Appendix 1: Context of the New Zealand Electricity Sector

This appendix presents contextual information on Aotearoa New Zealand's electricity sector, providing additional detail that was not captured in the main report. This detail supplements the main report, conveying the history and current state of the New Zealand electricity market.

This appendix will briefly present the history of New Zealand's electricity sector, before outlining its current state. We then expand upon the current regulation and operation of the sector, as well as other relevant trends. To inform our analysis, we leverage multiple sources including data requests, bespoke literature reviews and research, primarily analysis, and extensions of existing analysis.

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1. History of New Zealand's electricity sector

While New Zealand's electricity sector has always managed multiple priorities, different focuses have emerged over different timelines. Electricity consumption in New Zealand increased at an average rate of 22% per annum throughout the 1920s. By the 1950s, new generation had to be constructed to deal with shortages, as demand growth outstripped new supply.[1, 2]

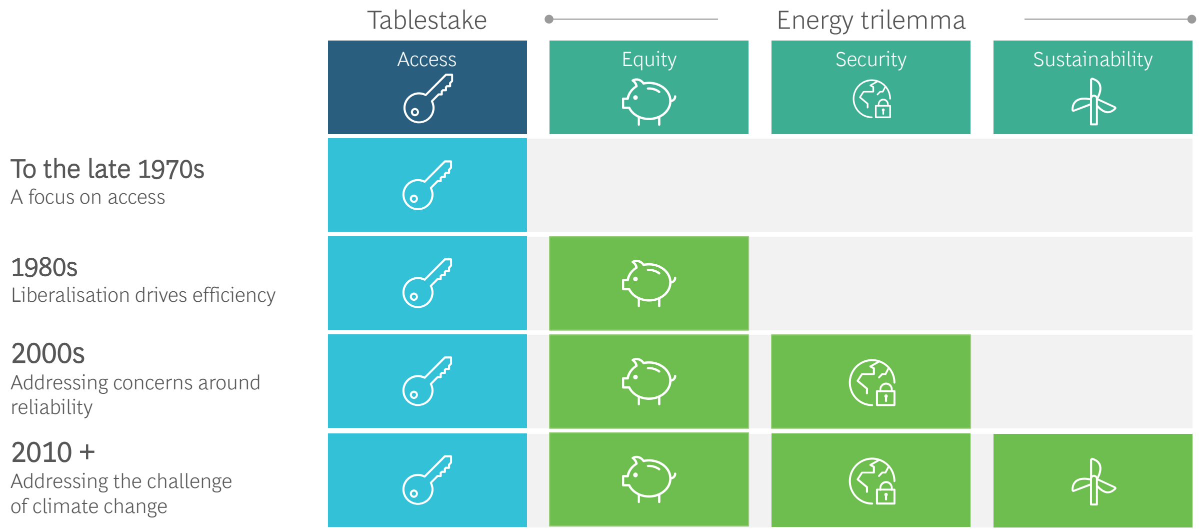
By the beginning of the 21st century, underinvestment in critical energy assets saw the system nearing its physical limits. Deteriorating network assets, which were also nearing capacity under increasing transmission loads, saw New Zealand's electricity grid show signs of strain.[3] Reliability of electricity supply was elevated as a sector priority.

Increasing concerns over electricity security, affordability, and governance prompted a Ministerial Review into the state of the market in 2009.[4] The Ministerial Review led to the Electricity Industry Act 2010, which created new incentives to better manage hydro storage during sustained periods of low electricity supply, improved competition in the generation and retail sectors, and saw the market regulator replaced by the Electricity Authority to streamline governance processes.[5]

While the importance of a low-carbon energy system has been recognised by various public and private sector initiatives over past decades, the increasing climate pressures of the 21st century have significantly accelerated decarbonisation efforts. In 2008, The New Zealand Government set a target to reach 90% renewable electricity generation (in a normal hydrological year) by 2025.[6] This ambition was extended in 2020 with the aspirational goal of meeting 100% of New Zealand's entire electricity demand using renewables by 2030.[7]

The developments that have led to New Zealand's energy system today have made the country's electricity sector one of the most resilient and reliable electricity markets in the world. However, the focus of the sector is now evolving further to support decarbonisation while continuing to maintain equity and security of electricity (see Exhibit 1).

Exhibit 1: The multiple priorities of New Zealand's electricity sector, with different focuses emerging over different timelines



[1] New Zealand Ministry for Culture and Heritage, The 1920s, 2020

[2] Engineering New Zealand, New Zealand Electricity System, 2022

[3] Transpower, Managing risks to transmission assets, 2011

[4] New Zealand Government, Ministerial Review of Electricity Market, 2009

[5] Ministry for Business, Innovation and Employment, Chronology of New Zealand Electricity Reform, 2015

[6] New Zealand Government, Carbon neutral electricity by 2025, 2008

[7] Labour Party, 100% renewable electricity generation by 2030, 2020

2. New Zealand's electricity sector today

Today, New Zealand's electricity sector services 40 TWh of annual demand.[8] Retailers buy electricity in the New Zealand Energy Market's (NZEM's) wholesale spot market, then on-sell it to consumers downstream. This structure can be seen in Exhibit 2 below.

Exhibit 2: Structure of New Zealand's electricity sector

	Upstream	Midstream		Downstream		
	Generation	Transmission	Distribution	Retail	Metering	Behind-the-meter
Description	5 major generators (Genesis, Meridian, Mercury 51% government owned, 49% listed, Contact listed, Manawa listed + Infratil majority shareholder); ~85% renewables: hydro, geothermal, wind; non-renewables thermal coal, gas	National grid state owned monopoly	29 geographic based electricity distribution companies, i.e., local monopolies; range of ownership from private, Council owned, to local trusts	4 big retailers (gen-tailers); number of smaller retail players and major player sub-brands	Major player in metering is Vector. Market also includes retailers, distributers & other smaller players	Fragmented & diverse market consisting of small-scale generators, behind-the-meter battery & solar PV companies, and electric vehicle and charging infrastructure providers, as well as DER aggregators. Gentailers provide various DER offerings
Major players	Meridian, contact, Mercury, genesis, Manawa Energy	Transpower	vector, unison, Powerco, wellington electricity we, Orion	Meridian, genesis, contact, Mercury	vector, Intellihub	SolarZero, genesis, contact, Meridian, Mercury
GWh (2021)	43,112 generated	-1,369	-1,532 lost	39,551 consumed		

Source: Ministry for Business, Innovation, and Employment, BCG analysis

While over 30 retailers compete in the electricity retail space, there are 4 major vertically integrated gentailers: Contact Energy, Genesis Energy, Mercury, and Meridian Energy whom together hold over 80% share of the retail market.[9] Exhibit 3 and Exhibit 4 below provide more detail on the 4 major gentailers.

Exhibit 3: 88% of generation from 4 major gentailers in New Zealand

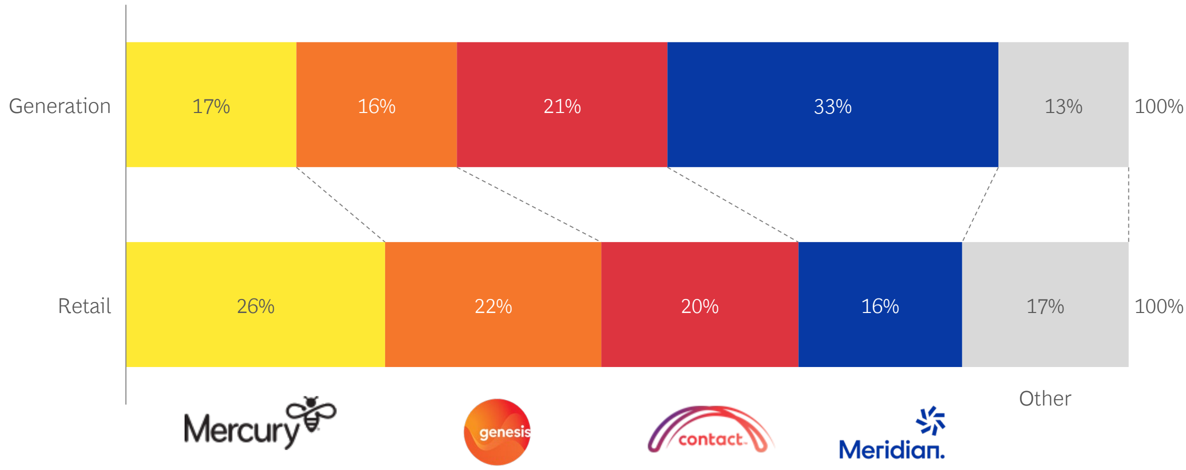
	Meridian	genesis	Mercury	contact
Assets	Hydro, wind	Coal/gas fired station, hydro, wind, plus joint ownership of Kupe gas field	Hydro, wind, geothermal	Hydro, geothermal, gas, diesel
Generation capacity	2,784MW	2,023 MW	1,565 MW	2,023 MW
HQ Location	Wellington	Auckland	Auckland	Wellington
Ownership	51% New Zealand government, 49% NZX and ASX listing	51% New Zealand government, 49% NZX and ASX listing	51% New Zealand government, 49% NZX and ASX listing	NZX listed
Market cap[1] (NZD)	$11.6b	$2.8b	$7.1b	$5.6b
Revenue (FY2022)	$3.7b	$2.8b	$2.2b	$2.6b

Note: 88% based on total capacity of 9,342MW in 2020, excluding cogeneration
1. As at 20 October 2022
Sources: Ministry for Business, Innovation and Employment; Electricity Authority; company websites; NZX, BCG analysis

[8] Climate Change Commission, Data and Modelling, 2021

[9] Electricity Authority, Market share trends, 2022

Exhibit 4: Market share by gentailer

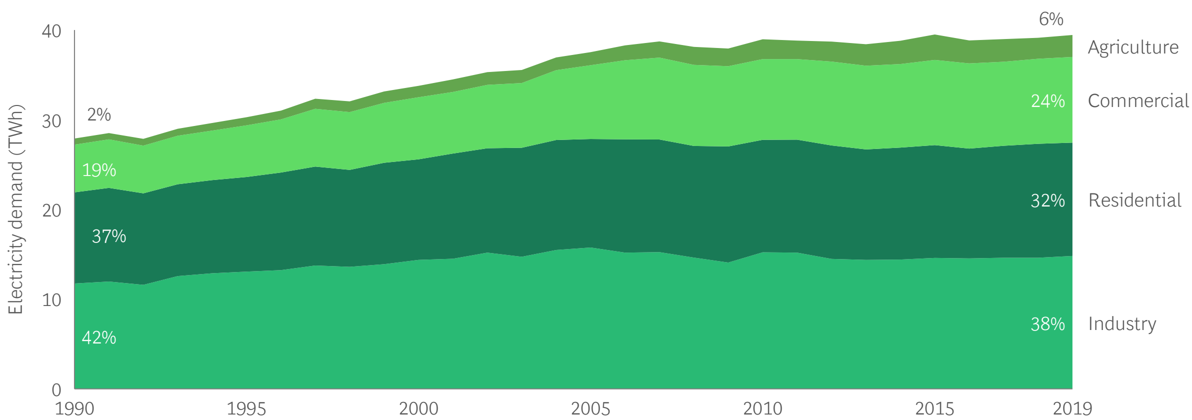


Source: Electricity Authority; Forsyth Barr, BCG analysis

Electricity is transported via the transmission network and over 155,000 kilometres of distribution lines. Bulk electricity transfer occurs along a centrally planned transmission highway, which links the major demand centres in the North Island, where over three-quarters of the population live, to where ~57% of supply is generated in the South Island. The high voltage direct-current (HVDC) interconnector between the North and South Islands has a capacity of 1,200 MW, but plans to upgrade the cables by 2031 will increase the capacity to 1,400 MW. The 29 Electricity Distribution Businesses (EDBs) connect to the transmission network at substations and deliver electricity to end consumers; each of these EDBs experiences different requirements and challenges based on their size, local community demographic, geography, and existing capacity.

As seen in Exhibit 5 below, the largest source of electricity consumption is industrial processes, followed by residential demand. New Zealand's single largest electricity user is Tiwai Point Aluminium Smelter in Southland, which consumes 12% of the electricity generated in New Zealand.[10] The smelter was constructed alongside the 850 MW Manapouri hydropower station, which is contracted to meet much of the smelter's electricity needs.[11] Other large industrial users include New Zealand Steel's Glenbrook mill (up to 1,100 GWh per year, equivalent to the electricity consumption of Wellington City), as well as pulp and paper mills.[12]

Exhibit 5: New Zealand electricity demand by sector



Source: Climate Change Commission, BCG analysis

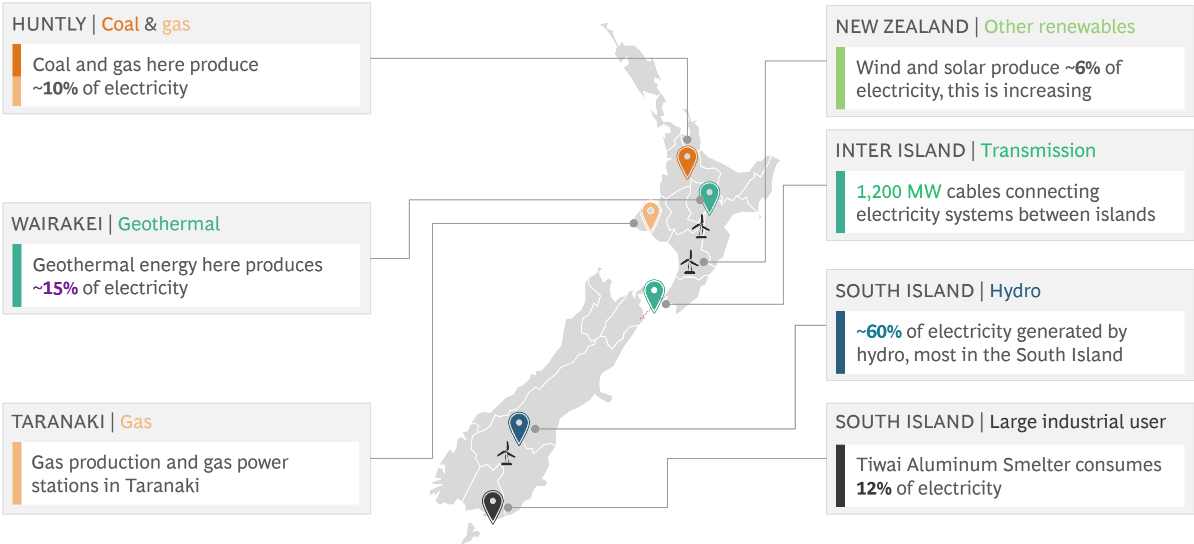
[10] Climate Change Commission, Ināia tonu nei: A low emissions future for Aotearoa, 2021

[11] Energy Link, Manapouri Low Output, 2022

[12] New Zealand Steel, Energy Resources & Recovery, 2020

A geographical view of the current energy system has been presented in Exhibit 6 below.

Exhibit 6: Geography of New Zealand's energy system



Source: Ministry of Business, Innovation and Employment Energy Balance tables; Climate Change Commission, BCG analysis

Competitive outcomes and pricing in the New Zealand Electricity Market (NZEM)

Within the electricity sector today, the NZEM strives to maintain competitive outcomes and set prices based on supply and demand factors. A 'generation dispatch' decision is made where electricity generation and demand are matched on an instantaneous basis, with the market settled via the wholesale electricity price in half-hourly increments. Within a trading period, the market operator compiles the market participants' offers to generate and ranks them based on bid price. The generators who offer the lowest bids are dispatched, with the highest successful bid setting the price to compensate *all* suppliers in that period. In principle, this price-setting framework, combined with the competitive bidding dynamics between different generators, sees the least-cost combination of supply dispatched to satisfy demand.[13]

In the longer term, this generation dispatch decision should signal the right mix of investment to meet long-term demand for electricity.

2.1 Regulation of transmission and distribution in New Zealand's electricity system

While New Zealand's electricity generation and retail sectors currently operate as competitive markets as discussed above, the national transmission system network and 29 regional EDBs remain monopolies regulated by the Commerce Commission.

The regulation of transmission lines

The transmission network, or "National Grid", was administered by the Ministry of Energy, along with the generation assets, until the Electricity Corporation of New Zealand (ECNZ) was set up in 1987. Up to this point in time, major upgrades to generation and transmission were all centrally planned. The National Grid (renamed Transpower) was split out of the ECNZ in 1994. In further sector reforms that occurred in 2010, Transpower also became the system operator, responsible for managing the electricity system in real time, as well as managing supply emergencies and providing short- to medium-term forecasts on security of supply.

[13] Electricity Authority, How spot prices work, 2022

Both the Electricity Authority and Commerce Commission regulate Transpower as transmission provider. The Electricity Authority's role is to set pricing and the grid reliability standards that Transpower must meet, i.e., the Electricity Authority sets how Transpower can apportion their regulated revenue. The Commerce Commission, as the country's competition regulator, regulates Transpower's revenue on 5-yearly cycles and approves major capital investments.[14] This occurs through 2 mechanisms:

1. The price-quality path, which governs Transpower's revenues for each pricing year, with the paths being reset every 5 years. The latest price-quality path for Transpower was set in 2019 for the period April 2020 to March 2025.
2. The capital investment proposal framework where Transpower may submit separate proposals to seek approval for certain capital investment projects for the national grid or the high-voltage electricity transmission network.

The regulation of EDBs

Prior to the economic reforms of the 1980s and 1990s, local distribution assets were held by 61 electricity supply authorities as statutory monopolies.[15] Today, 29 EDBs acting as monopolies, incorporated as companies, connect Transpower's transmission network to end consumers.

Like transmission, the Electricity Authority and Commerce Commission both regulate the EDBs. The Electricity Authority administers the Electricity Industry Participation Code and monitors pricing, while the Commerce Commission regulates revenue, quality, and information disclosure. The Commerce Commission regulates distribution companies through price-quality paths that determine either the maximum average prices that EDBs can charge, or the total revenue that can be recovered from consumers. Price-quality paths also set the quality standards that EDBs must meet. The price-quality paths currently focus on equity and security. Mechanisms for price-setting and regulated revenue earning are set by the Commerce Commission through 2 pricing methodologies:

1. The Default Price Path (DPP) is a low-cost approach to revenue-setting and is the approach undertaken by most EDBs due to its comparatively low-burden submission requirements. The DPP is set for each EDB for 5-year periods. The DPP includes incentives designed to drive good consumer outcomes i.e., performance incentives for reliability improvements, and incentives for reducing operating and capital expenditures. While not an individual price path, the DPP does consider, to some extent, the requirements of an EBD based on their network characteristics.
2. The Customised Price Path (CPP) uses more business specific information and relies on more in-depth audit, verification, and evaluation; to date, only 4 proposals for CPPs have been received due to the high cost and burden of the CPP process.

[14] Commerce Commission, Transpower input methodologies, 2022

[15] Ministry for Business, Innovation and Employment, Chronology of New Zealand Electricity Reform, 2015

2.2 Network investment in New Zealand

To facilitate decarbonisation, the renewables pipeline and electrification will need to be supported by expansions and upgrades to New Zealand's electricity networks. As discussed in the main report, $8 billion and $22 billion will need to be invested in the 2020s to upgrade transmission and distribution infrastructure respectively.

However, the outlook of spend requirements for the sector can be highly unpredictable and will be influenced by a number of factors, including:

1. What type of generation technology is built, and where
2. The cost of materials for new infrastructure
3. The degree of smart network investments
4. The rate of uptake of electrification (i.e., whether the pivot is gradual or a step change, and urban versus rural differences)
5. Existing capacity headroom within different networks
6. The uptake of demand response and Distributed Energy Resources
7. Peakiness of demand

For example, Auckland-based Vector in its 2022-2032 Asset Management Plan (AMP) reflected on the cost of materials for new infrastructure and the rate of electrification uptake, with EVs having adverse impacts on the availability of materials:

"Over the last 12 months we have observed high levels of volatility on the supply-side of network maintenance and capital delivery (construction). Supplier lead times and costs for network equipment have increased significantly due to disruption to international and domestic freight routes, resource constraints and a surge in demand from consumer goods manufacturers competing for raw materials needed by the electricity sector.

"Surging demand for EVs has increased the requirement for specialised materials such as silicon steel, commonly used in the fabrication of power and distribution transformers. We anticipated these pressures in early 2020, taking action to increase inventory levels and partner with strategic suppliers for greater visibility of supply chain risk. This work continued in 2021 with the development of pricing models to help mitigate against price shocks. We expect that 2022 will see continued volatility in the availability and price of raw materials, labour, and freight, with domestic freight a particular area of concern."[16]

In the South Island, Orion foresees that Distributed Energy Resources will have a significant impact on its network. It notes in its AMP:

"We are seeing increased interest in new types of Distributed Energy Resources (DERs)…they challenge the traditional approach to network operation and planning which assumes larger centralised power supplies which feed one-way to our customers. In contrast, DERs can change power flows from single to multi-directional which places additional demands on our low voltage networks which were not originally designed for this type of operation."[17]

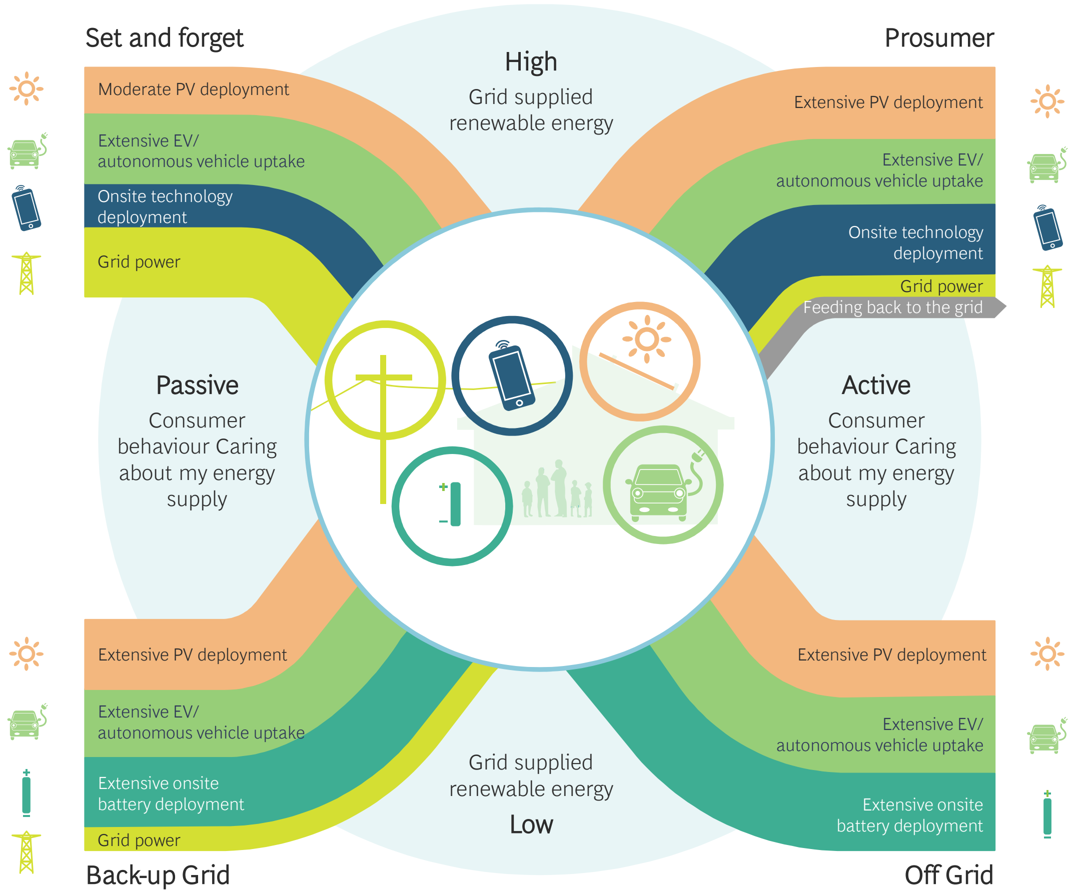
Given the increasing role electricity will have in meeting New Zealand's energy needs, system availability of electricity will become increasingly important. The more electricity is relied upon, the less tolerant customers will be of outages. Hence system availability across the network is integral to ensuring a reliable supply of energy.

The ENA Network Transformation Roadmap seeks to address some of the challenges that the sector is expected to face. The roadmap plots the importance of relative levers in ensuring security of supply against scenarios with combinations of low versus high grid-supplied renewable energy, and passive versus active consumer behaviour regarding energy supply (see Exhibit 7).

[16] Vector, Electricity asset management plan update, 2022

[17] Orion, Asset Management Plan 2022, 2022

Exhibit 7: ENA Network Transformation Roadmap



2.3 The role of thermal plants in New Zealand's electricity system

Even as decarbonisation gains momentum, thermal power stations play a key role in New Zealand's electricity sector.

The role of thermal power stations in electricity generation

Slow-start thermal, which requires at least 6 hours of starting and ramping time before contributing to electricity supply at full capacity, provides intermediate and baseload generation.[18] Fast-ramping technologies, in particular open-cycle gas turbines (OCGT), provide firming during times of peak demand.

New Zealand's largest power station, the collective 953 MW of generation capacity at Huntly, illustrates the combined role of these assets. 2 older units, referred to as the Rankines, can be fired by both coal and gas. There is a third Rankine unit but it is used infrequently. These units provide hydro firming, as well as slow-start peaking generation. There are also 2 gas plants (one combined-cycle gas turbine and an open-cycle gas turbine unit). The former provides baseload and some peaking, while the latter supplies more dynamic energy that is responsive to variable market needs, particularly in times of peak demand. Today Huntly Power Station provides very important peaking and dry year services to the electricity system. Other thermal peakers, situated in proximity to New Zealand's North Island gas fields in the Taranaki, also provide fast-ramping generation.

Together, New Zealand's diverse generation mix needs to meet electricity demand patterns that differ on an intraday and seasonal basis. Peak system load (about 7 GW in 2021) tends to occur in the early evening when consumer demand for heating and cooking is at its highest.[19] A second, smaller peak can

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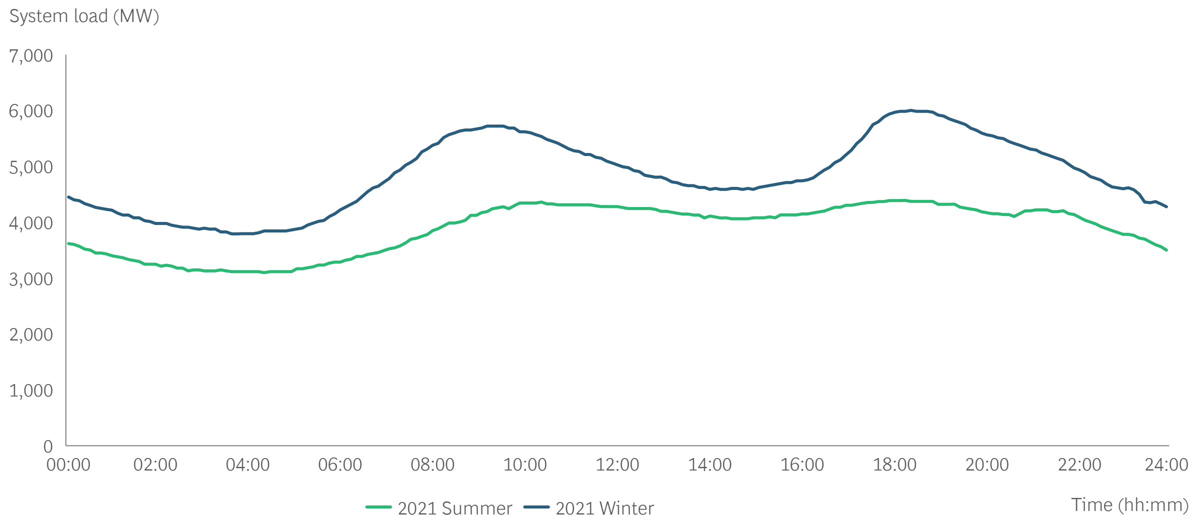
[18] Transpower, Whakamana I Te Mauri Hiko: Monitoring Report March 2022, 2022

[19] Transpower, Whakamana I Te Mauri Hiko, 2020

also be observed when consumers first wake up in the early morning. The system loads during winter tend to be higher than those experienced over summer due to additional heating demand (see Exhibit 8).

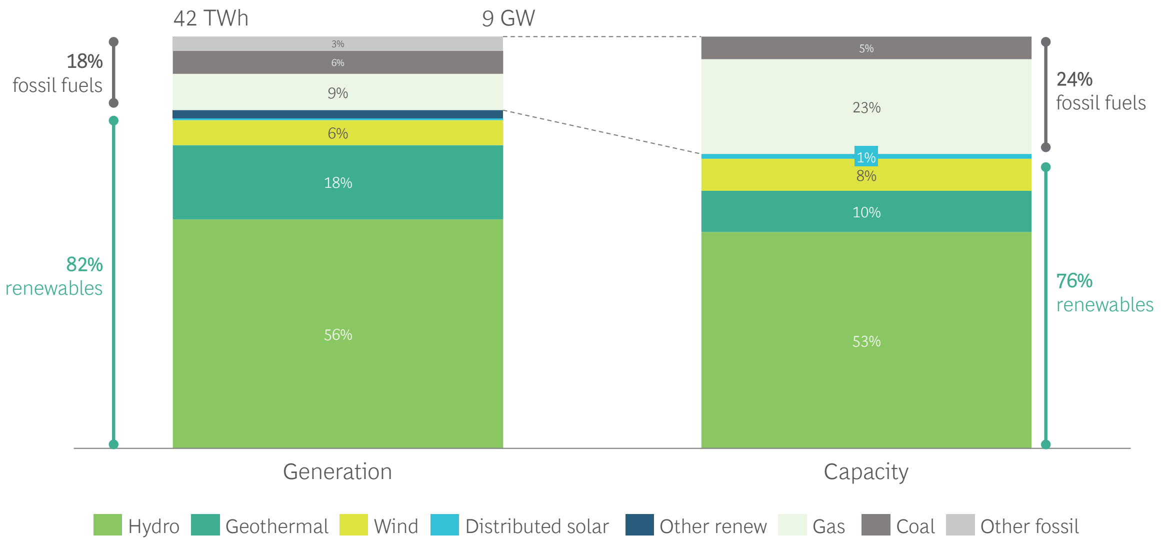
Exhibit 8: Typical summer and winter daily load profiles



Source: Transpower, BCG analysis

The variability in electricity needs highlights the importance of flexibility and dispatchability of supply in New Zealand's energy system. As a hydro-dominated system with non-trivial volumes of geothermal capacity, the grid already naturally accommodates a high proportion of dispatchable renewable generation. However, hydrological constraints mean non-renewable capacity still needs to be available today when lake levels risk running low. Thermal power stations are also needed today to meet peaks. As a result, fossil fuel-fired plants still comprise about 25% of the grid's total capacity (see Exhibit 9).

Exhibit 9: 2021 New Zealand electricity generation & capacity



Source: Transpower
Note: 2020 data; "Other" is unspecified so unable to be split between renewable and non-renewable sources

The role of thermal plants in power system stability

Fossil fuel-fired plants, as well as hydro and geothermal assets, together account for ~90% of New Zealand's grid-connected generation and naturally provide critical system security service.[20] These generation types play an important role in maintaining the stability of the power system using the energy stored in their rotating turbines. The turbines are synchronised to the alternating current (AC) frequency of the broader power grid to inherently provide a service known as system inertia. In the case of a supply-demand imbalance, inertia works to slow any potential frequency deviation, allowing recovery services, provided through the ancillary market, time to kick in and bring the system back to balance. In the extreme event the electricity grid is completely destabilised after a major supply disruption, these synchronous generation types can also provide black start services to re-energise the power system and restore other generators to service.

On the other hand, technologies that generate direct current (DC) power, including wind and solar resources, rely on inverters to convert their supply into the AC electricity that flows through New Zealand's power grid. In the absence of a grid-forming inverters to synthetically create inertia, the lack of spinning turbines involved in the electricity generation process mean inverter-based resources cannot provide an inertial response to contribute towards system security.

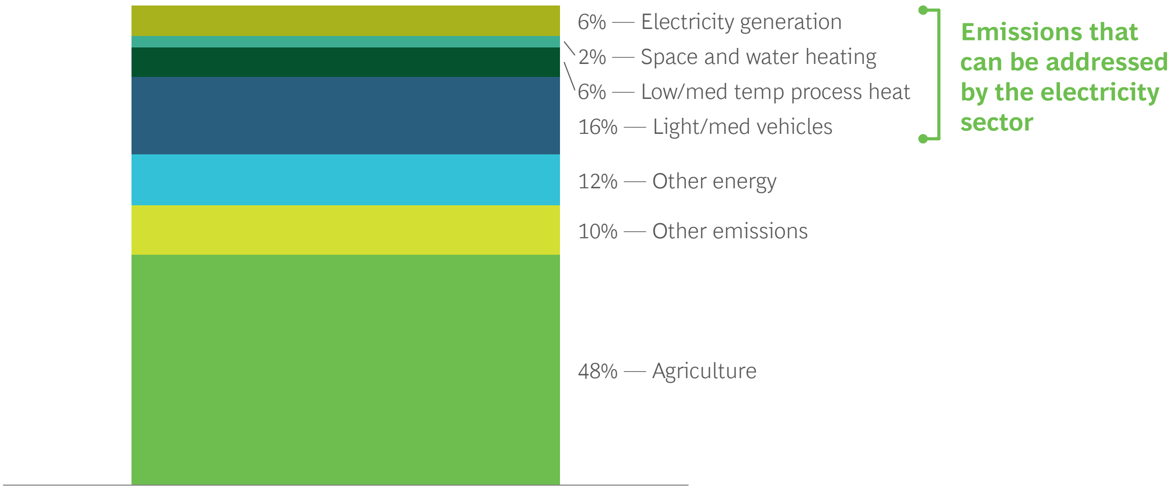
2.4 Current state of electrification in New Zealand

In combination with technology improvements and several government-led initiatives, New Zealand's success in balancing the energy trilemma has played an important role in beginning to drive electrification demand, especially across the transport, industry, and building sectors. While reliable and affordable electricity supply has supported the economic case for electrification, a low-emissions grid has bolstered its decarbonisation potential. Although these electrification efforts have achieved significant emissions reductions so far, converting the fossil fuel consumption of the transport, industry, and building sectors to clean electricity still holds vast decarbonisation potential. Approximately 30% of 2019 gross emissions are estimated to be addressed by the electricity sector, so long as appropriate investment is made to supply the increased demand with clean electricity (see Exhibit 10).

[20] Transpower, Opportunities and challenges to the future security and resilience of the New Zealand power system, 2021

Exhibit 10: The electricity sector can directly support emissions reduction in activities accounting for ~30% of New Zealand's emissions

New Zealand 2019 gross emissions (Mt CO2-e)



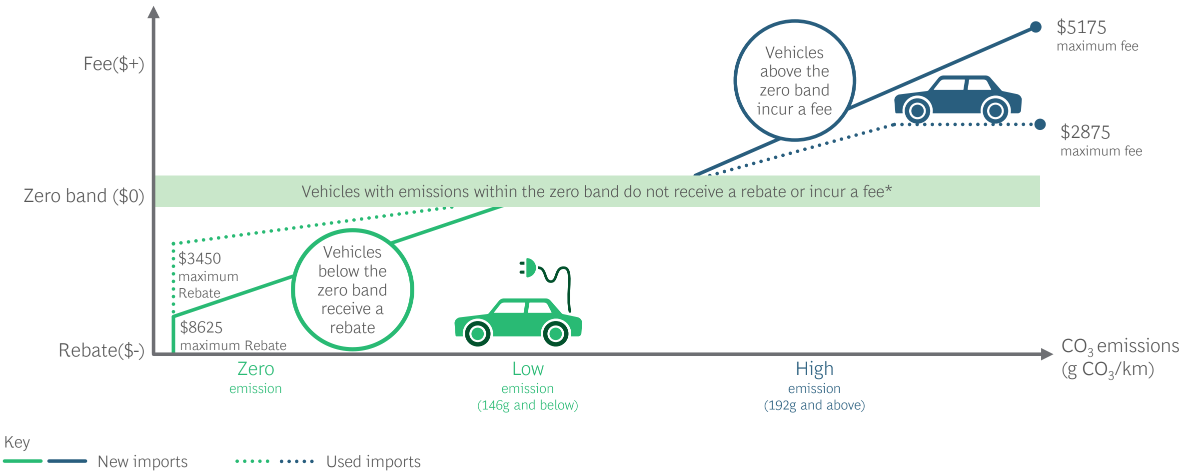
Source: Climate Change Commission

Improving economics, as well as various public and private sector initiatives, continue to prove the value case for electrification.

Electrification in transport

The Government is currently targeting a 41% decrease on 2019 transport emissions by 2035.[21] Building on progress made so far under the 2021 Clean Car Discount scheme, rebates will continue to subsidise the upfront costs of Electric Vehicles (EV), while fees applied to internal combustion engine vehicles will disincentivise emissions-intensive vehicle choices. Exhibit 11 below visualises how the scheme works.

Exhibit 11: 2022 Clean Car Discount Scheme



Note: GST included

The discount led to a ~5 times increase in average monthly registrations for electric vehicles, for both plug-in hybrid EV registrations and battery electric registrations between 2021 and 2022 (see Exhibit 12).

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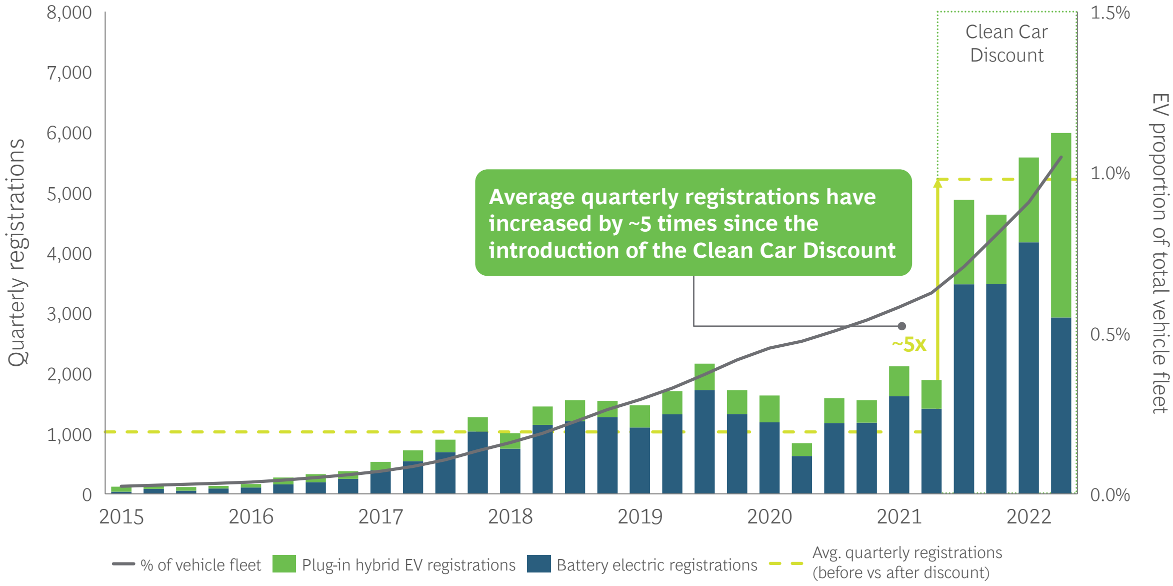
[21] Ministry of Transport, Climate change – emissions work programme, 2020

Exhibit 12: 5 times increase in New Zealand's electric vehicle registrations since the introduction of the Clean Car Discount



Source: Ministry of Transport

On the supply-side, the Clean Car Standard will see vehicle offerings increasingly favour electric alternatives by applying tighter emissions standards to imported vehicles over time.[22] Since the Clean Car Standard was passed through the Clean Car Act, the emissions intensity of the light vehicle registrations entering New Zealand's passenger fleet has already fallen significantly.

Although at a slower pace, New Zealand's heavy transport sector is also starting to electrify. Since the start of 2022, almost 100 EVs have been added to New Zealand's heavy vehicle fleet. The uptake of electric trucks and buses is supported by their exemption from road user charges (RUCs) until they comprise 2% of the heavy vehicle fleet. Light EV owners enjoy similar relief from paying RUCs, saving them an estimated $600 per year until March 2024.[23]

Other government initiatives are also accelerating the electrification of New Zealand's vehicle fleet.

Low Emission Transport Fund

The Government is striving to alleviate 'range anxiety' (the fear that an electric car's battery will run out before the destination is reached) by co-funding over 1,200 private and public EV charging stations through the new Low Emission Transport Fund (LETF, see Exhibit 13).[24] While the national charging network already includes 316 public chargers with no more than 75 km between each one, building out New Zealand's charging infrastructure along highly trafficked routes will continue to help drive mass switching towards EVs.[25]

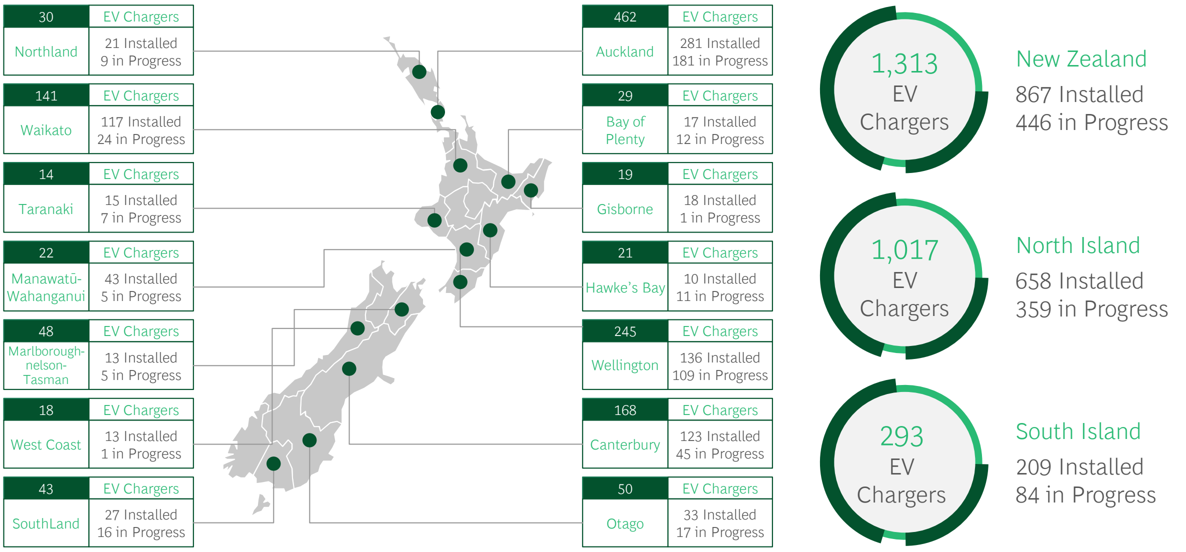
[22] Ministry of Transport, Clean Cars, 2022

[23] Energy Efficiency & Conservation Authority, Electric vehicles and Aotearoa, 2021

[24] Energy Efficiency & Conservation Authority, EV chargers co-funded by the Government, 2022

[25] Energy Efficiency & Conservation Authority, New Zealand Public EV Charger Map, 2022

Exhibit 13: 1,313 LETF co-funded EV charging stations



Note: New Zealand total includes chargers co-funded by not yet allocated to specific regions on the map
Source: Energy Efficiency and Conservation Authority

State Sector Decarbonisation Fund

The Government's $220 million State Sector Decarbonisation (SSD) Fund has also provided $30 million across 29 projects to electrify the public sector's vehicle fleet and install charging infrastructure. The 978 government-owned electric vehicles purchased via the SSD fund are projected to save 23,000 tonnes of CO_2-e emissions over the next decade. In combination with the electrification of public building space heating and other decarbonisation projects supported by the SSD fund, an electrified vehicle fleet will contribute to the Government's goal of realising carbon-neutrality across public sector operations by 2025.[26]

Electrification in process heat

Industrial process heat will be another key driver of electrification demand. Improving economics continue to enhance the appeal of commercial fuel-switching – electrification of low-heat use cases can already save 40-70% of operating energy costs.[27] However, upfront costs can be a deterrent to making electric conversions. As mentioned in the main report, the recent $650 million expansion to the Government Investment in Decarbonising Industry (GIDI) program will play an important role in helping process heat users overcome electrification capital hurdles.

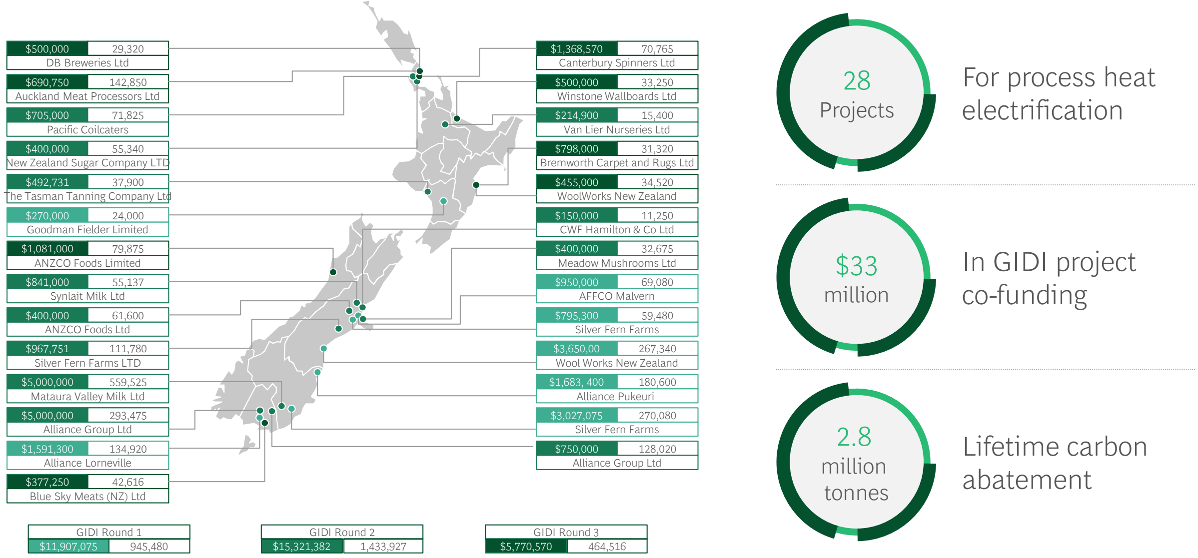
Recognising the importance of reliable and affordable electricity supply in supporting electrification efforts, upgrades to transmission and distribution infrastructure that specifically support fuel-switching are also eligible to receive funding under GIDI. The first 3 rounds of the existing GIDI fund have awarded 28 electrification projects a total of $33 million in co-funding, equating to close to an expected 3 million tonnes of lifetime CO_2-e emissions reductions (see Exhibit 14).[28]

[26] Energy Efficiency & Conservation Authority, State sector decarbonisation, 2021

[27] Transpower, Electrification Roadmap, 2021

[28] Energy Efficiency & Conservation Authority, Approved GIDI projects, 2021

Exhibit 14: 28 GIDI-funded process heat electrification projects



Source: Energy Efficiency & Conservation Authority

With the opportunity to electrify most process heat before 2050, industrial electricity demand is expected to grow materially in the near future. The commercial case for industrial heat electrification is also being supported by gentailers' offers to establish long-term electricity contracts at competitive prices to support fuel-switching projects. A recent ban has also been placed on the installation of new low and medium temperature coal-fired boilers, with the requirement to phase out existing facilities by 2037 further supporting the prevailing electrification trends.[29]

2.5 Current state of distributed energy resources in New Zealand

Distributed Energy Resources (DER) are smaller generation units that are located near their point of use and are often on the consumer's side of the meter. Almost 1 GW of New Zealand's installed electricity capacity is not directly connected into the grid, reducing the burden of load required to be carried via the transmission and distribution networks.[30]

Distributed solar photovoltaics (PV)

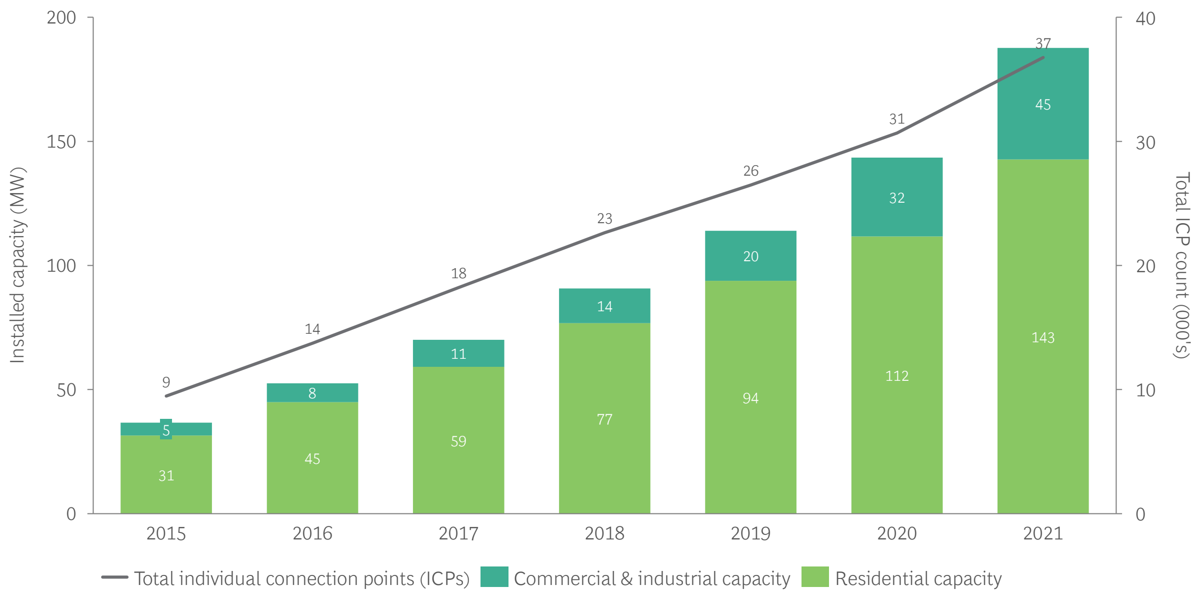
A significant proportion of distributed generation comes from renewable sources, with supply produced by about 200 MW of distributed solar PV. Rooftop solar and DER has had a relatively slow start to uptake across the New Zealand power system. Households are beginning to adopt it however, with residential solar installations growing significantly in recent years, both in terms of number of connections (32% average annual growth since 2015) and average capacity (4.3 kW compared to 3.5 kW in 2015) (see Exhibit 15). Today, approximately 2% of New Zealand households have solar panels on roofs.[31]

[29] New Zealand Government, Government delivers next phase of climate action, 2021

[30] Electricity Authority, Installed distributed generation, 2022

[31] Electricity Authority, Installed distributed generation, 2022

Exhibit 15: 4 times increase in residential & commercial solar connections since 2015



Source: Electricity Authority, BCG analysis

Battery energy storage systems

Battery energy storage systems (BESS) that exist to temporally manage consumers' electricity needs are another category of DER. Very little storage capacity exists behind-the-meter in New Zealand, with an estimated 70% of solar connections operating as standalone PV systems.[32]

The grid-scale battery storage market in New Zealand is also still relatively nascent.[33] This is despite battery technologies' potential to create value in both the energy and ancillary service markets by providing frequency-correcting services that may reduce inertial requirements, as well as their ability to defer the need for network investments.[34]

Demand response

Demand response (DR) is another DER in the New Zealand energy system – DR involves flexing units of demand to help balance the 2 sides of the electricity market. The benefits to the system of this kind of demand-side participation can be shared back with the owner of the interruptible load, as agreed through a pre-arranged contractual agreement.

Since 2011, Transpower has coordinated New Zealand's flexible demand resources through the Demand Response Management System (DRMS). The DRMS platform was used to test the value proposition for flexible demand resources and scale New Zealand's market for DR to a meaningful MW capacity. In 2019, a locally built flexibility management system (FlexPoint) was launched to centrally and automatically coordinate the DR capabilities of various emerging technologies, including batteries, EV charging stations, and IOT devices.[35] In 2020 Transpower had 233 MW of demand response on its FlexPoint platform[36].

DR can also look like bespoke commercial agreements with large electricity users to flex their consumption profiles in line with available supply. For example, the contract between Meridian Energy and New Zealand's Aluminium Smelter (NZAS) in Tiwai Point contains a 250 GWh 'Smelter Demand

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[32] Transpower, Distributed Energy Resources – Understanding the potential, 2020

[33] Mercury, A Kiwi first: Direct grid-connected battery is large and in-charge, 2018

[34] Australian Energy Market Operator, 2020 System Strength and Inertia Report, 2020

[35] Transpower, Distributed Energy resources and Flexibility Services, 2022

[36] Transpower, Distributed Energy Resource Management briefing to IPAG, 2020

Response' provision, which Meridian Energy can trigger at low hydro levels requiring the Tiwai Point aluminium smelter to reduce load.[37]

At the distributed level, demand-side participation might involve the commercial aggregation of flexible DER to temporally shift load that would otherwise occur at peak demand. Practically, this could entail the smart charging of the EV fleet, or the use of smart devices by distribution businesses to control consumers' hot water systems en masse. In 2018, over half of New Zealand's power connections operated with hot water systems with ripple control, meaning up to 15% of total network load was interruptible during times of peak demand (see At a glance below).[38]

At a glance: Ripple control in New Zealand

Ripple control is a demand management tool that has been available to New Zealand's electricity sector since the 1950s. All 29 EDBs operate ripple control systems that allow them to send signals to consumer devices (mostly hot water systems) to alter their energy consumption. EDBs deploy ripple control for 2 main reasons:

- Ensuring demand does not exceed capacity, protecting network security
- Deferring expenditure on network upgrades, keeping bills lower

Today, the load connected to ripple control equates to approximately 15% of New Zealand's annual peak demand, however the share of customers with ripple control is declining as retailers remove ripple control relays, solar panel installers disconnect relays, and consumers purchase alternative hot water energy sources.

The cost to manage ripple control is estimated to be $10-$27 per KW of controllable load; this compares to an estimated $130 per KW to provide additional peak distribution capacity. However, while the economics appear attractive, EDBs are not structurally incentivised to use ripple control in all case; in some instances they could increase the load on their network without it and therefore invest in upgrades from which they will receive a regulated return.

Other technologies to communicate with devices and manage load that do not rely on ripple control are also becoming increasingly common, such as smart devices that communicate with the smart meter.

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[37] Meridian Energy, Electricity Agreement Conformed and Redacted as at January 2021, 2021

[38] Energy Efficiency & Conservation Authority, Ripple Control of Hot Water in New Zealand, 2020

3. Glossary

In this section, we have endeavoured to clarify all acronyms / technical terminology that have been used throughout the appendix. The table below is intended to serve as a reference when reading through the report.

Term	Description
AC	Alternating Current
AMP	Asset Management Plan
BESS	Battery Energy Storage Systems
BEV	Battery Electric Vehicle
CAA	Climate Adaptation Act
CAPEX	Capital Expenditure
CPP	Customised Price Path
DC	Direct Current
DER	Distributed Energy Resources
DPP	Default Price Path
DR	Demand Response
DRMS	Demand Response Management System
ECNZ	Electricity Corporation of New Zealand
EDB	Electricity Distribution Business
EDGS	Electricity Demand and Generation Scenarios
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FlexPoint	Locally built flexibility management system launched to centrally and automatically coordinate the DR capabilities of various emerging technologies
Gentailer	Generator-retailers
GIDI	Government Investment in Decarbonising Industry program
Greenhouse gases	Carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons. These gases all cause changes in the Earth's atmosphere.
Gross emissions	The greenhouse gases that an economy produces
GW	Gigawatt
HVDC	High Voltage Direct Current
ICCC	Interim Climate Change Committee
LCOE	Levelised Cost of Energy
LETF	Low Emission Transport Fund
MBIE	Ministry for Business, Innovation, and Employment
Mt	Megaton
MW	Mega Watt

NBA	Natural and Built Environments Act
Net emissions	The greenhouse gases that an economy emits minus those gases taken out of the air, e.g., by new forests being planted.
NZ ETS	New Zealand Emission Trading Scheme
NZAS	New Zealand's Aluminium Smelter in Tiwai Point
NZEM	New Zealand Energy Market
NZGIF	New Zealand Green Investment Finance
OCGT	Open-Cycle Gas Turbines
OPEX	Operating Expenditure
PPA	Power Purchase Agreement
PV	Photovoltaics
Rankines / Rankine units	A type of steam turbine currently in use at Huntly power station
RMA	Resource Management Act
RUC	Road User Charge
SPA	Spatial Planning Act
SSDF	State Sector Decarbonisation Fund
tCO_2-e	The unit for measuring the climate impact of the greenhouse gases and stands for tonnes of carbon dioxide equivalent. Each of the different greenhouse gases has a different impact on the atmosphere, so a weighting is given to the other gases so that we have an idea of the overall impact of greenhouse gases emitted.
TW	Terawatt
TWh	Terawatt hours
UN	United Nations