as it currently exists

Generation: Around 80 per cent of New Zealand's electricity comes from renewable sources. However, this percentage fluctuates because of the variability of the renewable sources available such as rain, wind and solar energy. Electricity in New Zealand is generated primarily by four major companies. Three of these companies, Genesis, Mercury and Meridian Energy, operate under a mixed ownership model in which the government holds a majority stake. Contact Energy is a private sector company.

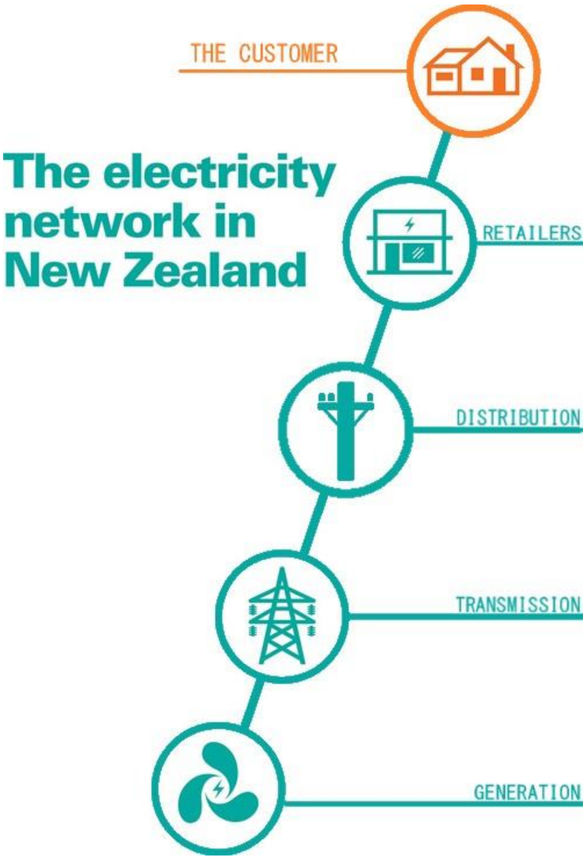


Figure 1: Displays a simplistic diagram of the energy network in New Zealand

Transmission: In New Zealand, transmission is controlled by Transpower. Transpower is a state-owned enterprise, which has sole ownership and the right to operate New Zealand's national electricity transmission system. This supplies electricity to lines companies using high capacity, high voltage transmission lines. Transpower is responsible for ensuring that electricity supply and demand match throughout the day. Furthermore, it is tasked with ensuring the grid is reliable and secure.[165]

New Zealand's electricity grid is an AC transmission system, with a DC connection from the southern South Island at Benmore Station on the Waitaki River, across Cook Straight by undersea cable to the southern end of the North Island. This type of transmission is called a high voltage direct current (HVDC) system. The national grid spans over 12,000km of transmission lines, with more than 170 substations.[166]

Distribution: Electricity is distributed throughout New Zealand by 27 lines companies (all members of the Electricity Network Association). Lines companies connect to the national grid and distribute the electricity to consumers through their local networks.

Retail: Electricity retailers sell electricity to customers. Retailers buy electricity from generating companies and bill customers for the electricity they consume. Their bills to customers also include the cost of national transmission and local distribution.[167]

History of the New Zealand electricity sector

In 1998, the Electricity Industry Reform Act (EIRA) was enacted. This is commonly referred to as the Bradford reforms. The EIRA aimed to create a competitive electricity market and provide consumers with a real choice of supplier and lower electricity prices. This was done through the deregulation of the electricity market. The reforms split the Electricity Corporation of New Zealand into three

[165] NZIER-assessing-the-New-Zealand-wholesale-electricity-market.pdf (cac.org.nz)
[166] Electricity industry | Ministry of Business, Innovation & Employment (mbie.govt.nz)
[167] Overview of the electricity industry | ENA

competing state-owned enterprises: Mighty River Power (now Mercury), Genesis and Meridian. Contact Energy had been previously created from the Electricity Corporation in 1996.[168] Secondly, the reform enforced a rule that local power companies could not own both a lines business (the local distribution wires) and a generation or retail company. However, this limited regulation did not prohibit companies from owning both generation and retail companies.

In an attempt to introduce some regulation into the electricity sector, the government introduced the Electricity Authority on 1 November 2010 under the Electricity Industry Act 2010 (EIA). The EIA provides the framework for the regulation of the electricity industry. Section 12 of the EIA establishes the Electricity Authority as an independent Crown entity governed under the provisions of the Crown Entities Act 2004. Section 15 of the EIA sets out the main statutory objective: "To promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers." Section 15 of the EIA also sets out an additional objective for the Authority to protect the interests of domestic consumers and small business consumers in relation to the supply of electricity to those consumers. The Authority oversees the operation of the electricity system and markets by developing, setting, and enforcing the rules the market must follow and through contractual arrangements with market service providers. It also aims to hold the industry accountable by actively monitoring the market's behaviour and performance.[169]

The Waikato region's role in the sector

The Waikato region plays a major role in New Zealand's electricity generation. This is in part due to the significant renewable energy generation assets in the region. Waikato is home to the majority of New Zealand's geothermal energy production. Additionally, significant hydroelectric power stations are situated on the Waikato and Tongariro rivers. The nine hydro stations on the Waikato River produce around 10 per cent of New Zealand's total electricity.[170] The Waikato also has consistent strong wind for wind generation, primarily located around Raglan.[171] Finally, solar generation is another viable economically efficient electricity production method in the region.[172]

Of course, not all electricity production in the region is renewable. The Waikato is home to the Huntly power station, which is New Zealand's largest power station producing 953MW of energy annually. Huntly provides a backup for New Zealand: when renewable production is limited, Huntly is able to provide the necessary electricity. However, the power station emits a large amount of $C0^2$ emissions, and while it is required to meet peak demand at times, its operation is inconsistent with the goal of decarbonising the energy sector.

The Waikato has a very strong transmission infrastructure, which attracts investors into the region. Infrastructure is so strong in part because a large amount of electricity generated in the North Island must travel through the Waikato towards Auckland to be used. For companies looking to invest in energy generation, it is likely to be cheaper, other things being equal, to develop in areas of the country with strong transmission infrastructure, such as the Waikato. This is because other parts of the region would require upgrades to transmission infrastructure if new energy projects were developed. This cost would have to be paid by the energy companies.

[168] The 'Bradford reforms' 25 years on - Consumer NZ
[169] Who we are | Electricity Authority
[170] Hydro Generation | Hydro Power Stations | Mercury
[171] Te Uku wind farm | Meridian Energy
[172] Energy (waikato.com)

Market share

There are five main electricity generators in New Zealand: Mercury, Genesis Energy, Contact Energy, Meridian, and Manawa Energy. Meridian is the largest of the five companies, having close to one third of New Zealand's total generating capacity. Over 90 per cent of the time, Meridian is needed to meet demand in New Zealand.[173] Combined, Meridian, Mercury, Genesis, and Contact Energy account for about 90 per cent of power generation. Manawa Energy is the smallest of the main five companies, which produces roughly 5 per cent of New Zealand's existing generation capacity.

The retail market share is largely controlled by the four main generators: Mercury, Genesis Energy, Contact Energy, and Meridian. These four companies are often referred to as 'gentailers', as they both generate and sell energy through retail. Manawa Energy was formerly the gentailer "Trustpower", however in 2022 they sold their retail arm to Mercury, in order to solely focus on generation.[174] Combined, these four generators account for about 85 per cent of the retail market share. The parent company's market share is determined by looking at the number of installation control points (ICPs) it has. An ICP is basically a physical connection point on a local or embedded network. It is a way of measuring the company's presence and influence in the electricity sector by counting the number of connection points it has on different networks.[175] The market share of the primary electricity retailers as at 20 November 2023 is shown below[176].

Company	**ICP Count**	**Percentage**
Mercury	583,304	25.45%
Genesis Energy	541,464	23.62%
Contact Energy	437,389	19.08%
Meridian Energy	370,539	16.16%
Nova Energy	95,090	4.15%
Pulse Energy Alliance	81,853	3.57%
Electric Kiwi	69,570	3.03%
2 degrees	51,065	2.23%
Flick Electric	35,845	1.56%

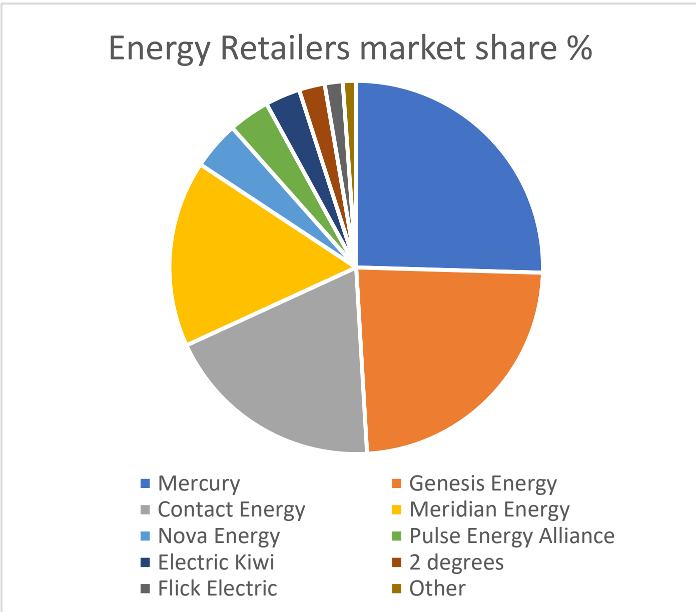


Figure 2: Pie chart displaying the energy retailers' market share

Around 15 per cent, or 357,000 New Zealanders get their electricity from retailers outside the big four, as at 20 November 2023. In 2004, the number of New Zealanders getting their electricity from retailers outside the big four was 4 per cent.[177] This shows a structural shift in the industry, as more

[173] Long-form report (ea.govt.nz)
[174] Trustpower to become Manawa on Thursday - NZ Herald
[175] Biggest Power Providers NZ: Who Has the Largest Market Share? (canstarblue.co.nz)
[176] https://www.emi.ea.govt.nz/Retail/Reports/HR5D1V?_rsdr=M1&RegionType=NZ&_si=v|3
[177] The 'Bradford reforms' 25 years on - Consumer NZ

New Zealanders have shifted to smaller brands, which has created a vocal group of smaller challenger brands.[178]

Distribution, as mentioned earlier, is separated into 27 lines companies. The figure below shows the companies that operate in the Waikato region. There are six lines companies, with three of those companies also spanning regional boundaries.

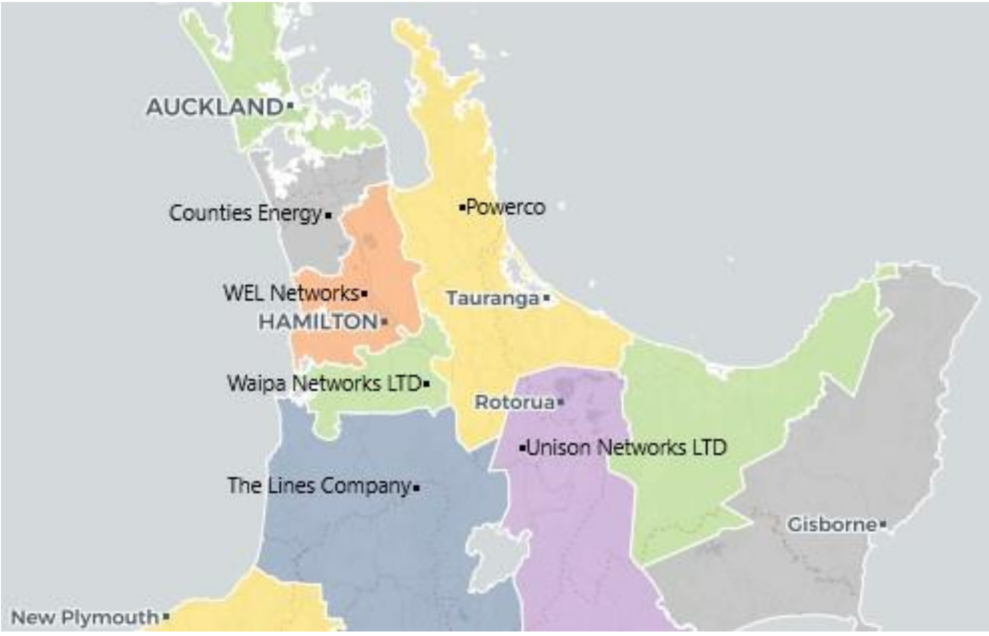


Figure 3: Map displaying the Lines companies located in the Waikato region.

Market power

Market power refers to a firm's ability to influence the prices of their products or services. Under perfect competition, firms do not have the ability to control the prices they set. However, this is not the case in all segments of the electricity market.

The electricity distributors and Transpower have a natural monopoly in their respective sectors, due to the large amount of network infrastructure required to enter the market. These companies could, in an unregulated environment, potentially charge a rate of their choosing, uninhibited by competition from other suppliers. Because of this, the Electricity Authority chooses the rate at which Transpower charges its customers for the services provided,[179] while distributors are subject to price-quality regulation by the Commerce Commission.[180]

The generation sector, with only four main firms, can be described as an oligopoly. Oligopolies form when a few companies have significant control over a market. In this case, this could be expected to allow these electricity gentailers to set their price above marginal cost.

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[178] How the New Zealand electricity market works – and what needs to be fixed | The Spinoff
[179] Regulation | Transpower
[180] Distributors' obligations | Electricity Authority (ea.govt.nz)

How does pricing work?

Electricity generators or gentailers sell electricity at a wholesale price to retailers. The wholesale market operates on a spot pricing mechanism. Prices are determined by supply and demand conditions in real-time. Generators submit offers to supply electricity at different price levels, and the market clearing price is the price at which supply equals demand. This market operates on a half-hourly basis, and prices can vary throughout the day.

The spot price of electricity can become volatile and change quickly. To help remedy this, the forward electricity market (or electricity futures), allows electricity buyers to purchase a forward contract. This contract protects buyers against volatile spot prices by fixing their electricity price for a specified period. This creates more certainty in the market, as electricity buyers (sellers) will have more stable costs (earnings).[181]

The four big gentailers have the ability to sell their product to their own retail arms first, and then sell what is left over to the wholesale market. This is called vertical integration and is the cause of significant controversy. Many of the smaller retail competitors have accused the gentailers of setting higher prices for third parties than what they sell to themselves. The Electricity Authority has investigated the claims and has ruled there needs to be greater transparency from gentailers around pricing to inform public understanding.[182] The ability of gentailers to produce and sell electricity would not be possible in the European Union (EU) where there are laws that ensure that all generators, suppliers and networks must operate separately from each other.[183]

Structure of the government owned gentailers

A 2009 report assessing the New Zealand wholesale electricity market highlighted that, although three of the major participants in the New Zealand wholesale electricity market are (partially) owned by the Crown, their principal objective, as set out in the State-Owned Enterprises Act 1986, is to be "as profitable and efficient as comparable businesses that are not owned by the Crown". In effect, the directors of the State-owned firms also have a legal obligation to ensure that they are exercising all available unilateral market power to maximise profits,[184] rather than alternative objectives (such as the decarbonisation of the economy).

Research from First Union, 350 Aotearoa and the Council of Trade Unions (NZCTU) suggests that power companies have paid out billions in excess dividends to shareholders.[185] Over the last decade, $10.8 billion in dividends has been paid to shareholders, while only $4.5b has been invested in new power projects. During this time, national generating capacity has increased by only one per cent. The research also suggested that private ownership of the electricity industry has hampered progress towards a just transition to a low-emissions economy.[186]

[181] The forward electricity market explained | Electricity Authority (ea.govt.nz)
[182] How the New Zealand electricity market works – and what needs to be fixed | The Spinoff
[183] Electricity Price Review Submission (mbie.govt.nz)
[184] Microsoft Word - 840047_1.DOCX (researchgate.net)
[185] Generating-Scarcity-2023-update.pdf (union.org.nz)
[186] Electricity Generators deliver "excess dividends" at a cost to people, planet, and the economy - NZCTU (union.org.nz)

Price of electricity

Over the past 20 years, electricity consumers in New Zealand have faced some of the steepest price rises in the world.[187] According to the Electricity Price Review 2018, residential power prices in New Zealand have increased by 48 per cent since 2000 in real terms (i.e. after adjusting for inflation).[188] This means that over this period there was an average annual real increase of 2.2 per cent. However, since 2018 the real price of electricity has reduced a small amount. This is largely due to a reduction in the amount being paid for the lines component of electricity.

The large market share of the four major gentailers, and the lack of competition between the firms drives up the cost of electricity for residents and businesses. James Stevenson-Wallace, Chief Executive of the Electricity Authority has stated that:

"The Authority is concerned that all consumers might be paying too much for their electricity, because Meridian, supported by Contact, appears to have sold electricity to New Zealand's Aluminium Smelter (NZAS) for $500 million less than it cost to produce. The arrangement could be wasteful. The subsidy maintains demand and keeps prices high in the wholesale market. As a result, households might be paying up to $200 more every year."[189]

This analysis suggests all generators benefit from NZAS operating, because it keeps prices high for all other consumers. This is a clear example of the lack of competition pushing the prices of electricity up, as this sale to NZAS would be very unlikely to have been made at a loss in a perfectly competitive market.

The New Zealand Institute of Economic Research (NZIER) has found that a uniform marginal pricing mechanism still controls the electricity market. This uniform marginal pricing mechanism has been found to be linked to the cost of thermal generation, including gas and coal prices, and carbon emissions. This encourages power generators such as the four major gentailers to boost their renewable energy production. However, the analysis indicates that this approach has led to sudden price increases and elevated future prices. This benefits the major generators with lower fuel costs and ample renewable capacity, particularly during periods of high demand where they can further increase prices. Ultimately, the increases in costs are transferred onto the consumers.[190]

The market power rents in the New Zealand electricity market have been analysed in a study via a simulation from 2010-2016.[191] Market power rents refer to the economic profits or returns earned by a firm or entity due to its ability to exercise market power. The study simulated a competitive market versus the current market power system and found that a competitive market produced 37 per cent less revenue, in this case that equalled $5.6 billion less revenue.

Analysing competitive forces: Porter's 5 Forces analysis

The Porter's 5 Forces Analysis model can be used to identify and analyse the five competitive forces that shape every industry. This can help in determining the industry's strengths and weakness.

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[187] Power costs on the rise for Kiwis - NZ Herald
[188] How the New Zealand electricity market works – and what needs to be fixed | The Spinoff
[189] Wholesale market review points to concerns about power costs and the Tiwai contract | Electricity Authority (ea.govt.nz)
[190] NZIER-assessing-the-New-Zealand-wholesale-electricity-market.pdf (cac.org.nz)
[191] Market Power in the New Zealand electricity wholesale market 2010–2016 - ScienceDirect

1. Competition in the industry

Efficient competition in the electricity sector would result in the price of electricity being dependent on the level of supply and demand. However, a review by the Electoral Authority showed that in the New Zealand electricity sector, elevated prices do not always match underlying supply and demand conditions.[192] This is in large part due to the lack of competition in the sector.

The four major gentailers have a high market share in the sector, which can be characterised as an oligopoly. Markets operating under a monopoly or oligopolies can often justify government intervention. This intervention may range from requirements for transparency through to the regulation of pricing, or even in extreme cases, breaking up the monopoly into many competitors to introduce competition. The electricity reforms did attempt to do this when they split the Electricity Corporation of New Zealand to form the four electricity generators. However, the electricity sector reforms did not break up the electricity sector to the extent that it dealt with issues around competition and pricing.[193]

2. Potential of new entrants into the industry

The electricity sector has high entry barriers for various reasons. Firstly, significant capital requirements for building or acquiring power generation infrastructure. In addition, regulatory approvals, compliance, and licensing pose additional hurdles for new entrants.

Furthermore, the structure of allowing the vertical integration of gentailers is restricting independent generators from being able to competitively enter the market.[194] Vertical integration provides greater power to the gentailers as they control different stages along the supply chain. In this case the four main generating companies are able to sell the electricity to themselves, becoming the main retailing companies.[195] As a result, competitors have accused them of setting higher prices for third parties than for themselves. Additionally, vertical integration of the four large gentailers has enabled them to self-hedge against the spot price volatility, which smaller or independent retailers have limited ability to do therefore curbing out competition from smaller generators and retailers. This has enabled short-term profits to pay dividends to shareholders and share options to executives, rather than reinvesting in new generation capacity.[196]

This has had a significant impact to the long-term development of electrical infrastructure in New Zealand. Overseas, historically 40 – 50 per cent of new generation has been developed independently. In New Zealand however only a small fraction of new generation has been developed by independent developers. In addition, historically this has not been profitable for these developers.[197]

In regard to transmission and distribution, another significant barrier is infrastructure. An enormous amount of infrastructure is required to begin to provide either service, and that acts as a barrier to entry.

[192] Long-form report (ea.govt.nz)
[193] Power costs on the rise for Kiwis - NZ Herald
[194] mbie.govt.nz/dmsdocument/4158-ecotricity-electricity-price-review-first-report-submission
[195] Electricity industry | Ministry of Business, Innovation & Employment (mbie.govt.nz)
[196] NZIER-assessing-the-New-Zealand-wholesale-electricity-market.pdf (cac.org.nz)
[197] Electricity Price Review Submission (mbie.govt.nz)

3. Power of suppliers

The four main energy generators are widely considered to have the ability and incentive to unilaterally exercise market power, due to the high market share of the sector combined with the lack of competition in the market. The firms have the ability engage in unilateral anti-competitive behaviour, resulting in prices that are above marginal cost, and therefore above the level that would occur under perfect competition. This demonstrates the high level of power that the four major gentailers hold as suppliers to the other segments of the sector.

4. Power of customers

A review of the electricity price submitted to the Ministry of Business, Innovation and Employment by Ecotricity found that consumers do not have an effective voice in the electricity sector.[198]

As electricity is a necessity good, demand can be expected to be relatively price inelastic. Consumers will not significantly alter their consumption patterns in response to price fluctuations. This removes a large amount of the power from the consumers. As the price of electricity has continued to steadily rise throughout the last two decades, there are limited alternatives, which force consumers to continue to pay the higher rates. There is no significant effect on residential electricity consumption from changes in electricity prices. [199]

5. Threat of substitute products

Electricity is a fundamental and essential service, and there are limited substitutes for the energy it provides. Consumers will continue to consume electricity for the foreseeable future. However, the emergence of decentralised renewable energy sources (e.g. solar panels) does provide a potential alternative. Consumers can install solar panels, which allows them to produce their own electricity. Currently, the high cost of installing solar panels has limited the number of consumers switching, but as technology advances, this may change. In addition, companies are offering to pay for the installation of solar panels, in return for the consumer paying a set rate for their electricity for a fixed period of time.

It is also possible that significant improvements in energy efficiency measures and technologies may act as substitutes by reducing overall demand. However, this is dependent on factors such as preferences, technology, and market structure. Increased efficiency in resource use can also paradoxically cause an increase in consumption in the long term.[200]

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[198] Electricity Price Review Submission (mbie.govt.nz)
[199] Electricity price and habits: Which would affect household electricity consumption? - ScienceDirect
[200] Understanding the Jevons paradox: Environmental Sociology: Vol 2, No 1 (tandfonline.com)

Appendix 6 Record of partner and stakeholder engagement

Staff representatives from the following organisations provided responses to the targeted partner and stakeholder engagement (either in meetings or via written responses). The information and views shared in response to the engagement questions are summarised in Section 12 of the inventory.

Amplify

BlueFloat Energy

Boffa Miskell

Contact Energy

Copenhagen Offshore Partners

Energy Efficiency & Conservation Authority

Fonterra

Future Proof Implementation Advisor

Genesis

Geothermal Institute - University of Auckland

Go Eco

Hauraki District Council

Martin Lynch Consulting Limited

Matamata-Piako District Council

Mercury

New Zealand Geothermal Association

Oji Fibre Solutions

Ōtorohanga District Council

Rotorua Lakes Council

Taupō District Council

Te Waka

Transpower

University of Waikato

Waikato District Council

Waikato-Tainui

Waipā District Council

Waipā Networks

We.EV

Wintec

Appendix 7 Suggested partners and stakeholders for a review of the Waikato regional energy strategy

The following organisations are suggested key partners and stakeholders for a review of the Waikato Regional Energy Strategy. This is a working list that should be added to as part of project planning for the review.

Central Government

- Ministry of Business, Innovation and Employment
- Ministry for the Environment
- Energy Efficiency & Conservation Authority
- Electricity Authority
- KiwiRail
- Waka Kotahi NZ Transport Agency

Electricity Generators and Retailers

- Mercury
- Contact Energy
- Genesis
- Copenhagen Offshore Partners
- BlueFloat Energy and Elemental Group
- Meridian Energy
- Manawa Energy

Industry Peak Groups - Supply

- New Zealand Geothermal Association
- Bioenergy Association
- New Zealand Wind Energy Association
- Aotearoa Wave and Tidal Energy Association

Transmission Companies

- Transpower
- Counties Energy
- WEL Networks
- Powerco
- Waipā Networks
- The Lines Company
- Unison Networks

Energy Users

- Oji Fibre Solutions (Oji Fibre Solutions is an energy user and generator).
- Fonterra
- Tatua
- Open Country
- Synlait Milk

- AFFCO New Zealand
- Greenlea Premier Meats
- We.EV
- Tainui Group Holdings
- Further process heat users identified through the Energy Efficiency & Conservation Authority's Regional Energy Transition Accelerator (RETA) programme for the Waikato region.[201]

Territorial Authorities

- Waikato District Council
- Hamilton City Council
- Waipā District Council
- Matamata-Piako District Council
- Hauraki District Council
- Thames-Coromandel District Council
- South Waikato District Council
- Ōtorohanga District Council
- Waitomo District Council
- Rotorua Lakes Council
- Taupō District Council
- Future Proof Implementation Advisor

Iwi

Key iwi partners

- Hauraki Māori Trust Board
- Pare Hauraki Collective
- Raukawa Charitable Trust
- Te Arawa River Iwi Trust
- Te Kotahitanga o Ngā Hapū o Ngāti Tūwharetoa
- Te Nehenehenui
- Tūwharetoa Māori Trust Board
- Waikato-Tainui

Iwi authorities (mainly inside the Waikato region)

- Ngaati Tamaoho Trust
- Ngaati Whanaunga Inc
- Ngai Tai ki Tamaki Tribal Trust
- Ngāti Amaru Ngāti Pou Hapū
- Ngāti Hauā Iwi Trust
- Ngāti Hāua Iwi Trust (Ki Taumarunui)
- Ngati Hei Charitable Trust
- Ngāti Huarere Ki Whangapoua Trust
- Ngati Koroki Kahukura Trust

[201] The Waikato RETA will be completed before the time of a review of the Waikato Regional Energy Strategy and will identify the major process heat users in the region.

- Ngāti Maru Rūnanga Trust
- Ngāti Paoa Iwi Trust
- Ngati Pukenga Ki Waiau Society Incorporated
- Ngāti Tahu-Ngāti Whaoa Rūnanga Trust
- Ngāti Tamaterā Treaty Settlement Trust
- Ngāti Tara Tokanui
- Ngāti Turangitukua Charitable Trust
- Pouakani Trust
- Rahiri Tumutumu ki Hauraki
- Tainui o Tainui
- Te Akitai Waiohua Iwi Authority
- Te Kupenga O Ngati Hako Incorporated
- Te Puāwaitanga o Ngāti Hinerangi Trust
- Te Runanga o Ngati Kea Ngati Tuara
- Te Rūnanga o Ngāti Porou Ki Hauraki
- Te Whānau Ā Haunui
- Waahi Whanui Trust
- Te Rūnanga o Rereahu

Iwi authorities (mainly outside the Waikato region)

- Hineuru Iwi Trust
- Nga Tangata Tiaki o Whanganui
- Ngāti Hāua Iwi Trust (Ki Taumarunui)
- Ngati Rangi
- Ngati Whakaue
- Te Arawa Lakes Trust
- Te Mana o Ngati Rangitihi Trust
- Te Maru o Ngāti Rangiwewehi
- Te Rūnanga o Ngāi Te Rangi Iwi Trust
- Te Rūnanga o Ngāti Manawa Trust
- Te Rūnanga o Ngāti Ranginui
- Te Rūnanga o Ngāti Tama o Taranaki
- Te Rūnanga o Ngāti Tamakōpiri
- Te Rūnanga o Ngāti Whare
- Tūhoe - Te Uru Taumatua
- Tuhourangi Tribal Authority
- Uenuku Charitable Trust
- Mōkai Pātai Waitangi Claims Trust
- Te Ure o Uenukukōpako

Economic Development Agencies

- Te Waka
- Amplify

Neighbouring Regional Councils

- Auckland Council

- Bay of Plenty Regional Council
- Taranaki Regional Council
- Horizons Regional Council
- Hawke's Bay Regional Council

Crown Research Institutes

- GNS Science
- Scion
- Manaaki Whenua Landcare Research
- NIWA

Research and Education/Training

- University of Waikato
- Geothermal Institute - University of Auckland
- University of Canterbury
- Wintec

Community and commercial

- Go Eco
- Boffa Miskell
- Martin Lynch Consulting Limited
- Aurecon

Appendix 8 United Nations Framework Classification for Resources (UNFC)[202]

Context

To help the community, iwi, investors, and other stakeholders, the large-scale geothermal resources in the Waikato region were assessed using the United Nations Framework Classification (UNFC) for resources. This was conducted by Jacobs, and supported by the Waikato Regional Council, and is the first application of the UNFC to a large scale regional geothermal assessment, positioning the council as a world leader.

The UNFC method assesses projects along three axes: environmental-socio-economic viability, technical feasibility, and degree of confidence. It groups projects according to their state of maturity in the development process and how viable they are. This is useful in terms of planning and recognising future pipelines of energy and other resources.

The assessment provided a thorough evaluation of geothermal resources in the region, including a total estimated output of electrical energy and heat energy, and cumulative production of viable electricity projects, and viable heat projects, over time. The council now has a robust view of the present and near-future geothermal energy potential of the Waikato, and of how geothermal projects across the region will perform over time.

The UNFC is applicable for use with other renewable energy resources, providing a uniform standard for assessing different electricity and heat projects across a region. Moreover, projects assessed using the UNFC may range from those already operating to a conceptual development that is only considered for the purpose of assessing what future production may be realistically possible.

The UNFC could therefore be applied to other renewable energy resources in the Waikato, as part of similar large-scale regional assessments, or district scale assessments, to gain perspective of the present and near-future potential of other renewable energy resources in the region, and how projects will perform over time. This would enable the identification of the most viable projects of a particular renewable energy resource type, and across all renewable energy resources in the region. Moreover, it will be clear from the evaluation scoring where improvements are needed to increase project viability; thereby also informing resourcing needs.

Furthermore, renewable energy development opportunities identified by such assessments can enable determination of a priority list of projects, and aid spatial planning and the development of regional and district level energy plans/strategies.

The UNFC evaluation reports could also be produced by developer/operators on a regular basis such when the System Management Plans (SMP) are updated on a four- or five-year cycle.

In addition to the potential benefits of the UNFC at a regional and district level, the outputs generated from assessments using the UNFC can inform national energy policy.

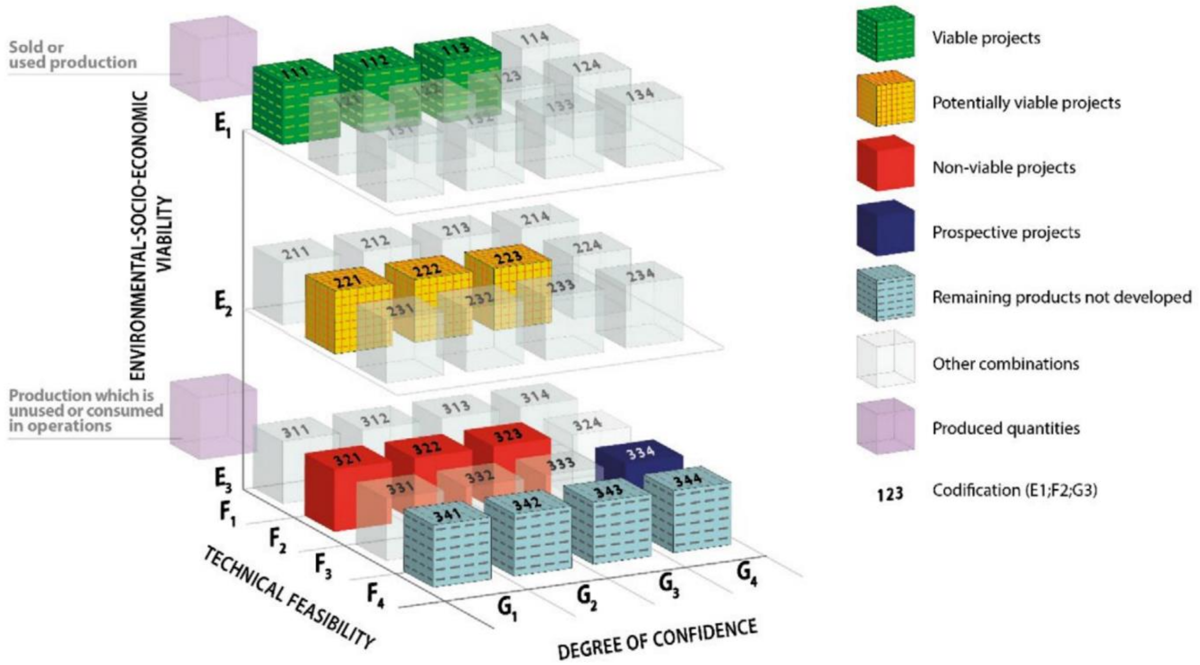
UNFC-2009 is a generic principle-based system in which quantities are classified on the basis of the three fundamental criteria:

E) Environmental-Socio-Economic Viability
F) Technical Feasibility, and

[202] https://unece.org/DAM/energy/se/pdfs/UNFC/publ/UNFC_ES61_Update_2019.pdf

G) Degree of Confidence.

A project classified according to these three criteria can then be plotted in the three-dimensional space, as per the below figure. Categories (e.g. E1, E2, E3) and, in some cases, sub-categories (e.g. E1.1) are defined for each of the three criteria as set out and defined in Annexes I and II of the Generic Specifications.



Specifications

There are similar specifications for different renewable energy sources and a growing expectation that all renewable energy projects could be reported within a similar framework.

The UNFC has been progressively developed to classify a wide range of different resource based projects and specifically to classify the quantities of useful products that they may produce. The classification system is intended to provide a clear and consistent framework for reporting on the maturity of the projects and hence how likely they will actually deliver what is expected. This provides transparency and confidence to markets, investors, regulators, and national and global reporting agencies.

- Renewable energy sources United Nations (unece.org)

This document provides the specifications that enable the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) incorporating specifications for its application (as set out in United Nations Economic Commission for Europe (UNECE) Energy Series No. 42 and ECE/ENERGY/94) to renewable energy resources.

- Commodity specific specifications for specific types of renewable energy resources:
  - Geothermal United Nations (unece.org)
  - Bioenergy United Nations (unece.org)
  - Solar ECE/ENERGY 2019/15 (unece.org)
  - Wind ECE/ENERGY/2019/16 (unece.org)

Assessing the three-axes criteria for classification between renewable energy sources

- The definitions of categories and subcategories are consistent across all resource types listed under the UNFC – with minor language modifications where appropriate to reflect the specificity of the resource type.
- For each category an additional column is included to provide additional context and requirements for the specific renewable energy type.
- For example, E axis table, category E1, for wind and geothermal is as follows:

Wind

Category	*Definition*	*Supporting Explanation (UNFC, Part I, Annex I)*	*Sub-category*	*Definition UNFC, Part I, Annex II)*	*Additional Wind Energy Context and Requirements*
E1	*Extraction and sale has been confirmed to be economically viable*	*Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions. All necessary approvals/ contracts have been confirmed or there are reasonable expectations that all such approvals/contracts will be obtained within a reasonable timeframe. Economic viability is not affected by short-term adverse market conditions provided that longer-term forecasts remain positive.*	E1.1	*Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market condition.*	The generation and sale of electricity via a new or existing wind project is viable, and it can be demonstrated that **all** the following project elements are in place or it is reasonably certain that the elements will be put in place in a reasonable time frame: • Access to source: land lease/ownership of the site (on or offshore) for the project • Access to market: power purchase agreement (or equivalent), whereby the generated electricity can be sold for the project lifetime or until the end of the contract or economic limit has been reached • Authorization/entitlement: permits to build and operate the project • Economic case: the project is economically viable over the project lifetime based on current, anticipated or contractually agreed prices, costs, tax incentives and taxes • Social and environmental considerations: local communities, government agencies and/or non-governmental agencies support the project and there are no counter-indications that pose a risk to the viability of the project.
E1			E1.2	*Extraction and sale is not economic on the basis of current market conditions and realistic assumptions of future market condition, but is made viable through, but is made viable through government subsidies and/or other consideration. government subsidies and/or other consideration.*	In addition to the requirements for E1.1 as listed above, the calculation of economic viability is dependent on regulatory or policy support, typically in the forms of tax and/or price incentives. This includes any regulatory support and/or grants or subsidies needed to make the current project economically viable. Policy support mechanisms are typically phased out over time and the economic case shall reflect this. Support shall not be assumed to become more beneficial in the future unless already so specified in the regulations.

Figure 4 E axis table from category E1 in the Wind energy UNFC specification

Geothermal

UNFC Category	*UNFC Definition*	*UNFC Supporting Explanation*	*UNFC Sub-Categories*	*UNFC Sub-Category Definition*	*Additional Geothermal Energy Context*
E1	*Development and operation are confirmed to be environmentally-socially-economically viable.*	*Development and operation are environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions. All necessary conditions have been met (including relevant permitting and contracts) or there are reasonable expectations that all necessary conditions will be met within a reasonable timeframe and there are no impediments to the delivery of the product to the user or market. Environmental-socio-economic viability is not affected by short-term adverse conditions provided that longer-term forecasts remain positive.*	***E1.1***	*Development is environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions.*	E1.1 is provided to differentiate projects that are environmentally-socially-economically viable without subsidies. Use of E1 is acceptable if the use of subsidies is not clear or it is inappropriate to make this differentiation.
			E1.2	*Development is not environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions, but is made viable through government subsidies and/or other considerations.*	This includes subsidies needed for present or future operation. If subsidies were used in the past (e.g. to drill a well), they are no longer relevant to the classification of the Geothermal Energy Resource.

Figure 5 E axis table from category E1 from the UNFC geothermal energy specification

- Axis key terms are consistent across all renewable energy resource types, for example '*foreseeable future'* is considered 5 years or less.
- A hydropower sub-group under the Renewable Energy Classification Working Group is under initiation. The sub-group will be working to develop hydropower specifications and guidelines.
- For the geothermal specification, for each of the three UNFC (2019) axes (E, F and G), decision trees are provided to aid classification of Projects according to UNFC. By following the arrows from decision box to decision box, the user will end up in a box giving the most suitable classification at the highest hierarchical level for the given axis.

Definitions

- ***Renewable Energy Source:*** the equivalent of the terms "deposit" or "accumulation" used for petroleum and solid mineral resources. It is the primary energy (e.g., earth thermal energy, energy from sun, wind, biomass, river, flow, tides, waves) available for extraction of (and conversion into) ***Renewable Energy Products.*** The main difference with fossil fuels or solid minerals is that, during the lifetime of the project, the Renewable Energy Source is being replenished. In this definition the term "hydro" includes energy generated from waves, currents and tides.
- ***Renewable Energy Product:*** directly linked to (or a direct replacement of) a fungible energy commodity and is saleable in an established market. Examples of energy products are electricity, heat and biofuels. Other products extractable from the ***Renewable Energy Source*** in the same extraction process may not qualify as a Renewable Energy Product; nevertheless, they may contribute to the economic viability of the Project.
- ***Renewable Energy Resources:*** the cumulative quantities of extractable ***Renewable Energy Products*** from the ***Renewable Energy Source***, measured at the ***Reference Point***.
- ***Reference Point:*** a defined location within a development at which the reported estimate or measurement is made. The Reference Point may be the sales, transfer or use point from the development or it may be an intermediate stage, in which case the reported quantities account for losses prior to but not subsequent to the delivery point. The Reference Point shall be disclosed in conjunction with the classification. Where the Reference Point is not the point of

sale to third parties (or where custody is transferred to the entity's other operations), and such quantities are classified as E1, the information necessary to derive estimated sales shall also be provided.

- A ***Project*** is a defined development or mining operation which provides the basis for economic evaluation and decision-making. In the early stages of evaluation, including exploration, the Project might be defined only in conceptual terms, whereas more mature Projects will be defined in significant detail. Where no development or mining operation can currently be defined for all or part of a deposit, based on existing technology or technology currently under development, all quantities associated with that deposit (or part thereof) are classified in Category F4.
- ***Project lifetime***: the forecasted ***Renewable Energy Resources*** associated with a ***Project*** are constrained by the ***Economic Limit*** on ***Project lifetime***.
- ***Project life*** *(geothermal context):* the maximum Resource Consent life of 35 years is applied to new electricity projects and projects requiring consent renewal. The project life of operating projects refers to the remaining resource consent life but can be extended with resource consent renewal and facilities refurbishment.
- The ***Economic Limit*** is defined as the extraction date beyond which the remaining cumulative net operating cash flows from the ***Project*** are negative, a point in time that defines the project's economic life.

While the output from a renewable energy ***Project*** might decrease over time (e.g. due to reduced efficiency in the extraction and conversion process) it can nonetheless remain cash flow positive for a very long time (e.g. hydroelectric projects).

A significant difference from non-renewable energy Projects is that the economic limit will often not be an appropriate basis for the resource assessment because renewable energy is often replenished at an equal or higher rate than consumed and other ***Project*** limitations may become relevant before the ***Economic Limit*** is reached.

Generally, it will be necessary to limit the quantification of ***Renewable Energy Resources*** to a defined Project lifetime of a number of years. This Project lifetime can be determined from the design basis of the facilities or key components of those facilities or based on industry practice or benchmarks for similar Projects.

Routine maintenance requirements do not constrain the Project lifetime, but a need for significant capital reinvestment, requiring a new ***Project*** investment decision and/or regulatory approval, would have to be captured, from a resource assessment perspective, as a separate ***Project*** of lower maturity.

The reporting entity's Entitlement (see Section D) to the ***Renewable Energy Resources*** may also be limited in time and, if of lesser duration than the design life of the facilities and the ***economic limit***, will be the constraining factor for the entity's resource reporting.

Application of the United Nations Framework Classification

With the support of Waikato Regional Council, Jacobs conducted a large-scale regional assessment of existing, planned and potential geothermal developments in the Waikato region using the UNFC system and methodology. A total of 22 "projects" are identified and assessed, located on 10 geothermal systems (the Development, Limited Development and Research systems). The operators of the major projects and new developments in the region, including Mercury NZ and Contact Energy have been involved in the reporting process and are very supportive.

The present status of projects includes some already in long-term operation, in active development, undergoing major redevelopment with new plants, direct heat use projects, and undeveloped opportunities with no known development plan. As such, this represents a good example of how UNFC can be applied to all stages of development.

For undeveloped systems with high probability of discovery and indicators of high temperature (e.g. Tokaanu-Waihi-Hipaua and Reporoa), only electricity projects are assessed given historical interests in these geothermal systems for electricity generation.

The generation potential of undeveloped projects was estimated using the power density method and assumes a power density factor of 10 MW/km^2 for all projects with limited information available.

The UNFC also has classifications for applying technology that is still under development such as the current research for “supercritical” systems (hotter and deeper than conventional convective hydrothermal systems), that may provide potential energy production in the future. These have not been applied in this first assessment of the Waikato region but could be included in the future to classify this energy potential.

The project size takes into consideration existing infrastructure, terrain conditions, land status, and any other environmental or social factors that may impact on physical access to the source. In undeveloped projects, the estimated area is based largely on resistivity data and may result in relatively larger project size compared to developed projects due to having more uncertainties.

To evaluate each project, a standard template was developed and populated with publicly available data and data provided by project owners, capturing a simplified description of the project and energy source and the key factors that are needed to assess classification on the E-axis, F-axis, and to assess energy production with uncertainty represented on the G-axis. Furthermore, the assessed projects are categorised according to their status within the UNFC framework.

Projects that are presently generating electricity (e.g., Ohaaki, Mokai I & II, Rotokawa RGEN & NAP, Ngā Tamariki OEC 1-4) or supplying heat to end-users (Mokai Direct Use, Horohoro Direct Use) have E1 and F1 scores for the E-axis and F-axis, respectively. This is consistent with the expectation that environmental-socio-economic issues are to be largely addressed when a project enters its operational stage. Also, existing projects must be technically feasible to be operational, consistent with the F1 scores given.

Overall, the application of UNFC has proven very successful and provided a concise compilation of all projects and their characteristics on a common assessment basis. Geothermal operators were engaged in this process and have shown a high degree of interest and cooperation, and are participating preparing assessments where time has allowed. Operators are considering how they would continue to update these as required, and the potential for wider application of the UNFC reporting.

Table 5-1. Summary of the UNFC classifications for Waikato geothermal projects

#	Geothermal System	Project	Product	MWe Best Est.	MWt Best Est.	E	F	G
1	Horohoro	Horohoro	Electricity	23	-	E3	F3.3	G4.1 – G4.3
2		Horohoro Direct Use	Heat	-	191.7	E1	E1	G1 – G3
3	Mangakino	Mangakino	Electricity	15	-	E3	F2.2	G4.1 – G4.3
4		Mangakino Direct Use	Heat	-	125.0	E3	F2.2	G4.1 – G4.3
5	Mokai	Mokai I & II	Electricity	104	-	E1	F1	G1 – G3
6		Mokai Direct Use	Heat	-	14.5	E1	F1	G1 – G3
7	Nga Tamariki	Nga Tamariki OEC 1 - 4	Electricity	79.	-	E1	F1	G1 – G3
8		Nga Tamariki OEC 5	Electricity	37.0	-	E2	F1.3	G1 – G3
9	Ohaaki	Ohaaki**	Electricity	36	6	E1.1	F1.1	G1 – G3
10	Rotokawa	Rotokawa RGEN & NAP	Electricity	160	-	E1	F1	G1 – G3
11	Atiamuri	Atiamuri	Electricity	15	-	E3	F3.3	G4.1 – G4.3
12		Atiamuri Direct Use	Heat	-	125	E3	F3.3	G4.1 – G4.3
13	Tokaanu-Waihi-Hipaua	Tokaanu-Waihi-Hipaua	Electricity	100	-	E3	F3.2	G4.1 – G4.3
14	Reporoa	Reporoa	Electricity	66	-	E3	F3.2	G4.1 – G4.3
15	Wairakei-Tauhara	Poihipi / Ti Mihi**	Electricity	40+152	-	E1	F1	G1 – G3
16		Wairakei A&B + Binary + Te Mihi Stage 2 + Cascade uses**	Electricity	111+11	?	E1	F1	G1 – G3
17		Tenon / Natures Flame + other direct use**	Heat	-	29	E1	F1	G1 – G3
18		Te Huka U1/U2**	Electricity	22	-	E1	F1	G1 – G3
19		Tauhara PS (174 MWe) **	Electricity	174*	-	E1	F1.2	G1 – G3
20		Te Huka U3**	Electricity	51.4*	-	E1	F1.2	G1 – G3
21		Tauhara 'South' / unused consent**	Electricity	TBA	-	E2	F2.2	G1 – G3
22		As yet unconsented area**	Electricity	-	-	E3	F3	G4.1-4.3

**Preliminary estimates based on publicly available data.*

***Further details are provided in Appendix 3*

Figure 6 Summary of the UNFC classifications for Waikato geothermal projects (Ussher. G et al., 2023)

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Ussher G, Lebe JL, Calibugan A, Brotheridge J, Quinao J, Hendri R, McLeod J. 2023. Application of the United Nations Framework Classification for geothermal projects in the Waikato region. Proceedings of the 45th New Zealand Geothermal Workshop. Auckland, NZ. https://www.worldgeothermal.org/pdf/IGAstandard/NZGW/2023/80.pdf

Addendum to: Waikato Regional Energy Inventory (March 2024)

February 2025

Purpose

This Addendum updates the March 2024 Waikato Regional Energy Inventory. In doing so it brings the evidence base up to date prior to the review of the Waikato Regional Energy Strategy. Renewable energy will form the fuel to drive economic growth in the region.

Introduction

The Waikato Regional Energy Inventory was compiled to:

- create an updated evidence-base for a review of the Waikato Regional Energy Strategy so as to contribute to the transition to a low-emissions regional economy; and
- allow the regional council and the Waikato communities to engage with central government energy initiatives from a position of knowledge.

The inventory draws together what is known about energy, and what we understand climate futures to be. Among other things, it itemises the known spatial extent of existing and potential energy resources in the region and briefly describes the technology used to access them. It recognises the current reliance of electricity as a just in time energy carrier and the opportunities to expand its role in the transition from fossil fuels. It also identifies opportunities to produce other energy carriers from renewable electricity either for industry, export, storage, or alternative fuels in hard to electrify uses.

A draft Inventory was completed in March 2024 and presented to the Waikato regional Council Strategy and Policy Committee at its 08 April meeting. At that time, it was recognised that the transition of were some elements that were specifically excluded and one such are was the

Structure

This addendum is presented in three parts:

1. Changes to the Operating Environment including government policy initiatives
2. Changes in the supply side, including generation from renewables and transmission; and
3. Changes in the Demand side – or the use of energy

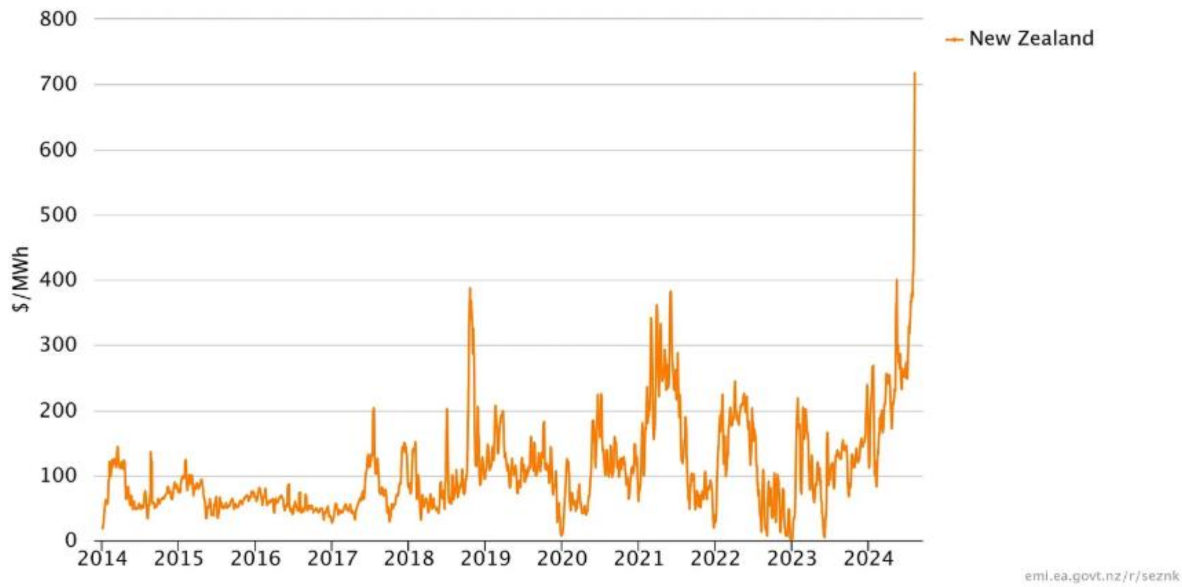
Changes in the operating environment

2024 was a dry year with hydro storage lakes at 55% of their average in August 2024, the lowest in 90 years, a result of abnormally low inflows to Meridian Energy's Fiordland and Waitaki systems. This underscores the national reliance on hydro generation of electricity and to an extent the failure to invest in alternative sources of generation and storage for renewable generation sources. Typically, this takes three forms maintaining the potential energy of stored water at altitude, short-term electrical storage in battery cells or conversion to chemical storage as green molecules.

The electricity market responded to the dry year with increased wholesale prices In accordance with the expectations of findings of the March 2024 Energy inventory that the market responds to scarcity and is focussed on providing a return to shareholders, not necessarily providing electricity at affordable prices – potentially stifling growth not only within the sector but also the national economy.

The impact of the dry year on energy prices was compounded by reduced natural gas production. New Zealand's natural gas reserves have been steadily declining since 2019 and are expected to remain on that pathway such that production is expected to drop below demand over the next three years[203]. Increasing wholesale prices for electricity in the absence of significant generation and transmission build.

In July[204], Retailer Electric Kiwi Electric Kiwi made the decision to stop accepting new electricity customers due to elevated wholesale energy prices. Citing wholesale energy prices increases of 73% in the preceding six months and current wholesale energy futures prices for the calendar year 2025. (the products Electric Kiwi buy in order to supply energy to customers) have now reached a point where every new unhedged customer would be loss making for their business. The August 2024 price peak is shown in context in the following graph in comparison to the historical cost of electricity (Electricity Authority data)



[203] NZ Herald 11 July 2024 NZ Gas production set to fall below demand – MBIE NZ gas production set to fall below demand - MBIE - NZ Herald
[204] Stuff 25 July 2024 Why Electric Kiwi is closing to new customers. Why Electric Kiwi is closing to new customers | Stuff

In September 2024, Winstone Pulp International[205] announced closure of two central North Island timber mills citing unsustainable energy prices. Althouhg the two mills (Karioi and Tangiwai) are outside the region's southern boundary; the action is an example of the impact of the current electricity market. Response was swift with Associate Energy Minister, Hon. Shane Jones asserting the Electricity Authority was not fulfilling it's function.

Electrify New Zealand

Electrify New Zealand was a National party election manifesto commitment and was supported implicitly by the ACT party and NZ First party in clause 10 of both coalition agreements. On 26 August 2024, the coalition government announced the Electrify NZ plan[206] primarily involving changes to planning and regulatory settings to:

- Establish a one-stop fast-track approvals and permitting regime.
- Reduce consent and reconsenting processing times for most renewable energy consents to within one year.
- Extend the default lapse periods for consents from five years to 10 years.
- Increase the default consent duration for consents to 35 years.
- Amend the National Policy Statements for Renewable Electricity Generation and Electricity Transmission, so they are more directive and enabling of renewable electricity and transmission.
- Develop further national direction to enable a range of energy and infrastructure projects (including a new NPS-Infrastructure and subsequent standards for different types of energy generation and infrastructure).
- Introduce a Bill to enable a regime for offshore renewable energy to be in place by mid-2025 to give developers greater confidence and certainty.
- Update a variety of regulatory settings, so New Zealand's infrastructure system can cope with the economy-wide shift to electrification.

This policy (albeit limited to electrification) is being implemented through energy related elements included in specific phases of resource management review and replacement and in bespoke legislation and well as reviews and reports by working parties from other government entities.

Review to ensure electricity market is fit-for-purpose

On 15 November 2024, Hon Simeon Brown and Hon. Shane Jones jointly announced a review of the electricity market to ensure it is fit for purpose. The review was initiated by the coalition government in the wake of the winter power crisis referred to as an 'Energy security crisis' at the time by the Prime Minister. The review considers whether current regulations and market design support economic growth and access to reliable and affordable electricity. The terms of reference set out how a secure and affordable electricity supply requires markets that:

- Incentivise timely investment in infrastructure and resources to reliably meet current and future demand (by existing market participants and prospective new entrants).

- Achieve efficient outcomes: considering productive, allocative and dynamic efficiency.

[205] RNZ 10 September 2024: Hundreds of jobs lost as Winstone shuts mills Hundreds of jobs lost as Winstone shuts mills | RNZ News
[206] Next steps on Electrifying New Zealand | Beehive.govt.nz

- Are effectively competitive at wholesale and retail levels, ensuring entry is feasible and placing downward pressure on prices, so export businesses are globally competitive.
- Have effective regulation in markets where competition is not possible.
- Are regulated in a predictable and proportionate way, enabling participants and consumers to plan, invest and trade with confidence.

Central Government Actions

The incoming coalition government created changes to the way natural and physical resources are managed and allocated which has directly **and** indirectly impacted the way energy is sourced and used in the region. This has occurred through primary legislation, secondary legislation, Changes to policy and has also influenced the direction of government entities. Key changes include:

Fast-track Approvals Act 2024

The Fast-track Approvals Act was introduced to Parliament under urgency in March 2024 as part of the Coalition Government's plan for its first 100 days in office. It came into force on 23 December 2024. On 06 October 2024, the Government announced that 149 projects would be included as a Schedule of the Bill once it is passed. The objective of the legislation was to among other things facilitate the development of infrastructure, which includes pipelines, electricity generation and transmission structures and transport related structures[207]. There were 22 renewable energy projects nationally and four in the Waikato region. They are:

Applicant	Project name	Type	Capacity
Tauhara North No. 2 Trust	Rotokawa Solar farm	Solar	105MW
Harmony Energy NZ #8 Ltd.	Hinuera Solar Farm	Solar	110Mw
Tararua Wind Power	Waikokowai	Wind	650Gwh
Kaimai Wind Farm Ltd.	Kaimai Wind farm	Wind	100Mw

Additionally, and although outside the region (Kawerau), Foresta Group Holdings pine chemical and torrefied wood pellet plant using the German E3 Carbon[208] process was also included in the schedule and is included in this update as it is one of the parties in negotiation to supply Genesis Huntly[209] with a required 3000,000 tonnes of torrefied wood pellets per year to replace coal.

Applicant	Project name	Type	Capacity
Foresta Group Holdings Limited	Foresta Wood Pellets	Biomass	60,000/pa tonnes

It is unclear from the Project's application for inclusion into the specified projects schedule to the Act whether the process heat source is biomass or direct use of geothermal steam[210]. The Kawerau site will be the first of nine proposed plants in NZ changing the way pine forests are used. From a focus on fibre to one of biochemicals with biomass as the by-product. This allows a different forest regime to that required to fibre from logs to one prioritising energy cropping by increasing the planting density and harvesting sooner.

Resource Management (Freshwater and Other matters) Amendment Act 2024

This legislation came into force on 25 October 2024 and although being primarily focused on Freshwater matters, included process changes making it easier for central government, through ministerial action to speed up and simplifies the process for preparing and amending national direction, including national environmental standards, national planning standards, national policy statements and the New Zealand Coastal Policy Statement.

[207] Resource Management Act s2 Interpretation Resource Management Act 1991 No 69 (as at 25 October 2024), Public Act 2 Interpretation – New Zealand Legislation
[208] FORESTA Signs Technology License Agreement with E3 CARBON - Foresta Group Holdings Limited (ASX:FGH) - Listcorp.
[209] Genesis steps up biomass talks with Foresta | Energy News
[210] Fast-track projects | Ministry for the Environment

Resource Management (Consenting and Other System Changes) Amendment Bill (RM Bill#2)

The second resource management amendment bill was introduced in mid-December 2024 and expected to be enacted mid-2025. This legislation is the vehicle to action the variety of regulatory policy changes referred to in the Electrify New Zealand and Hydrogen Action Plan.

Package of national direction

New national direction has been delayed and is now expected in March 2024 as updates to existing National Policy Statements for: Renewable Electricity Generation; Electricity Transmission; and for Greenhouse Gas Emissions from Industrial Process Heat, and national Environmental Standards for Electricity Transmission Activities and for: Greenhouse Gas Emissions from Industrial Process Heat with a new standard anticipated for Renewable Electricity Generation.

The Minister for Resource management reform Hon. Chris Bishop has signalled a 'pause' while integration with the eventual resource management replacement is being considered. As Cabinet is expected to make decisions on the major legislative architecture for the replacement of the Resource Management Act in the first quarter of 2025, it is entirely possible that this will be delayed even further.

The new package of national direction is expected to include changes to amend the National Policy Statements for Renewable Electricity Generation and Electricity Transmission so they are far more directive and enabling of renewable electricity and transmission.

Develop further national direction to help enable a range of energy and infrastructure projects – including a new NPS-Infrastructure, and subsequent standards for different types of energy generation and infrastructure.

Government reform of the Science sector

On 23 January 2025, Hon. Judith Collins KC as Minister for Science, Innovation and Technology announced the merger of seven Crown Research Institutes into three Public Research Organisations focussing on:

- Bioeconomy.
- Earth Sciences; and
- Health and Forensic Sciences.

This has the potential to facilitate research collaboration for bioenergy, biofuels and their feedstocks as part of the Bioeconomy that does not currently exist between the existing agencies (SCION, AgResearch, Landcare Research, and Plant and Food Research).

Government Policy Statement: Electricity

On 11 October 2024, Hon. Simeon Brown released the GPS Electricity[211] directing the Electricity Authority to implement the recommendations of the Market development Advisory Board without delay[212]. It focusses on affordability and security of supply

Government Policy Statement: Transport

[211] Government Policy Statement on Electricity - October 2024.pdf
[212] Adelia Hallett, Energy News www.energynews.co.nz 6 November 2024

The 2024 GPS on land transport signalled a new policy direction for the government. The National Land Transport Programme (NLTP) was released in early September 2024 and included all the activities that were submitted for funding assistance through the National Land Transport Fund via activities submitted in the Waikato Regional Land Transport Plan.

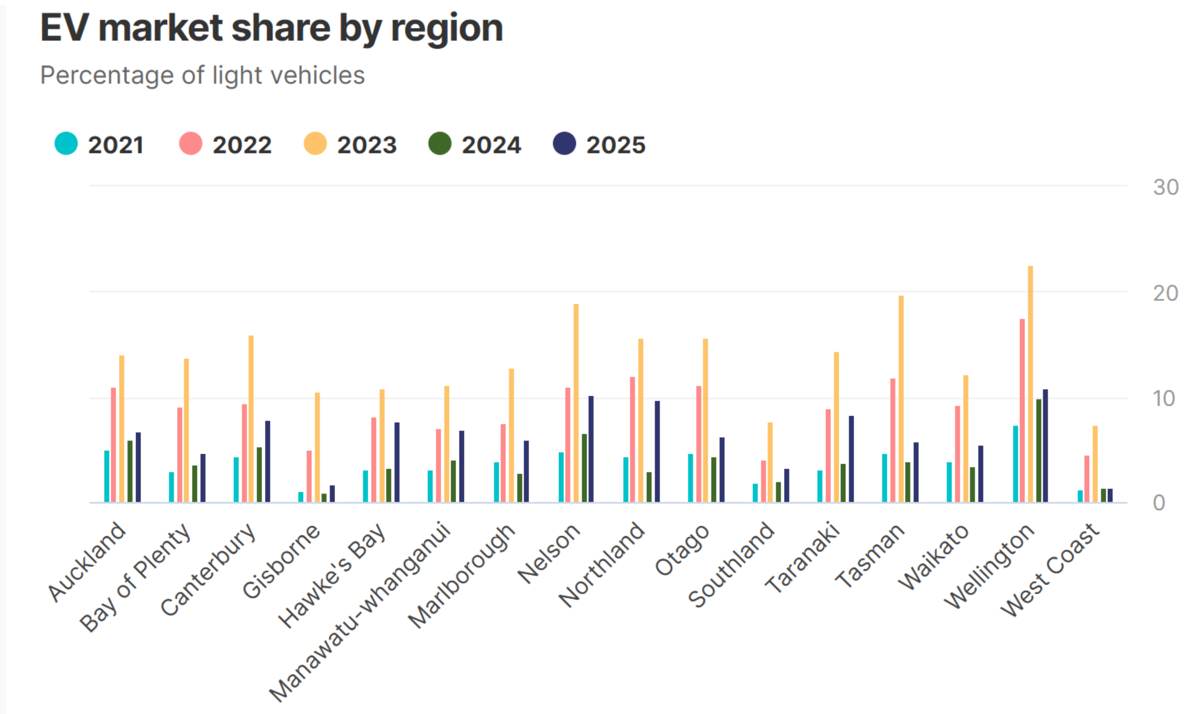
There has been record investment for the Waikato region in the 2024-27 NLTP, however, there are several programmes where investment levels are well below what was sought, including local road improvements, public transport infrastructure, walking and cycling improvements and road safety.

Effect of government policy changes on EV sales in the region

Several things have affected the sale of EV cars in the region since the change of government.

- The Clean Car Discount ended in January 2024
- Electric vehicles and plug-in hybrids have been charged road user charges from April 2024.
- ACC levies have also increased from $42.09 in 2024 to $109.05 this financial year.

This has resulted in reduced sales nationally and not just in the Waikato region, shown in the figure below[213]:



Changes in line with the Coalition Government's National Party's Government's Electrify NZ commitment to provide 1,000 fast charges by 2030

There has been a significant increase in the number of EV charger connections. There are now around 200 EV charging connections across 73 different locations in the region (up from 47 chargers across 36 locations reported in the March 2024 Energy Inventory).

[213] Source NZTA in EV Market Share by Region

And among other things, this Bill would specify default maximum time frames for consent processing and establish default consent durations for renewable energy and infrastructure consents to improve process and outcome certainty for system users

Crown minerals Amendment Bill

The intention of this legislation is to reverse the 2018 ban on new offshore petroleum exploration. This initiative was a commitment in the National and ACT parties' coalition agreement to *"Repeal the ban on offshore oil and gas exploration".* The legislation provides for non-tender methods for exploration and changes to decommissioning requirements including:

- More flexibility in the structure and type of financial instrument that can be used to cover financial liability
- Liability will be limited to the most recent purchaser of the permit and past owners will not be covered by trailing liability issues; and
- Current permit holder will be held liable in perpetuity as occurs in the United Kingdom and Australia.

Analysis from ex-industry workers cite increasing costs of offshore drilling with each well costing upwards of $50 million and low probability of economic resource return (one in eight wells are productive) as the reason exploration had already ceased before the 2018 legislation and that the fundamentals had not changed, with drilling costs increasing. This may not amount to any further offshore petroleum exploration without extensive government support which is not being offered to renewable projects.

Offshore Renewable Energy Bill

The Offshore Renewable Energy Bill has been introduced to parliament as is currently with the with the Transport and Infrastructure Select Committee. The Bill proposes a new framework by which offshore renewables will be authorised. It aims to do this by creating:

- a two-stage permit regime for developers
- consultation requirements
- decommissioning and financial security obligations
- safety zones around offshore renewable energy infrastructure
- provisions for administration, monitoring, and enforcement of the regime and associated offences and penalties.

Waikato Regional Council did not submit on this for capacity, timing of approval processes and the Bill reflects favourably on matters submitted on previously in the discussion document. It is seen by officers as a necessary step in the right direction to enable industrial use of marine energy resources.

The proposed legislation is a standalone Bill with single issue focus and does not mesh well with other legislative changes which may allow incompatible uses of the same area. This has the potential for one industry to sterilise the resource for another merely by virtue of timing and result in a less-than-optimal value use of marine space. The WRC has learned that spatial planning can separate incompatible uses (Geothermal policy that separates protection of fluid driven surface features from large scale use of reservoir heat) In this situation the two are separated and users have been appreciative of the certainty provided and have configured their projects accordingly.

There is indeed a policy vacuum where incompatible uses are proposed in the coastal marine are and exclusive economic zone and where spatial planning can be used to provide for the best use to the nation of the resources present. For instance, both seafloor mining and offshore wind are limited to the area where the relevant resource is present. Where this is co-located, the two cannot exist in the same place at the same time and some sort of decision is required, potentially based upon value to the nation and minimising adverse effects. Marine spatial planning can assist here.

“Perhaps the most concerning thing, though, is not the Bill itself, but rather its relationship with the deeply flawed Fast-track Approvals Act. Here, offshore renewables are put at a significant disadvantage; they are specifically not allowed to use the fast-track process, but incompatible activities can.

New Zealand's second emissions reduction plan 2026–30 (ERP2)

On 11 December 2024, the government published its second emissions reduction plan[214] required by the Climate change Response Act 2002. With 37% of New Zealand’s gross emissions coming from the Energy sector, it has an entire chapter dedicated to emissions reduction opportunities.

This includes the integration of fuels such as biomass, industrial process heat from geothermal and use of green molecules (Hydrogen economy). Synthesis of these energy related opportunities for decarbonisation which are highly relevant to the Waikato regional situation will require more than the present focus on electricity and electrification. It is a large part of the answer but not the whole picture. A National Energy Strategy that brings together the energy sector with other fuels and demand side opportunities is still required to achieve the benefits of a transition to a low emissions economy.

[214] Ministry for the Environment ERP2, New-Zealands-second-emissions-reduction-plan-202630.pdf

Government entity policy and regulatory changes

Electricity Authority – Managing peak electricity demand

In response to last winter's high spot process for electricity, the Electricity Authority has initiated six projects[215], one of which is to make changes to the market structure for peak demand times in response to asset maintenance outages coming into effect on 1 January 2025.

The Electricity Authority is established to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers." In fulfilling this role, it released a Consultation Document on 17 January 2025 into the role of Power Purchase Agreements[216] or long-term contracts to support generation. They are often used to provide an alternative route to market for entrant generators and an alternative procurement option for electricity buyers or traders and therefore have the ability to promote competition within an envelope of support.

The present electricity market has been described in the March 2024 Inventory as being optimised to deliver profits for shareholders, rather than provide the conditions to decarbonise the New Zealand economy and this initiative may address this and one of the barriers that forced the withdrawal of BlueFloat energy from the NZ market.

Overseas Investment Office guidelines for solar and wind farms

In February 2025 the Overseas Investment Office released updated technical guidance for overseas investors[217]. It recognises that complying with the requirements and then securing the necessary consent at the right time, requires careful consideration and can add significant time (and cost) when bringing the project to market. It notes that solar and wind farms are becoming more common in New Zealand. Since 2022 several solar farms have been consented under the Overseas Investment Act 2005. Where an overseas investor is involved.

Historical Overseas Investment Office treatment of the two renewables differs, with solar farm investments facing higher scrutiny than wind farm investments. Solar farms do not allow for as many complimentary land uses and tend to require more land to operate compared to wind farms, resulting in greater scrutiny at a regulatory level.

This risk presents an element of uncertainty for overseas investors in large-scale solar, affecting both direct overseas investment and local developers relying on funding from overseas. This results in an imbalance between the two types of renewable energy – in most cases, overseas investors in solar farms will need to spend more on the regulatory consent process[218]. The guidance attempts to address this imbalance.

Unlike other types of investment, solar farms have unique characteristics, with differences found in relation to land tenure, complementary land use, and complex commercial arrangements. All solar

[215] Electricity Authority, Managing peak electricity demand. Managing peak electricity demand | Our projects | Electricity Authority

[216] Electricity Authority, Entrant generators-context, headwinds and options for power purchase agreements Working paper published for Energy Competition Task Force to support PPAs | Electricity Authority

[217] Solar and windfarms under the Overseas Investment Act 1005, Toitū Te Whenua Land Information New Zealand Solar and wind farms under the Overseas Investment Act 2005.pdf

[218]MinterEllisonRuddWatts Insights 11 February 2025 New OIO guidance clears the air for wind and solar farming

investments generally result in similar benefits, and these have previously been sufficient to secure consent under the benefit to New Zealand test.

The rights required by the developer of a large-scale solar farm will be more than can be accommodated by an easement. However, the rights required by the developer of a large-scale wind farm might well be a suitable use of an easement.

An exemption from the farm land advertising requirement may be appropriate for solar farms where it conflicts with the commercial need for due diligence. A national interest assessment may be required if a non-New Zealand government investor is involved. A national interest assessment may also be required for investments over 250MW and for investors whose installed capacity will exceed 250MW because of the investment.

Electricity Market Review

In the wake of last years' record high electricity prices, and with calls for reform and break-up of the gentailer positions by coalition partner NZ First, Cabinet ordered a review of the electricity market. The terms of reference released in November 2024[219], focus on whether the market is delivering least cost energy to consumers, including firms competing internationally.

The coalition government has refrained from using positive policy levers to incentivise emission reduction behaviour and uptake of renewable energy options. It cancelled the previous administration's Government Investment in Decarbonising Industry (GIDI) Fund at the end of 2023 and the Clean Car Discount to encourage the purchase of electric vehicles, preferring to rely on market forces. In order for markets to achieve government energy security, and cost objectives and transition objectives the setting must be appropriate for that purpose.

On 11 February 2025, the coalition government announced that international, UK based, Frontier Economics would lead the review which would be supported domestically as expert advisors by New-Zealand based Concept Consulting. This was at the insistence of the Associate Energy Minister Hon. Shane Jones that he did not want anyone who had ever worked for and been 'tainted by' New Zealand's gentailers[220].

The draft report is to be delivered within two months of the reviewer's engagement, and the final report delivered within four months of engagement. That places the work in the second quarter of the year.

Released a low-emission hydrogen plan

In recognition that not all the economy can be electrified, for example, heavy transport and industry, the government released a Hydrogen Action Plan[221] in December 2024. The hydrogen economy is a derivative of electricity generation but provides flexibility for both storage and use of energy. This is covered in the Inventory under green molecules.

The plan leverages actions already occurring as part of the resource management reforms to streamline consenting processes enabling the use of hydrogen and to support access to international investment and markets.

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[219] Terms of reference for a review of electricity market performance | Ministry of Business, Innovation & Employment
[220] Energy News, Govt mum on names of market reviewers | Energy News
[221] Beehive Hydrogen Action Plan.pdf

Use of hydrogen in the in the New Zealand context is also a valuable component for the transition to a low-emissions economy. It offers opportunities in sectors that are hard to electrify, hard to abate greenhouse gas emissions and can provide export opportunities. Hydrogen or associated products can be used for:

- Transport fuels for heavy and special purpose vehicles (hydrogen in fuel cells), for shipping and Sustainable Aviation fuels (bio-methanol / ethanol).
- Industry as feedstock chemicals, e-fuels, steel and for process heat.
- Power for back-up generation, electricity, grid peaking support and demand response, and
- Export of hydrogen and derivatives such as ammonia, methanol and eSAF

What the government has not done.

The coalition government has yet to deliver a National Energy Strategy which was deferred until the end of 2024 year. A national strategy is critical to the alignment of electrification initiatives and other opportunities such as biomass and green molecules for both energy storage, for industrial feedstocks and for use as portable transport fuels. A request with officials at the Ministry of Business Innovation and Employment has not been answered.

The promised national direction on electricity transmission and renewable electricity generation has been delayed aligning with the 14 other matters of national direction to be promulgated as part of the (phase two) Resource Management Reforms.

Commercial Responses

Two significant changes occurred during the year. The first was the exit of BlueFloat Energy from New Zealand to focus their operations on other jurisdictions. The Second was the exit of BlackRock investments as owner of NZ firm SolarZero.

Bluefloat and joint venture partners Elemental Group were progressing large scale offshore wind projects in the Exclusive Economic Zone off South Taranaki and Waikato west coast. The Waikato project as in two stages and represented generation potential of 1935MW.

The reasons cited were:

- Uncertainties with seabed allocation and
- Product route to market.

The seabed allocation was exacerbated by the inclusion of Trans-Tasman Resources seabed mining as a listed project in the Fast-track Approvals legislation introduced in March 2024 and now enacted. One of the sites BlueFloat/Elemental project were progressing in offshore South Taranaki was co-located with Trans-Tasman Resources mining site. The two uses are incompatible as it is not possible to connect a grid of offshore turbines and substations and at the same time and in the same place dig up the seabed to a depth of 10 metres. This is the reason there are No-Anchoring and No Benthic fishing zones around seafloor cables.

Investment uncertainty around seabed allocation is being addressed in part through the Off-shore Renewable Energy Bill proposed in December 20924. This is intended to among other things provide for a two-stage process of feasibility and then commercial use.

The product route to market issue is in-part being addressed by the Electricity Authority's investigation into options for power purchase agreements because of the August 2024 electricity price shocks to the spot market.

SolarZero, a joint venture between NZ government's Green Investment Finance fund and BlackRock Investments to went into liquidation in December 2024. The business model is for SolarZero to be a virtual solar PV generator into the New Zealand electricity market. It owns the solar panels, installs them, maintaining the array and changing the battery. This business model has been employed successfully through Scandanavia and round the world[222], because it has the consumer at the heart of it.

The reason for BlackRock's exit and SolarZero's liquidation seems to have little to do with the performance of the business. It was tracking largely to what was set out in the Information Memorandum. "What seems to have happened is a policy change in BlackRock. BlackRock has looked across its GRP investments and made some decisions about what to continue investing in and what not to"[223].

The way BlackRock exited may have a chilling effect on future international investment in infrastructure – a key central government objective for the future.

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[222] RNZ The Detail, Behind SolarZero's collapse Behind SolarZero's collapse | RNZ News

[223] Scoop Business, Update On SolarZero Liquidation By BlackRock Update On SolarZero Liquidation By BlackRock | Scoop News

Supply Side – generation

This section summarises known and publicly available changes to electricity or renewable use of energy since March 2024.

In the interim there has been advances on the use of Huntly power station with Genesis Energy considering options that includes conversion to biomass using black torrefied wood (biomass) pellets as a drop in substitute for coal. Additionally extending the role of Huntly as a grid firming option and the life of the three 250MW Rankine cycle units has been discussed with a market response and heads of agreement between the four main gentailers (Genesis, Mercury, Contact and Meridian). This will require significant investment over the next 10 years[224]. This has been described by Malcolm Johns as a cross roads between focusing on what Genesis needs, and structuring Huntly around that, or whether we structure Huntly around providing greater support to the whole system.

Geothermal

Tauhara Power Station just north of Taupō, owned and developed by Contact Energy and Tauhara Moana Trust[3] and opened in November 2024. At its peak it can produce up to 174 megawatts of electricity, enough to power about 200 thousand homes. The Tauhara II plant was the largest single addition globally in 2024.

Te Huka 3: Contact Energy's new $300 million geothermal power station, Te Huka Unit 3, supplied power to the national grid for the first time in October 2024. It runs at 51.4 megawatts (MW).

Te Mihi: In November 2024 it was announced that Ormat had secured the Engineering, Procurement and Construction contract for 101MW Te Mihi 2 geothermal power plant[225].

Ngā Tamariki: in March 2024, Mercury Energy and its Māori partners commenced construction on the fifth unit of the Nga Tamariki geothermal power station, which will add 46 MW of net capacity.

Mokai Power Station (113 MW) was reconsented for a further 35 years in a non-notified council process in March 2024.

In January 2025 it was announced that a new web-based tool is currently being developed to help greenhouse growers in New Zealand understand and evaluate the potential to transition to geothermal heating[226]. Heating of greenhouses using low temperature geothermal resources is common internationally. The project is expected to be ready by March 2026 delivering:

- A subsurface mapping tool to assess geothermal potential in the upper North Island;
- Economic feasibility insights to determine the costs and benefits of transitioning to geothermal in various settings.
- Increased awareness of geothermal energy as a renewable heating option for greenhouses, filling a critical gap in current decarbonization pathways.

In September 2024 Tauhara North No. 2 Trust and the Ministry of Primary Industries (MPI) engaged with consultancy firm Upflow on a project that aims to advance laboratory-scale research on the conversion of carbon dioxide and methane into protein-rich biomass using specific microorganisms. The research project, expected to take four years, will be a first-in-the-world in producing valuable

224 Energy News, Genesis may extend life of coal-fired units Genesis may extend life of coal-fired units | Energy News

225 Think Geoenergy, Ormat secures EPC contract for 101-MW Te Mihi 2 geothermal power plant, New Zealand

226 Think Geoenergy Web-based tool to help New Zealand greenhouse growers switch to geothermal

biomass using the emissions from geothermal power plants, and the microorganisms that thrive in the conditions of geothermal sites. The project will be funded (~ $5 million) from the Tauhara North No. 2 Trust and the Ministry of primary Industries. The greenhouse gas emissions to be used as feedstock for the microorganisms – a bacterium and an algae – will be captured from geothermal power stations in New Zealand's central North Island. The biomass produced can then be used as commercially valuable components, such as for animal feed. Upflow will be partnering with the Crown Research Institute Scion, the University of Canterbury, and algae experts from Cawthron Institute to provide the leadership and expertise for the project. The plan is to build a pilot-scale facility (at the scale of 1000 L) to process real geothermal gases[227].

In October 2024, a research project on CO_2 reinjection in geothermal power generation facilities by GNS Science, in collaboration with Mercury NZ Ltd., was awarded a $1,000,000 grant from the Endeavour Smart Ideas fund. At first glance, this may seem a like a positive climate change mitigation response, however, as fossil fuel use fir primary energy reduces, industrial (e.g. Bio methane and Sustainable Aviation Fuels) and food grade CO_2 will still be required. In the future, this may come form combustion of biomass.

In November 2024, Central Government announced a $60 million grant to GNS to research harnessing supercritical fluid[228], including drilling a deep, approximately 5,000 metres well, which will likely occur in the Waikato Region.

Electricity generation from Solar.

Construction is to commence at Te Aroha West, Tauhei in 2025 after a joint venture investment agreement between Harmony Energy Limited and First Renewables limited. The site is 182Ha and will have an installed capacity of 202MW (up from 147 MW indicated in the 2024 Inventory) This is expected to produce 280GWhours of electricity per annum.

Of particular interest is the way the energy is being brought to market without the use of Battery Electrical Storage (BES) to compensate for the intermittent nature of solar renewables. Typically, solar generation does not align well with high demand and therefore high market prices. This has been addressed through a power purchase agreement with Meridian Energy who have guaranteed to purchase 100% of the solar farm's output for the first 10 years.

The changes to known grid connected solar photovoltaic generation proposals as shown in the summary table below have increased from 908MW to over 1,253MW with changes identified in red.

Station	Ownership	Area (ha)	Size (MW)	Stage	Consent expiry
Waerenga	Waerenga Solar Farm Limited and Transpower NZ Limited	85-90	180	Consented	Provides for operation for 40 years from commercial operating date (expires two years after cessation of generation).
Rangiriri	Rangiriri Solar Farm Limited and	69	130	Consented	Provides for operation for 40 years from

[227] Scoop Making Livestock Feed From Greenhouse Gases In World-first Research | Scoop News
[228] New Zealand Government announces $60 million for supercritical geothermal - GNS Science | Te Pū Ao

Station	Ownership	Area (ha)	Size (MW)	Stage	Consent expiry
	Transpower NZ Limited				commercial operating date (expires two years after cessation of generation).
Tauhei	Harmony Energy	182	~~147~~ 202	Consented	2057
Komata North	Komata North Solar Limited	6	4.5	Consented	N/A
Waiterimu	Waikato Solar Farms Limited and Transpower New Zealand Limited	63	140	Proposed	N/A
Lake Whangape Energy Park	Glenergy Limited		248	Proposed	N/A
Whitianga	Lodestone Energy		54	Proposed	N/A
Waharoa	Lightyears Solar		4.5	Proposed	N/A
Rotokawa Solar Farm	Tauhara North No.2 Trust	362	105	Proposed	Fast Track Approval Application process
Hinuera Solar Farm	Harmony Energy NZ #6 Limited	152	110	Proposed	Fast Track Approval Application process
Annies Way, Rangiriri	Annies Way Solar Farm Ltd	131	75	Proposed	Fast Track Approval Application process
Ford Road Solar, Waihi	Fern Renewables	Unknown	Unknown	Proposed	N/A

Manufacture of BioGas

Biogas is addressed in the Inventory as 'other' sources of energy, The partnership between Ecogas and First Renewables Energy are now producing bio-methane for input into the North Island's natural gas reticulation pipelines at its Reporoa facility.

Information about the amount of bio-methane produced is limited on the partnership's website[229] citing only that it removes 75,000 tonnes of kerbside waste organics, predominantly from Auckland with the opportunity for other organic feedstocks in the future.

The anaerobic digestion process also produces a by-product fertiliser, called 'Fertify' which is applied to 2,000 ha of local framlands. The process is claimed to reduce 11,000 tonnes of CO_2 However, it is not stated where these emissions are prevented and whether the transport emissions from collection and cartage to site are deducted, That is; Are the forgone emissions, net or gross?

Electricity generation from wind

Over the last year central government coalition policy and subsequent action shave seen changes in the publicly available knowledge of wind generation projects. The key activities have been the positive and rapid execution of Fast-track legislation that has provided for the large 650MW Waikokowai wind project east of Huntly and the Larges seafloor mining proposal of Trans-Tasman

[229] Reporoa Organics Processing Facility — Ecogas

Resources in the same south Taranaki location as BlueFloat / Elemental offshore wind project. This and the lack of government action on electricity market reform has prompted Bluefloat Energy to reassess their New Zealand activities and concentrate on other markets230.

The changes to wind generation proposals as shown in the summary table below have reduced from 4,613MW to 3,0123MW with changes identified in red

Station (currently operating)	**Ownership**	**Number of turbines**	**Size (MW)**	**Commissioned**
Te Uku	Meridian Energy / WEL Networks	28	64	2011
Station (proposed)	Ownership	Number of turbines	Size (MW)	Stage
Taumatatotara	Ventus Energy	8	48.4	Consented
Kaimai	Ventus Energy	24	100	Proposed
~~Waikato Offshore Wind – Phase 1~~	~~BlueFloat Energy and Elemental Group~~	~~54~~	~~810~~	WITHDRAWN
~~Waikato Offshore Wind – Phase 2~~	~~BlueFloat Energy and Elemental Group~~	~~Unknown~~	~~1,125~~	WITHDRAWN
Waikato Offshore Wind	Copenhagen Infrastructure Partners and NZ Super Fund	Unknown	1,000	Proposed
Waikato Offshore Wind	Oceanex	67	1,000	Proposed
~~Waiuku~~	~~LET Capital~~	~~13~~	~~85~~	DECLINED
Glen Massey	Vestus	25	150	Proposed
Waikokowai	Tararua Wind Power Limited	51	650	Fast Track Approval Application process
Hapuakohe	Manawa Energy	Unknown	230	Proposed

[230] Offshore wind developer pulls out of NZ amid seabed mining concerns Offshore wind developer pulls out of NZ amid seabed mining concerns - Newsroom

EECA – Regional Energy Transition Accelerator

EECA's Regional Energy Transition Accelerator (RETA) programme develops and shares what is required to transition fossil-fuelled industrial process heat to renewable fuels. The programme encourages collaboration between demand-side and supply-side stakeholders and has recently concluded analysis for the Waikato region.

The Waikato report identified 91 sites which collectively consumed 12 Petajoules of process heat energy, primarily in the form of fossil gas, producing 730,000 tonnes per year of carbon dioxide equivalent (CO_2e) emissions from the fossil fuels used for process heat. The economics of these sites transitioning to a renewable fuel are analysed and by the end of 2036 following the economical pathway will have reduced the region's process heat emissions by 379,000 tonnes CO_2e per year, a 52% reduction compared to the emissions in 2022 from the sites considered in the study. This pathway would see 51 large heat pump installations, and 15 biomass boilers installed. Supporting these installations will require only minor modifications to local electricity networks, and the demand for biomass would increase by 378,000 tonnes per year.

However, the analysis also shows that business decisions are highly influenced by the cost of piped fossil gas, which may in the future exceed the baseline assumption price , therefore encourages businesses to plan their alternative energy supply options as soon as possible.

The process heat component of regional energy use was specifically omitted from the March 2024 Energy Inventory to avoid duplication with the Waikato RETA assessment report and noted that the Review of the Waikato Regional Energy Strategy would commence after both were paired to for the primary evidence base from which to proceed.

The Waikato RETA is expected to be completed in March 2025 with the key findings shared with the Waikato Regional Council's Climate Action Committee at its 26 February 2025 meeting.

Electrification of the transport sector

The Waikato region has already started making the transition to zero emissions buses with Taupō District served by zero emissions buses since the end of 2023.

The most recent experience is through the new contracts for bus services in Waipā District starting 1 January 2024. Six new electric buses started service in April 2024, along with a new timetable and increased frequency of services for both Cambridge and Te Awamutu. Two new double-decker buses have recently started in Waipā to meet peak demand.

The regional council is working to support the transition to zero emissions buses in other parts of the region. To date this has involved producing a discussion document that introduces factors to consider in the transition and offers options for management or control of strategic assets by Waikato Regional Council (the Council) in its role as a Public Transport Authority.

Additionally, the regional council is progressing a Implementation Plan,investigating the technical details required to support the transition to zero emissions buses, including future fleet size, vehicle specification, depot location, size and specifications, power requirements and grid connections, costs and benefits, and funding and financing options.

Through Budget 2024, the Government confirmed refocusing $59.7 million of existing funding over the next four years towards decarbonising the bus fleet, including zero emissions buses and charging infrastructure, and improvements to bus driver safety and working environments[231].

No further information on how this fund will be set up, or application criteria is available at this stage.

EV conversion of passenger rail rolling stock (Te Huia)

At NZTA request, Waikato Regional Council has completed a Detailed Business Case recommending that new rolling stock for the Hamilton to Auckland passenger rail service Te Huia should be added to the Lower North Island Rail Integrated Mobility rolling stock order. The DBC recommended that new rolling stock should be hybrid battery electric units that could utilise overhead power when available and bridge gaps using battery.

This Detailed Business Case was due to be considered by the NZTA Board to enable Waikato to apply for a crown budget allocation (Budget 2025 or 2026) for the same funding terms as have been achieved by Greater Wellington Regional Council (local share capped at 10%). However, NZTA has determined that it will not now consider this Detailed Business Case until the future of Te Huia is clear in mid-2026. This presents a significant risk to being able to access the Lower North Island Rail Integrated Mobility order and could result in a multi-year delay and a potentially greater cost for any new rolling stock on the Hamilton to Auckland (and potentially Hamilton to Tauranga) corridors.

[231] Beehive, Hon. Simeon Brown, Investing in transport for growth [Investing in transport for growth | Beehive.govt.nz]