Waitaha Hydro Scheme

Response to the Department of Conservation –
The New Zealand Electricity Industry and Market

Prepared for

Westpower

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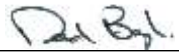
Revision 1	21 Sept 2015	First Issue		David Boyle

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EXECUTIVE SUMMARY

Based on the analysis in this report the Waitaha Hydro Scheme is likely to be financially viable in the reasonably foreseeable future. The Waitaha Hydro Scheme is one of the lower cost projects using the long run marginal cost methodology used for ranking generation in the electricity demand and generation scenarios (EDGSs), which are published by the Ministry of Business and Innovation (MBIE). The construction of the Waitaha Hydro Scheme will also increase energy efficiency by reducing transmission losses, and reduce the production of greenhouse gases, which is a key part of the New Zealand energy strategy.

Although it is difficult to predict exactly what the future demand in New Zealand will be, the actual generation constructed, or the future wholesale price of electricity will be, the EDGSs, are recognised by the industry as a good indicator of the future state, and reference to the scenarios have been used extensively in the Baldwin report and also in preparation of this report.

The demand and generation scenarios (EDGSs), that are published by the Ministry of Business and Innovation (MBIE), are estimates of outcomes given a set of assumptions, but they are not a prediction of what will actually occur, especially what generation will actually be constructed or when existing generation will actually be decommissioned.

Since the 2015 EDGSs were developed there have been a substantial number of changes to both the demand and generation forecasts, and these changes will likely bring forward generation plans and also result in an increase in the wholesale electricity price. These include:

- Because of uncertainty of the future demand at the Tiwai Point Aluminium Smelter, the EDGSs had scenarios for reduced or nil demand at Tiwai Point. Subsequently New Zealand Aluminium Smelters renewed its energy supply contract for 572 MW at Tiwai Point, out to 2030 with a guaranteed demand of 572 MW till 2017.
- It was announced that the planned decommissioning date for 500 MW of Huntly thermal generation plant has been brought forward and the remaining two coal fired generators will now be decommissioned by the end of 2018.
- It was announced that the 140 MW Southdown Power Station will be decommissioned before the end of 2015.The EDGSs assume that a portion would be decommissioned in 2015 but majority of the station would not be decommissioned till 2028.
- It was announced that the 400 MW Otahuhu B Power Station will be decommissioned before the end of 2015. The EDGSs assumes that a 400 MW CCGT would not be decommissioned until 2022-2024.
- It was announced that 1394 MW of consented generation projects, with lower theoretical costs than the Waitaha Hydro Scheme, have been abandoned by the proponents.

The Waitaha Hydro Scheme is one of the lower cost projects using the long run marginal cost (LRMC) methodology. Although there are other projects with theoretically lower LRMCs, if the nodal price received by the generators is also taken into account then the Waitaha Hydro Scheme becomes the 4th placed generation scheme and there is not a significant difference between the top ranked project, the 250 MW Tauhara geothermal power station, and the Waitaha Hydro Scheme. Low energy and demand growth rates tend to favour incremental increases in generation rather than construction of large generation schemes, as commissioning large generation blocks will likely reduce the wholesale electricity price as investors compete to get a return on their investments.

Consenting generation secures an option to build generation but does not guarantee that the generation will ever be constructed. 1479 MW of consented generation has been abandoned in the past two years. The decision to decommission existing generation or construct new generation is based on a number of commercial considerations by the owners / investors, and these differ between projects and also between investors.

1 INTRODUCTION

Westpower Ltd are proposing to construct a proposed run-of-river hydro scheme on the Waitaha River and have applied to the Department of Conservation for concessions to use conservation areas for the construction, operation, and maintenance of a hydro-electric generation scheme on and around the Waitaha River. In July 2014, Westpower submitted its application for concessions to the Department of Conservation and in May 2015 a report, " Proposed Waitaha Hydro Scheme: Assessment of Reasons, Financial Viability, and Alternative Locations" (the Baldwin report), was submitted to the Department by Baldwin Consulting that challenged the financial viability of the Waitaha Hydro Scheme proposal.

This report provides further information on the electricity system and electricity market, how the Waitaha Hydro Scheme fits with the NZ Energy Strategy and renewables targets, information on future demand and generation forecasts and where the Waitaha Hydro Scheme is ranked against other generation proposals, the probability of generation being constructed, and investor decisions to construct new generation.

2 THE NEW ZEALAND ELECTRICITY SYSTEM AND MARKET

The New Zealand electricity system is made up of:

- Generation – the power stations that produce electricity. There is mixture of generation that is connected to the National Grid and embedded generators that are connected directly into a distribution network or located at consumer premises.
- Transmission – the wires, cables and other equipment (the National Grid) that transport bulk electricity at high voltages from power stations to distribution networks and to a small number of direct connect customers who are predominantly large industrial users.
- Distribution – the local networks that carry electricity from the National Grid to residential, commercial and smaller industrial users. Distributors can also own generation but cannot act as retailers.
- Consumers – ranging from large industrial users through to residential households. There are around 1.9 million electricity consumers in New Zealand and they vary in size from 570 Megawatts (MW) at Tiwai Point Aluminium Smelter to less than 10 kilowatts (kW) for households.
- Retailers – the participants that buy wholesale electricity and on-sell it to consumers at their individual premises.

- Wholesale market – the spot market and contracts market where generators compete for the right to generate to meet demand, and retailers buy electricity for on-selling to consumers.
- System operation – real-time scheduling and dispatch of generation to match consumer demand and ensure power supply quality standards are met.

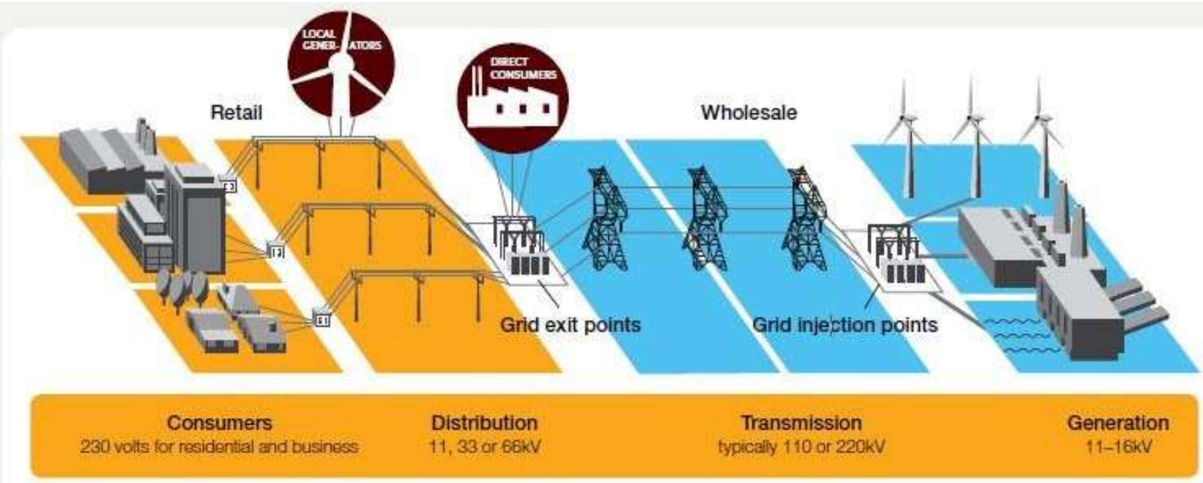
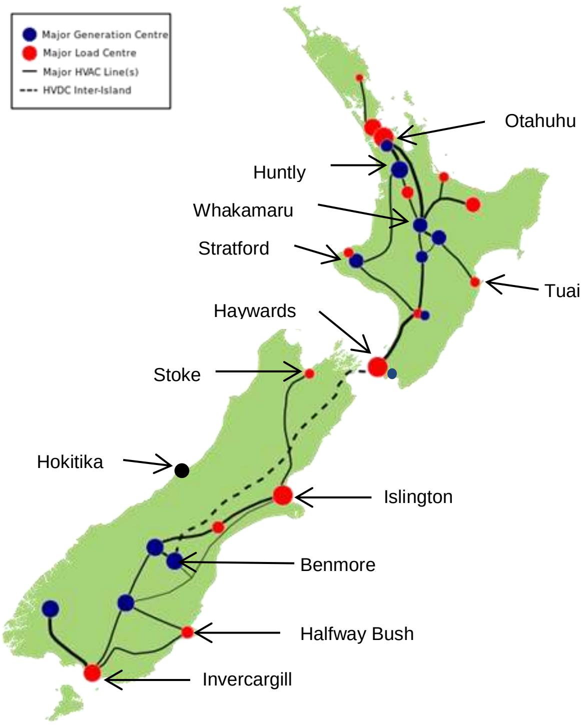


Figure 1: The NZ Electricity Supply System and Market

2.1 Electricity Generation

There is just under 10,000 MW of generation installed across New Zealand varying in size from small embedded generation less than 100 kW up to 1000 MW power stations. The larger generation tends to be grid connected because of the size and location, and the smaller generators tend to be embedded within the local distribution networks.



The major transmission network in New Zealand. Generation and load centres are shown as blue and red circles respectively. The major AC transmission corridors are shown as black lines, with the HVDC Inter-Island shown as a dashed line.

Figure 2: The major transmission network in New Zealand and generation and load centres.

A significant number of the power stations have to be located with the fuel source (water, wind, and geothermal) and these fuel sources are generally remote from the load centres as shown in figure 2. A significant proportion of the hydro generation is located in the lower part of the South Island, geothermal is predominantly in the Taupo/Bay of Plenty area, and a significant proportion of wind generation is in the Manawatu and Wellington areas.

In 2014, 79.9% of New Zealand's electricity was generated from renewable sources, hydro generation stations accounted for 56.2%, geothermal stations 15.9%, and the balance from bio-mass plants and wind farms 7.8%. The remainder was generated using gas 14.5% and coal 5.6%. The hydro and wind generation will vary from year to year depending on weather conditions.

Approximately 93% of the generation capacity is owned by five major electricity generating companies; Contact Energy; Genesis Energy; Meridian Energy; Mighty River Power; and Trustpower. All five are both generators and retailers of electricity.

The remainder of the generation is supplied by a number of other generators around New Zealand including hydro generation, fast start gas turbines, wind, geothermal, landfill gas, and cogeneration supplying electricity and process heat.

2.2 Transport of Energy from the Generators to the Consumers

A significant proportion of New Zealand’s electricity is generated at remote locations and requires a transmission system to transport it from the generation sources to the load centres.

Transpower owns and operates New Zealand’s electricity grid that transports bulk electricity across New Zealand from generators to load centres using high capacity, high voltage, transmission lines and cables. There is a high voltage AC transmission system running the length of both the North and South Islands, with a high voltage direct current (HVDC) link that connects the North and South Islands enabling energy to be transferred between the two islands. The DC link runs from Benmore Power Station in the lower South Island to Haywards substation in Wellington and includes submarine cables under the Cook Strait.

The regional distribution companies connected to the Transpower grid exit points then convey the electricity to the end use customers via their overhead lines and underground cable networks. There are 29 lines companies involved in the business of distributing electricity to consumers through regional networks of overhead wires and underground cables. Some of the largest distribution network owners are publicly listed, but most are owned by trusts or other local bodies.

Apart from a small number of major industrial users connected directly to the National Grid, such as the Tiwai Point Aluminium Smelter, the majority of consumer premises in New Zealand are connected to a distribution network.

2.3 Transmission and Distribution Charges

Transpower provides a service for transporting the electricity, and parties that are connected to the grid including the generators, distributors and direct connect customers are charged for this service. The amount that each party pays to Transpower is determined by the Transpower Pricing Methodology which is set by the Electricity Authority.

The distributors also supply a service transporting electricity through their networks and the end use customers need to pay for this and also the Transpower charges to the distributors.

Most lines companies do not directly bill the end use customers but sell their services to electricity retailers who provide a bundled service to consumers which includes the energy charges, and also the transmission and distribution line charges.

2.4 Coordinating the Grid and Generation

As the National Grid's System Operator, Transpower also provides a network coordination service. It schedules the generation of all power stations, monitors interconnected networks, ensures that reliability, voltage and frequency targets are met, and manages grid emergencies.

2.5 Retail

Electricity retailers provide a 'bundled' service for most consumers by buying electricity at wholesale (spot and contract) prices from the generating companies, and transmission or distribution services from lines companies. The retailers' charges to the end-users include the cost of the electricity supplied as well as charges for transmission and distribution. Some large consumers contract separately with retailers and lines companies for energy and network services.

The current legislation requires full ownership separation of distribution (lines) businesses from supply (retail and generation) businesses. The main reasons for the separation were to encourage competition in generation and retailing and to prevent cross subsidisation of generation and retailing from lines customers. These cross-ownership restrictions were subsequently relaxed twice to allow lines businesses to own some generation and to sell the output from those stations.[1] The Electricity Industry Act 2010 allows Westpower to generate up to 50 MW without triggering the arm's-length separation rules, and to generate up to 250 MW before triggering ownership separation rules. Even with the addition of the Waitaha Hydro Scheme, the total amount of generation owned by Westpower is below the 50 MW threshold so there is no separation required between the distribution and generation activities. There is no barrier to vertical integration from generation to retail.

In 2015, there were 29 retail brands in New Zealand selling electricity, but the retail space is dominated by the five largest generating companies, who between them sell over 90% of the energy. There are also smaller companies such as Todd Energy that have generation and are also retailers.

The generation and retail companies use this vertical integration of being generators and retailers as a natural hedge to manage risks associated with volatility of the spot market. For example, during a dry year, the high prices in the wholesale market price benefit the generation arm, but hurts the retailers who buy at wholesale prices and sell electricity to consumers at fixed prices. When prices are low, the loss of profits in the generation side is offset by the profits in the retail business.

The generator/retailers have also extended their risk management strategy further by aligning their retail and generation businesses to the same geographic locations. For example, the majority of Meridian Energy's generation assets are in the South Island where their retail strongholds are. Mighty River Power's generation assets are exclusively in the North Island, and Mercury Energy's customer base is also primarily in the North Island.

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[1] Chronology of the NZ Electricity Reforms
http://www.mbie.govt.nz/info-services/sectors-industries/energy/electricity-market/electricity-industry/chronology-of-new-zealand-electricity-reform/chronology-of-nz-electricity-reform.pdf

There is a cost to maintain a trading function for bidding into the spot and hedge markets and some smaller generators will sell energy to larger generators as it is not economic for them to have their own trading functions.

2.6 THE NEW ZEALAND ELECTRICITY MARKET.

In economic terms, electricity (both power and energy) is a commodity capable of being bought, sold and traded similar to other commodity markets. Like other commodity markets, the electricity wholesale market consists of spot and hedge markets. These markets must both be present for commodity markets to function well. There are a number of functions and parties involved in the electricity market as illustrated in figure 3.

Figure 3: Elements of the New Zealand Electricity Market

Most consumers buy electricity on contract from retailers, who in turn, purchase electricity on the wholesale market. Most domestic consumers are on fixed unit cost and they are hedged by the retailer they buy from, the retailer insulating the domestic customer from the spot price changes.

Retailers and a small number of customers, typically large industrial users, buy electricity directly from the spot market. These parties will typically also enter into financial contracts, often called hedges, which smooth out some or all of the volatility in spot prices. Hedges are fixed-price long-term agreements at which the bulk of electricity is exchanged. It prices exchanges between buyers and sellers of electricity that is not sold under a long-term agreement. The spot and contracts markets are collectively called the wholesale electricity market.

Generators compete in the electricity spot market to generate electricity to satisfy demand. They do this by submitting 'offers' to the System Operator. Each offer covers a future half-hour period (called a trading period) and is an offer to generate a specified quantity at that time in return for a minimum payment. The System Operator uses this price information to rank offers in order of price, and selects the lowest cost combination of offers to satisfy demand. The highest priced generator actually required for a given half hour sets the spot price for that trading period, and all generators are paid the spot price for their production.

Electricity spot prices are volatile due to the unique physical attributes of electricity such as non-storability and uncertain and inelastic demand. Electricity spot prices can vary significantly across trading periods and locations, reflecting factors such as generator bidding strategies, changing demand (e.g. lower prices in summer when demand is subdued) and supply (for example, higher prices when hydro lakes and inflows are below average) and electrical losses and constraints on the transmission system (for example, higher prices in locations further from generating stations).

The wholesale price can vary considerably across time as illustrated in figure 4 below.

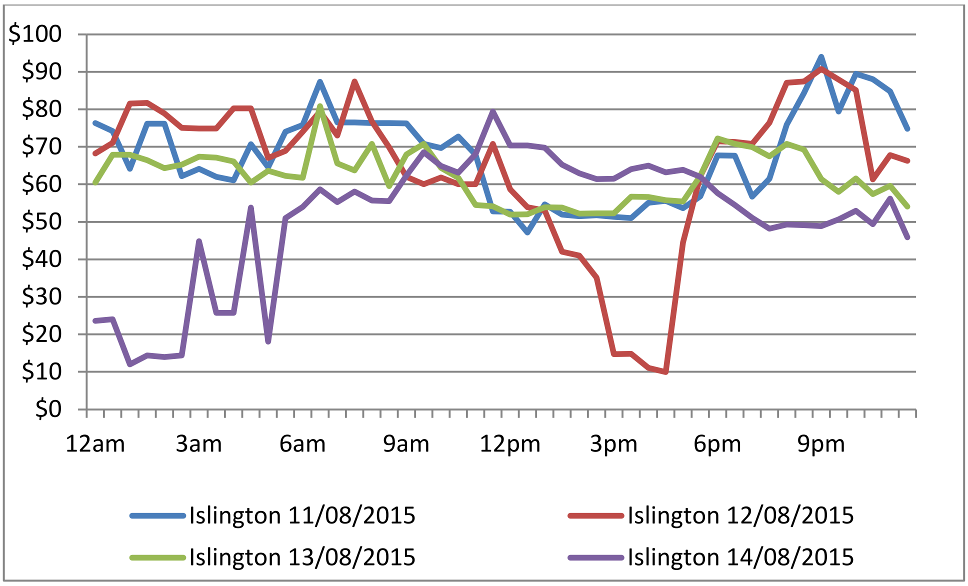
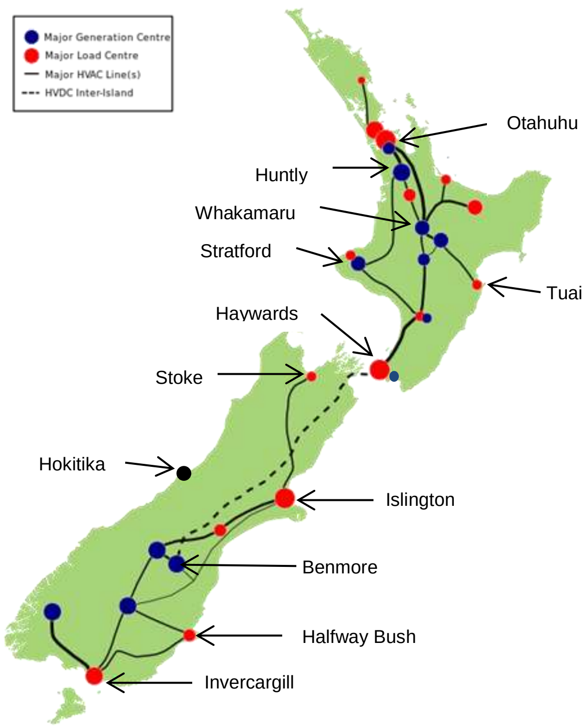


Figure 4: Final wholesale price at Islington (Christchurch) 11/08/2015 to 14/08/2015

2.7 Nodal Prices

Trades take place at approximately 285 nodes (grid injection points and grid exit points) across New Zealand every half-hour. Generators make offers to supply electricity at 59 grid injection points (GIP) at power stations, while retailers and major users make bids to buy electricity at 226 grid exit points (GXP) on the National Grid. Final prices at each node, taking account of grid losses and transmission constraints, are processed and confirmed the following day. Losses, combined with any constraints on the flow of electricity along the transmission lines, are real costs of transporting the energy, and these are reflected in the wholesale price of electricity. The purchaser (the retailer or wholesale buyer) pays the price at the exit point, not the injection point. The price is usually higher at the point where electricity exits the transmission grid compared to the price at the point where it was injected into the grid and the further the GXP is away from the GIP the higher the losses and the higher the wholesale price at that node.

The ratio of the price at the GXP relative to the price at the GIP is called the ‘location factor’. In the absence of transmission constraints, the location factor expresses the percentage of actual losses of electricity incurred in transporting it on the grid from its injection point to its exit point. In the South Island, the main reference node is Benmore 220 kV as Benmore is the centre of the largest generation area in the South Island and also the terminal point for the HVDC link. When energy flows from the North Island to the South Island it is injected into the South Island grid at Benmore.



Average location Factors 2003-2014

Node	**Location Factor**
Otahuhu	1.032
Huntly	1.011
Whakamaru	0.973
Stratford	0.982
Tuai	0.965
Haywards Hill	1.000
Stoke	1.092
Islington	1.061
Hokitika	1.124
Benmore	1.000
Halfway Bush	1.021
Invercargill	1.039

Fig 5: Location factors across New Zealand – average for 2003-2014

What is also important to note is that the higher nodal prices also apply to any generation injecting at that GXP, so income for 1 MW being injected at Benmore, with a location factor of 1, is lower than that of 1 MW being injected at Hokitika at the same time. The difference in nodal prices between points on the grid will also form part of an investor's decision when deciding to invest in new generation. This will be discussed further in later parts of the document.

2.8 Transmission Losses

Just like the transport of any physical product, there is energy consumed to transport electricity across the transmission grid and through the distribution networks from the generators to the consumer installations, and the longer the distance, the more energy is consumed to transport it. As energy travels along transmission and distribution networks, electricity is lost as heat due to resistance in the lines. The greater the distance the electricity travels and the lower the voltage of the line, the higher the losses.

The difference between the energy injected into the network (by generators) and the actual energy delivered to the consumers is referred to as losses. In 2014 there was 42,231 GWH generated and of this 2,960 GWH (7%) was to supply the combined transmission and distribution losses. Transmission losses accounted for 3% and distribution losses for 4%.

The losses are made up of two main components:

(i) A fixed component that arises from the standing losses in the transmission lines and cables, and other grid and distribution equipment; and

(ii) A variable component that is the largest component and is proportional to the electricity flow and the distance the electricity has to travel.

The majority of the variable losses occur in the high voltage (HV) and low voltage (LV) network overhead lines and cables, and the transformers used to change voltage levels in the transmission and distribution systems. The variable losses are commonly referred to as the resistive losses.

All materials have a resistivity property that opposes the flow of electrical current through the material, and the product of the current through the resistance is heat. The resistance per km depends on the size of the conductor and the type of material that the conductor is made from. Materials such as gold, silver and copper have very low resistivity but are relatively expensive, so the most common material used for conductors is aluminium. Aluminium is relatively inexpensive and durable and has a resistivity of just over 1.5 times that of copper.

For a particular conductor material, the resistance is inversely proportional to the cross-sectional area of the conductor, so the larger the cross-sectional area, the lower the resistance. Similarly, more conductors in parallel result in a larger overall cross-sectional area, with lower overall resistance and hence lower overall losses.

The resistive losses, in Watts, are a product of the resistance of the conductor multiplied by the square of the current flowing through the conductor. Because of the square relationship, if the current through a conductor doubles the losses will quadruple. Similarly if the current is halved the losses will be reduced to one quarter.

The further the demand is from the generation, the larger the losses. The energy required to transport the electricity (losses) as a proportion of the energy delivered is much higher per MW for customers that are a long way from major generation sources as is the case with Nelson/Marlborough and the West Coast.

Introduction of local generation reduces the losses, as a smaller proportion of the demand has to be transported and benefits are proportionally greater for demand that is a long distance from the generation source. The upper South Island (north of the Waitaki Valley) has to import the majority of its energy from the south.

The West Coast load is mostly supplied from the northern infeed, with power flowing through the region via the 110 kV circuits from Kikiwa to Dobson via Inangahua. Some loads are fed from the south via low capacity double-circuits 66 kV from Coleridge.[2] The transmission system from Benmore to Christchurch and over Arthurs Pass to Hokitika is approximately 530 km long, and the longer route via Kikiwa is approximately 750 km long. The generation at Waitaha will be approximately 60 km south of Hokitika so the there is a considerable reduction in the distance the energy has to be transmitted, and a resulting reduction in transmission losses.

Losses are also related to the voltage of the lines and cables with losses reducing significantly as the voltage level increases. Power transmission through a line is the product of current through the line multiplied by the voltage of the line. For the same power flow, if the voltage doubles then the current can halve, and because of the squared relationship between the current and the line resistance the transmission losses will be one quarter.

As noted above, in 2014 there was 2,960 GWH (7%) of combined transmission and distribution losses. These are the total losses across the year but losses vary considerably

[2] Transpower's 2014 Annual Planning Report, section 16.2.2, page 241- www.transpower.co.nz/sites/default/files/uncontrolled_docs/Annual_Planning_Report_2014.pdf

across time as the power flow changes because the losses are the square of the current flowing through a material, and the losses are much higher at periods of peak energy flow (high demand) than they are at periods of low demand.

Reducing the transmission losses increases energy efficiency because of the lower transport costs for the energy, and will also result in a reduction in the production of greenhouse gases. The reduction in the production of greenhouse gases is discussed further in section 3 below.

3 THE NEW ZEALAND ENERGY STRATEGY AND RENEWABLES TARGETS

The Waitaha Hydro Scheme generation will result in improved efficiency by reducing transmission losses, and reduce greenhouse emissions.

The New Zealand Government is committed to best practice in environmental management for energy projects and reducing greenhouse gas emissions. By 2050, the aim is to achieve a 50 percent reduction in our greenhouse gas emissions from 1990 levels. The New Zealand Emissions Trading Scheme will help drive investment into technologies that produce fewer emissions.[3]

The National Policy Statement on Renewable Electricity Generation states:

New Zealand's energy demand has been growing steadily and is forecast to continue to grow. New Zealand must confront two major energy challenges as it meets growing energy demand. The first is to respond to the risks of climate change by reducing greenhouse gas emissions caused by the production and use of energy. The second is to deliver clean, secure, affordable energy while treating the environment responsibly.

The contribution of renewable electricity generation, regardless of scale, towards addressing the effects of climate change plays a vital role in the wellbeing of New Zealand, its people and the environment. In considering the risks and opportunities associated with various electricity futures, central government has reaffirmed the strategic target that 90 per cent of electricity generated in New Zealand should be derived from renewable energy sources by 2025 (based on delivered electricity in an average hydrological year) providing this does not affect security of supply.[4]

While New Zealand's energy demand is forecast to grow at a slower rate than has been forecast in the past, it is still forecast to continue to grow. What has been seen in the past 5 or so years is an increase in the amount of new renewable generation that has been constructed, especially geothermal and wind generation, and also the decommissioning of some of the existing gas and coal fired generation including two Huntly 250 MW generators. This trend is set to continue with the planned decommissioning of the 150 MW Southdown gas fired generation and 400 MW Otahuhu CCGT by the end of 2015, and decommissioning of the remaining two 250 MW coal fired generators at Huntly Power Station by the end of 2018.

[3] New Zealand Energy Strategy 2011 to 2021 - http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-strategies/documents-image-library/NZES.pdf

[4] National Policy Statement on Renewable Electricity Generation - www.mfe.govt.nz/sites/default/files/nps-reg-2011.pdf

The Waitaha Hydro Scheme will contribute to the implementation of the NZ Energy Strategy in the following ways:

1. Construction of renewable generation should result in a reduction in the amount of energy that has to be supplied from gas fired generation, and a subsequent reduction in the production of greenhouse gases.
2. Construction of generation close to the demand will reduce transmission losses, increase energy efficiency, and also result in a reduction in the production of greenhouse gases. Given that there is a limited amount of renewable energy fuel available, reducing the amount of losses supplied from the renewable generation results in a reduction in the amount of energy that has to be supplied from gas fired generation.
3. The losses are highest at periods of peak demand, and this is the most likely time that the gas fired generators, especially open cycle gas turbines will be operating. Reducing the transmission losses reduces the peak demand and will result in the reduction of the energy requirement from the gas fired generators and a resulting reduction in the greenhouse gases produced. The open cycle gas turbines produce significantly more greenhouse gases per MW than the combined cycle gas turbines as efficiency is approximately 15 % less than that of the combined cycle gas turbines.

There is also a financial benefit of reducing the volume of energy that is supplied by generation that produces greenhouse gases such as gas fired generation. If the Scheme results in the avoidance of an equivalent level of generation from gas thermal plants there will be an estimated reduction of 51,120 tonnes of carbon dioxide equivalent greenhouse gases (CO2-e). Applying a carbon price of $25 per tonne implies an annual saving of $1.3 million in terms of reduced emission units which would need to be purchased offshore by the New Zealand electricity generation sector.[5]

4 Electricity Demand and Generation Scenarios

The demand and generation scenarios (EDGSs), that are published by the Ministry of Business and Innovation (MBIE), are estimates of outcomes given a set of assumptions, but they are not a prediction of what will actually occur, especially what generation will actually be constructed or when existing generation will actually be decommissioned. It is important to understand what the EDGSs are intended to be used for and how they are developed.

4.1 The Purpose of the Electricity Demand and Generation Scenarios

The EDGSs are independent demand and generation scenarios prepared by MBIE, and their purpose is to provide a key reference point for preparing and assessing major grid investment proposals (>$20 Million) for the New Zealand transmission grid. They are also used for assessing Transpower's base capex expenditure proposals which Transpower submits to the Commerce Commission on a 5 yearly basis.[6]

[5] Refer Waitaha Hydro Scheme Application for Concessions and Assessment of Effects July 2014 , page 120. - http://www.westpower.co.nz/system/files/resources/Waitaha%20Hydro%20Scheme%20Concession%20Application%20and%20AEE%20July%202014.pdf

[6] Further details of the role of the EDGS can be found in paras 3-7 and the appendix 2 of the MBIE consultation paper on the 2015 EDGSs - http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015/Draft-EDGS-consultation-guide.pdf/at_download/file

The primary role of the EDGSs is set out in the Commerce Commission's Transpower Capital Expenditure Input Methodology Determination [2012] (Capex IM). Under the Capex IM, the EDGSs have an explicit role in the “investment test” for approving Transpower proposals for major capital expenditure. The net electricity market benefit in that test is determined as a weighted average of those benefits across a range of possible future scenarios. The EDGSs provide the relevant default scenarios. [7]

Many transmission investments need to be initiated years before additional demand or generation appears so the scenarios are used to determine a set of possible future states, and the net electricity market benefit of transmission investments are then assessed against those states. The 2015 scenarios and assumptions were consulted on with industry and the public to get feedback on the assumptions and scenarios.

While the primary objective is for the assessment of transmission expenditure, the scenario outputs including the wholesale energy price forecasts find use in a wide range of applications, as there are few (if any) other publicly-available and independent scenarios and forecasts for the New Zealand Electricity Sector.[8]

4.2 Changes To Assumptions since Draft EDGSs were Prepared

The scenarios were based on the best information available at the time, and as with any scenarios they will change over time. Since the EDGSs were published there have been a number of changes that have a significant effect on the published scenarios.

4.2.1 Changes to demand assumptions

The most significant change since the scenarios were prepared is the announcement on the 3rd of August 2015 that New Zealand Aluminium Smelters Limited (NZAS) and Meridian had entered into a revised contract for 572 MW until 2030, allowing the smelter’s three pot lines to remain fully operational.[9] This essentially nullifies the reduced Tiwai demand and Tiwai exit scenarios in the short to medium term.

4.2.2 Changes to the generation assumptions

The majority of the remaining scenarios assume that Contact Energy’s 400 MW combined cycle gas turbine power station (CCGT) at Otahuhu would remain in service until between 2022-2024, or be replaced by a smaller (250 MW) fast start gas turbine, and a new 400 MW CCGT would be constructed at Otahuhu to replace the existing 400 MW CCGT at Stratford.

On the 17th of August 2015, Contact Energy announced that it is proposing to shut down its 400 MW Otahuhu B Power Station by 30 September 2015[10] and also plans to demolish the plant and sell the 37 hectares of land that it owns at Otahuhu.[11] Given that Contact Energy

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[7] Further information on the MBIE demand and generation modelling can be found at www.mbie.govt.nz/info-services/sectors-industries/energy/energy-modelling/modelling/electricity-demand-and-generation-scenarios

[8] Trustpower submission on the 2015 draft EDGSs. - http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015-submissions-cross-submissions/Trustpower.pdf

[9] NZAS press release http://www.nzas.co.nz/files/2015080390628-1438549588-0.pdf

[10] Contact Energy press release on shutting down the Otahuhu B power station https://www.contact.co.nz/cenergymedia/contactenergy/files/pdfs/corporate/cen-close-otahuhu-power-station.pdf

[11] Comments from Contact Energy CEO published on stuff.co.nz http://www.stuff.co.nz/business/industries/71173247/contact-energy-profit-slips-43pc-to-133-million-will-shut-otahuhu

intends selling the Otahuhu site it is highly unlikely that the second CCGT generator will ever be constructed.

On the 4th of March 2015, Genesis Energy announced that it is proposing to shut down its 140 MW Southdown Power Station by 31st December 2015.[12] The EDGDs assumed that a portion of the Southdown Power Station would decommissioned in 2015 but the majority would remain in service till 2028 in all scenarios.

On the 8th of July 2015, Genesis Energy announced that it was abandoning plans to construct a 480 MW gas fired power station at Rodney and around 60 hectares of land set aside for the project is being sold.[13]

On the 6th August 2015, Genesis Energy announced that it's last two 250 MW coal-burning electricity generators at the Huntly Power Station will be permanently withdrawn from the market by December 2018.[14] In most of the scenarios, G3 at Huntly would be decommissioned by 2017 but in 50 % of the scenarios the last coal fired generator would not be decommissioned till 2020.

While there has been 2300 MW[15] of new generation commissioned since 2001, in reality the net increase is much smaller than this because a number of generators have already been decommissioned or are scheduled to be decommissioned by the end of 2018. By the end of 2018, the generation capacity in New Zealand will have only increased by 760 MW (9%) over generation levels in 2001 with:

- 500 MW at Huntly already decommissioned
- 400 MW at Otahuhu and 140 MW at Southdown planned to be decommissioned by the end of 2015
- Another 500 MW at Huntly planned to be decommissioned by the end of 2018

Of the 2300 MW of new generation around 28% is geothermal, 35% is gas turbines, 7% diesel and 28% (643 MW) wind generation. Because the geothermal, gas and diesel generators have reliable fuel supplies, the amount of time that they are available to generate electricity per year at full capacity is in excess of 75%.This is comparable to the thermal plants that have or are planned to be decommissioned.

Because wind varies year by year, week by week, day by day and even throughout the day, it is considered to be a variable fuel source. While wind farms in New Zealand have very high outputs compared to overseas ones, they still only generate at an average of 40% of their rated output.

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[12] Genesis Energy press statement on plans to shutdown Southdown Power Station - http://www.mightyriver.co.nz/Media-Centre/Latest-News/Renewables-growth-behind-closure-of-Southdown-ther.aspx

[13] Radio NZ report on Genesis Energy abandoning plan for Rodney Power Station - http://www.radionz.co.nz/news/regional/278228/genesis-axes-rodney-power-station-plan

[14] Genesis Energy Press release on Huntly coal fired generation at Huntly being withdrawn from the market - https://www.genesisenergy.co.nz/web/genesis-energy/genesis-news-item/-/asset_publisher/SXj7PCBceFc2/content/genesis-energy-limited-gne-announces-timetable-to-end-coal-fired-generation-in-new-zealand?_101_INSTANCE_SXj7PCBceFc2_read_more=true

[15] In the Financial Viability of Waitaha Hydro Proposal report by Tony Baldwin the total generation in Table 8 quotes 2207 MW but this appears to be an arithmetic error and total should be 2307 MW.

4.3 Demand Assumptions

MBIE constructed demand scenarios considering the following:

- The size and structure of the economy;
- The future of heavy industry in New Zealand, particularly the Tiwai Point Aluminium Smelter;
- The size and structure of the population;
- The price of electricity compared with alternative energy sources; and
- Energy efficiency and demand side participation in the wholesale and retail electricity markets.

MBIE considered that the key uncertainties in the demand out to 2040, for the purposes of the EDGSs, were electricity demand growth and demand from the Tiwai Point Aluminium Smelter. The resulting demand scenarios that were constructed were:

- Business as usual scenario with moderate demand growth – 1.1% growth;
- Low demand growth scenario – 0.7% growth;
- High demand growth scenario – 1.3 % growth;
- Partial closure of Tiwai Point Aluminium Smelter – Tiwai demand 400 MW; and
- Complete closure of Tiwai Point Aluminium Smelter – Tiwai demand 0 MW.

The smelter is the largest single electricity user in the country, accounting for almost 13% of national electricity usage in the 2013 calendar year. When the scenarios were prepared there was considerable uncertainty around the future operation of the smelter so MBIE included scenarios for baseload demand at Tiwai of 572 MW, 400 MW and 0 MW. In the scenario of Tiwai closing, electricity demand nationally would decline 11% as a result and take nine years to recover to the same level. As noted above, NZAS and Meridian had entered into a revised contract for 572 MW until 2030, allowing the smelter's three pot lines to remain fully operational. This essentially nullifies the reduced Tiwai demand and Tiwai exit scenarios in the short to medium term.

Each of the EDGSs has its own demand projections at the island level and peak demand projections for the North Island and New Zealand. They do not include regional or prudent peak demand projections or include Transpower's peak demand projections. But since Transpower's peak demand projection and the Ministry's EDGS base case scenario are each an input into determining the other, the peak demand projection for the base case scenario should be quite close to Transpower's expected peak demand projections. Some iteration may be required between these models to produce consistent results.[16]

Under all the scenarios, electricity demand is projected to grow throughout the projection period. With respect to the forecast demand in the West Coast area, the forecast demand has reduced from previous forecasts but demand is still forecast to increase on the West Coast and also across the grid.

[16] Refer paras 41-48 of the MBIE consultation paper on 2015 EDGS for further details on the process - www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015/Draft-EDGS-consultation-guide.pdf

4.4 Generation Input Assumptions

The location and timing of the generation is calculated using a Generation Expansion Model (GEM) developed by the Electricity Authority and is based on a number of assumptions, including the capital and operating costs of the generation plant, varying fuel costs, and carbon charges.

GEM was used to determine the optimal build profiles in the North and South Islands under each scenario, but GEM does not attempt to co-optimise the location of generation with the within - island AC transmission grid. GEM does not take into account the different nodal prices across the grid, which would be taken account of by investors assessing the economics of future generation builds.

It is important to note that GEM is purely a cost minimisation model. It does not consider the commercial objectives of individual market participants and nor does it consider the likelihood of various projects proceeding.

The capital and operating cost assumptions were provided by Parsons Brinkerhoff (PB) in the 2011 NZ Generation Data Update report that was prepared for the Ministry of Economic Development which is now part of MBIE.[17] The capital costs were developed by PB using published data where it was available and PB estimates where the data was not publicly available. PB used a target 'concept' level of accuracy for the cost estimates of ±30 percent. The costs in the 2011 report were subsequently escalated by PB for the 2015 EDGSs.

The LRMC model used for calculating the generation list is based on a number of assumptions and just provides an indication of the LRMC for a range of generating plant. The real cost of a project will vary on a case by case basis and is dependent on location, land costs, consenting costs, design, technology, steel prices, construction prices etc.

Due to the model picking the next project with the lowest LRMC to meet demand growth and since the project LRMCs are subject to a large variation in capital cost, the resulting list of projects and the order in which they occur is likely to differ considerably from reality.

The list of potential generation used for the EDGSs was drawn from the EA Generation Update October 2013 dataset published by the Electricity Authority.[18] The dataset only contains generation where resource consent had been applied for, that have received resource consent, or are under construction.[19]

As the Waitaha Hydro Scheme was not included in the EA Generation Update October 2013 dataset, it did not appear in the list of potential hydro generation developments in the MBIE 2015 generation scenarios.

4.5 The Eight Scenarios for Future Development

Eight scenarios for future development of the electricity sector out to 2040 have been produced using different combinations of inputs. MBIE considered that the key uncertainties for the electricity sector out to 2040 for the purposes of the EDGSs were electricity demand

[17] The full 2011 NZ Generation Data Update report can be found at http://www.med.govt.nz/sectors-industries/energy/pdf-docs-library/energy-data-and-modelling/technical-papers/2011%20NZ%20Generation%20Data%20Update%20v006a.pdf

[18] EA Generation Update October 2013- https://www.ea.govt.nz/dmsdocument/11455

[19] Refer to section 4.2.2,page 136 of the PB report http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/technical-papers/2011-nz-generation-data-update?searchterm=pb+

growth, demand from the Tiwai Point Aluminium Smelter, and the kind of generation that will be constructed to meet future demand. A mix of generation technologies is likely to be constructed, but the EDGSs considered cases with a greater tendency towards geothermal energy, gas fired generation and wind generation respectively. Tendencies towards particular generation types had implications for the predominant location of future grid connected generation. Those key areas of uncertainty were included in the design of eight equally - weighted draft scenarios:

a. Base case (mixed renewables with thermal support)

b. High geothermal availability (more geothermal generation)

c High gas availability (cheap plentiful gas)

d. Global low carbon emissions (with more wind and solar generation and high uptake of electric vehicles)

e. Lower Tiwai Point Aluminium Smelter demand (400MW baseload from 2017)

f. Tiwai Point Aluminium Smelter exits from 2017

g. Low demand growth

h. High demand growth

For each of the scenarios, a generation build schedule out to 2050 was produced from the generation assumption inputs and each contain a list of generators and commissioning years for the generator. This build schedule was based on the information that was known at the time the schedules were produced and as noted above, there have been a number of changes to the decommissioning dates of existing generators and also abandonment of some new generation projects. A cut down version of the generation build schedules which only goes out to 2030, can be found in attachment B.

The change in the decommissioning dates for the remaining two 250 MW coal units at Huntly will have little effect on the scenarios as there is only small advancement in the decommissioning dates. All of the scenarios assumed that the Otahuhu B CCGT would remain in service for a significant number of years, and based on the modelling there would need to be advancement of the commissioning dates for new generation in the EDGS generation build lists to cover the loss of 400 MW from Otahuhu B.

4.6 WAITAHA LONG RUN MARGINAL COST (LRMC)

The Waitaha Hydro Scheme would be ranked as the seventh project using the MBIE LRMC methodology and would have likely been constructed around 2020 in the majority of scenarios. If nodal pricing was factored into the ranking then Waitaha would move up to fourth place.

The LRMC model used for calculating the generation list is based on a number of assumptions and really just provides an indication of the LRMC for a range of generating plant. The GEM model picks the next project with the lowest LRMC to meet demand growth and since the project LRMC's are subject to a large variation in capital cost, the resulting list of projects and the order in which they occur is likely to differ considerably from reality. The LRMC calculations do not take into account difference in nodal prices for the different generators nor any commercial considerations for investor, both of which will be addressed later in the report.

As the Waitaha Hydro Scheme was not in the generation list for the EDGSs, the comparative LRMC was not calculated by PB. A calculation of the LRMC has been included in the Baldwin report and the report states that "*Just as MBIE caveats its model, the estimates above are not necessarily the Waitaha scheme's unit cost. Underlying cost assumptions will vary from one approach to another. The methodology applied in this report compares the proposed Waitaha scheme with other new generation projects in MBIE's model on a 'like for like' basis".*

Rank	Type	Project	Fully consented	MW	Capital cost $m	LRMC $/MWh	Update on Project Status August 2015
1	Geothermal	Tauhara stage 2	Yes	250	1201	79.06	
2	Gas - CCGT	Otahuhu C	Yes	400	610	83.04	Project abandoned in Aug 2015[20]
3	Hydro	Hawea Control Gates	Yes	17	53	87.49	
4	Wind	Hauauru ma raki stage1	Yes	252	627	89.43	Project abandoned in Aug 2013[21]
5	Wind	Hauauru ma raki stage2	Yes	252	627	89.43	Project abandoned in Aug 2013
6	Hydro	Lake Pukaki	Yes	35	114	90.45	
7	Gas - CCGT	Rodney CCGT stage 1	Yes	240	384	91.27	Project abandoned in July 2015 [22]
8	Gas - CCGT	Rodney CCGT stage 2	Yes	240	384	91.27	Project abandoned in July 2015
9	Wind	Turitea	Yes	183	478	94.91	
10	CCGT	Proposed CCGT1	Proposed	194	333	95.01	Generic plant with no proponent
11	Wind	Hawkes Bay windfarm	Yes	225	560	96.68	
12	Geothermal	Tikitere Lake Rotoiti	Applied	45	303	97.53	No evidence that a Resource Consent has been applied for
13	Hydro run of river	Waitaha	No	20	100	98.39	
14	Wind	Project Central Wind	Yes	120	314	99.05	
15	Hydro	Arnold	Yes	46	192	99.51	

Table 1: Approximate ranking of Waitaha in MBIE framework

The LRMC calculation for the Waitaha Hydro Scheme undertaken in the Baldwin report has not been recalculated. The calculated LRMC of the Waitaha has been ranked against another 27 generation projects in figure 57 (p 176) of the Baldwin report. Figure 57 has been

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[20] Contact Energy press release on shutting down the Otahuhu B Power Station https://www.contact.co.nz/cenergymedia/contactenergy/files/pdfs/corporate/cen-close-otahuhu-power-station.pdf

[21] Wind Energy Association - http://www.windenergy.org.nz/haururu-ma-raki

[22] Radio NZ report on Genesis Energy abandoning plan for Rodney Power Station - http://www.radionz.co.nz/news/regional/278228/genesis-axes-rodney-power-station-plan

reproduced here in table 1 but only the top 15 projects have been included and a column has been added that contains comments on the status of the project as at August 2015. Five of the projects ranked higher than Waitaha have been abandoned by their proponents, and there is no evidence that a resource consent for the Tikitere Lake Rotoiti geothermal project has been applied for.

After removing the generation that has been abandoned, the generic CCGT plant with no identified proponent, and the Tikitere Lake Rotoiti geothermal that has not been consented, the Waitaha Hydro Scheme moves from place 13 to place 7 based on the LRMC cost. Given its relatively high ranking with this calculation, the Waitaha Hydro Scheme would have likely been constructed around 2020 in the majority of scenarios, had it been included in the EDGSs.

As discussed earlier, the GEM modelling used for the EDGSs does not co-optimise the location of generation with the within - island AC transmission grid so it does not take into account the different nodal prices across the grid. The nodal process varies considerably across the grid with the lowest prices generally being at the major injection points and the highest prices in areas that are a long way from the generation sources.

Generation Project	Assumed Grid Injection Point	Island	Average Location Factor July 2003 - July 2014[23]	Average Location Factor Compared to Hokitika
Tauhara Stage 2	Wairakei 220kV	NI	0.962	-0.118
Hawea Control gates	Cromwell 33kV	SI	1.001	-0.079
Lake Pukaki	Twizel 33kV	SI	1.006	-0.074
Turitea	Bunnythorpe 220kV	NI	0.988	-0.092
Hawkes Bay windfarm	Whirinaki 220kV	NI	0.972	-0.108
Tikitere	Rotorua 33kV	NI	0.990	-0.090
Waitaha	Hokitika 66kV	SI	1.08 (1.139)	0.000

Table 2: Location factors for top ranked generators based on the LRMC modelling. The historical average for Hokitika is shown in ( ).

In the final prices dataset, published by the Electricity Authority, the average location factor at Hokitika between July 2003 and July 2014 is 1.139. The addition of the Waitaha Hydro Scheme will reduce the location factor at Hokitika when it is operating, but it is difficult to predict accurately what it will be without carrying out extensive and costly Loadflow studies. For the purpose of this analysis, a conservative approach has been used and an assumed location factor of 1.08 has been applied.

Table 2 contains the location factors for the generators that were ranked above Waitaha in table 1, and references them back to the Waitaha generation injection at Hokitika. The location factor will change over time, but if the historical location factors are applied to the LRMC then the Waitaha ranking would change, and it would be ranked second. If more conservative location factors of 1.08, 1.05 or even 1.03 are used for Hokitika, Waitaha would be ranked fourth. As with the LRMC calculation, this is a theoretical calculation, and the

[23] Location factor data from Electricity Authority - http://www.emi.ea.govt.nz/Datasets/download?directory=%2FDatasets%2FWholesale%2FFinal_pricing%2FLocation_factors%2F20140711_Location%20factors%20and%20nodal%20price%20data.xlsx

decision to build will be the commercial decision, based on a number of factors, which is discussed later.

The submission on the draft EDGSs from the New Zealand Geothermal Association contained a comment on the potential weakness of excluding the nodal prices from the modelling of the future generation modelling:

Ngawha generation does not show up in scenarios until 2027 in one scenario and 2033 in two other scenarios (and later in others). Despite this pessimism, Top Energy has just initiated consents for development, and would only do so if it thought the project was approaching commercial viability. This may reflect the weakness in the modelling through absence of nodal pricing. Clearly higher nodal prices in Northland could mean that this project is decades ahead of scenario projections.[24]

5 Probability of Generation Schemes being constructed

5.1 A Resource Consent is just an Option

There is over 5400 MW of generation consented, but having a resource consent in place for a generation project does not guarantee when or even if the generation will actually be constructed. The resource consent is just one step in the process for construction of a new generation scheme, but it is often a critical step, because it can affect the time to construct the plant and the financial viability of a project. Many proponents will secure the consents as a future option, as having a consent in place provides the investor with more certainty around the cost and timing of the generation project, if or when it decides to construct the project.

In the Mighty River Power Quarterly Operational Update for the three months ended 31 March 2013, Mighty River Power's General Manager Development, Mark Trigg stated:

Although the Company is unlikely to build a new power station in the next 3-5 years, generation projects require long lead times. The securing of consents and exploration of projects form steps in a lengthy process that position the Company to proceed as demand and economic conditions allow.[25]

5.2 Consented Generation Projects that will not be Constructed

There are a number of examples where investors have gained resources consents as a future option but have decided not to proceed with the projects. The four cases following total over 1400 MW of generation.

Otahuhu C 400 MW CCGT - Contact Energy commissioned its first 400 MW combined cycle gas turbine (CCGT) generator, Otahuhu B, at Otahuhu in South Auckland in 1999. The consent for a second 400 MW CCGT generator was granted in 2002, and in October 2006 Contact Energy's CEO at the time confirmed that Contact Energy had agreed to proceed to

[24] The submission on the draft EDGSs from the New Zealand geothermal association - http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-odelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015-submissions-cross-submissions/nzga.pdf

[25] Mighty River Power Quarterly Operational Update for the Three Months Ended 31 March 2013 - http://www.mightyriver.co.nz/Media-Centre/Latest-News/2013-Archive/Mighty-River-Power-Business-Update.aspx

the tendering stage for the construction of Otahuhu C – a 400 MW CCGT power station next to the company's Otahuhu B plant in Auckland.[26]

In October 2007, Contact Energy announced that it was continuing to defer investment decisions on its consented 400 MW Otahuhu C gas-fired Power Station in order to focus on renewable generation.[27] Contact Energy has subsequently constructed geothermal power stations in the Bay of Plenty and also two 100 MW gas fired fast start gas turbine generators at Stratford.

On the 17th August 2015, Contact Energy announced that it is planning to shut down the existing Otahuhu B CCGT by 30th September 2015[28] and also plans to demolish the plant and sell the 37 hectares of land that it owns at Otahuhu.[29] Given that Contact Energy intends selling the Otahuhu site, it is highly unlikely that the second CCGT generator that was consented in 2002 will ever be constructed.

Rodney Power Station - In July 2015, Genesis Energy announced that it was abandoning plans to construct a 480 MW gas fired power station at Rodney and around 60 hectares of land set aside for the project is being sold.[30]

Hauauru Ma Raki Windfarm - In August 2013, Contact Energy announced that it would not progress with the planned 504 MW Hauauru Ma Raki windfarm any further.[31]

Mokihinui Hydro Scheme – In May 2012, Meridian Energy announced that it had decided not to proceed with the 85 MW Mokihinui Hydro Scheme project near Westport.[32]

5.3 Investment Analysis

The decision to invest in new generation will be based on a number of commercial considerations. Each investor will have a basket of risks and benefits it will consider before investing in new generation. As the generation plants generally require reasonably large capital investments and have a relatively long life span, the short medium and long term scenarios must all be considered.

The commercial considerations for investors are also noted in MBIE's 2013 Energy Outlook Modelling Technical Guide which states:[33]

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[26] Contact Energy press release 17 August 2015- http://www.contactenergy.co.nz/aboutus/pdf/financial/2006_am_media_release.pdf

[27] Contact Energy press release 16 October 2007- http://www.scoop.co.nz/stories/BU0710/S00263.htm

[28] Contact Energy press release on shutting down the Otahuhu B Power Station https://www.contact.co.nz/cenergymedia/contactenergy/files/pdfs/corporate/cen-close-otahuhu-power-station.pdf

[29] Comments from Contact Energy CEO published on stuff.co.nz http://www.stuff.co.nz/business/industries/71173247/contact-energy-profit-slips-43pc-to-133-million-will-shut-otahuhu

[30] Radio NZ report on Genesis Energy abandoning plan for Rodney Power Station - http://www.radionz.co.nz/news/regional/278228/genesis-axes-rodney-power-station-plan

[31] Wind Energy Association - http://www.windenergy.org.nz/haururu-ma-raki

[32] Meridian press release on exiting from the Mokihinui Hydro Project - https://www.meridianenergy.co.nz/news-and-events/meridian-exits-mokihinui-hydro-project/

[33] Refer page 37 of the 2013 energy Outlook Modelling technical guide - http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/technical-papers/pdf-library/Energy-Outlook-2013-Technical-Modelling-Guide.pdf

It is important to note that GEM is purely a cost minimisation model. It does not consider the commercial objectives of individual market participants and nor does it consider the likelihood of various projects proceeding.

Some of the issues that may form part of the basket of risks and benefits include:

- Consenting risks and delays
- Development costs and risks
- Cost of connecting the generation to the local distribution system or National Grid
- Capital constraints
- Impact of additional borrowings on credit ratings
- Cost of financing investment
- Current or future transmission constraints
- Potential future stranding risk
- Existing generation plant mix - hydro/wind/geothermal/gas
- Generation capacity versus customer demand
- Location of fuel
- Future availability of fuel
- Future fuel costs
- Future carbon costs
- Costs of gas transmission
- Impact on market price of adding new generation into market
- Future income - wholesale price
- Expected nodal price for proposed generation
- Market risks (spot price exposure/hedging risk/reduced future demand)

There are a large number of generation schemes consented, and a number of these have been abandoned. There are only a handful of generation schemes that are being actively pursued, but none of which have been committed to at this time. These include:

- Nova Energy's 100 MW gas fired open cycle gas turbine in Taranaki[34]
- Top Energy's 25 MW expansion of its Ngawha geothermal power station in Northland[35]

[34] Press release on Nova Junction Road generation - http://www.scoop.co.nz/stories/BU1506/S00504/nova-seeking-expressions-of-interest-for-new-power-station.htm

[35] Top Energy Information on Ngawha Generation expansion http://topenergy.co.nz/ngawha-expansion-project/

- Westpower's 20 MW Waitaha Hydro Scheme.

5.4 Optimum Generation Size

Although the demand is increasing at a much slower rate than has been forecast in the past, it is still forecast to increase and this additional demand must be supplied. Low energy and demand growth rates tend to favour incremental increases in generation rather that construction of large generation schemes, as commissioning large generation blocks will likely reduce the wholesale electricity price as investors compete to get a return on their investments. Although there is a lot of generation consented, only a small percentage is small generation as shown in table 3.

Generation Scheme Capacity	Total Generation Capacity (MW)	Percentage of Total Generation Capacity	Number of Generation Schemes
250 MW and greater	3347	62%	7
100 MW to 249 MW	1315	24%	8
50 MW to 99 MW	390	7%	6
25 MW to 49 MW	258	5%	7
Less than 25 MW	122	2%	10
	5432*		

Table 3: Consented generation capacity

Note: The 5432 MW is a total of all consented generation including generation projects that have recently been abandoned

When looking at the data for the generation projects that are either consented or in the consenting process, it is important to look at the size of the generation. When looking at the capacity of the generation schemes, 86 % of the generation schemes are greater than 100 MW with 62 % greater than 250 MW.

5.5 Potential Effects of Nodal Prices on Investment Decisions

As noted earlier, the nodal price can have an effect on the theoretical ranking of generation projects. The nodal price can vary considerably across the grid with the lowest prices generally being at the major injection points and the highest prices in areas that are a long way from the generation sources. As the nodal price is both the price paid at that node and also the price received for injection at that point, based on the location factors, the value of the injected generation per MW for the Waitaha is considerably more than that for a number of other proposed generation projects.

As the revenue that an investor can expect to receive will be related to the nodal price at the injection point, the nodal price will have a bearing on the economics of a particular scheme and is an important part of the assessment by an investor.

6 TRANSMISSION SYSTEM CAPACITY

6.1 WEST COAST VOLTAGE ISSUES

In its 2015 transmission planning report, Transpower has highlighted potential over and under voltage issues in the future.

Low voltages will occur on the 110 kV transmission system in the West Coast region from approximately 2022 following an outage of the Kikiwa–T2 interconnecting transformer, or 110 kV Inangahua–Kikiwa–2 circuit.[36]

High voltages will occur on the 110 kV transmission system under light load conditions and high generation from the embedded and grid connected generators. This issue can be easily managed operationally at present. If there are increased levels of embedded generation, this issue will become more significant and may require more intensive operational control of the generating units' voltage set-points.[37]

The Waitaha Hydro Scheme will have synchronous generators which have the ability to produce reactive power to support the system when there are low voltage issues, and also absorb reactive power to reduce the voltage when there are high voltages issues. Provision of the voltage support by the Waitaha generation has the potential to delay the need date for additional voltage support plant, such as new capacitor banks at Hokitika.

6.2 MAXIMUM REGIONAL GENERATION

The West Coast region's generation capacity is 30 MW, which is lower than the local demand, and the deficit is imported through the National Grid. The Waitaha Hydro Scheme would increase this from 30 to 50 MW, but this is still below the worst case contingency generation injection limit of 105 MW at the Kikiwa 110 kV bus. [38]

[36] Transpower 2015 planning report, Section16.8.3
https://www.transpower.co.nz/sites/default/files/publications/resources/TPR2015Chapter16WestCoast.pdf

[37] Section16.10.1 of the Transpower 2015 planning report.-
https://www.transpower.co.nz/sites/default/files/publications/resources/TPR2015Chapter16WestCoast.pdf

[38] IBID, Section16.11.1

ATTACHMENT A: EXPLANATION OF TERMS USED IN THIS REPORT AND IN THE ELECTRICAL INDUSTRY

Ampere: The unit of measurement of electrical current produced in a circuit by 1 volt acting through a resistance of 1 Ohm.
Ancillary services: Services that ensure reliability and support the transmission of electricity from generation sites to customer loads. Such services may include load regulation, spinning reserve, non-spinning reserve, and voltage support.
Apparent power: The product of the voltage (in volts) and the current (in amperes). It comprises both active and reactive power. It is measured in "volt-amperes" and often expressed in "kilovolt-amperes" (kVA) or "megavolt-amperes" (MVA). See Power, Reactive Power, Real Power.
Biomass: Organic nonfossil material of biological origin constituting a renewable energy source.
Capacity Factor: Capacity factor is defined as the amount of electricity actually generated relative to the amount that would have been produced if the generator had been running at its full output over the same period. Capacity factor is not a measure of efficiency, nor a measure of the time spent operating
Circuit: A conductor or a system of conductors through which electric current flows (overhead lines or underground cables), and form an electrical connection between stations in the power system.
Cogenerator: A generating facility that produces electricity and another form of useful thermal energy (such as heat or steam), used for industrial, commercial, heating, or cooling purposes. Also referred to as a combined heat and power plant.
Combined cycle gas turbine (CCGT): An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit from 34-44 % for an open cycle gas turbine to 41-60% for a CCGT.
Combined heat and power (CHP) plant: A plant designed to produce both heat and electricity from a single heat source.
Current: A flow of electrons in an electrical conductor. The strength or rate of movement of the electricity is measured in amperes.
Demand: Energy delivered to loads and scheduling points by generation, transmission, and distribution facilities.
Distribution: The delivery of energy to retail customers.
Distribution system: The portion of the transmission and facilities of an electric system that is dedicated to delivering electric energy to an end-user.
Electricity: A form of energy characterized by the presence and motion of elementary charged particles generated by friction, induction, or chemical change.
Electricity generation: The process of producing electric energy or the amount of electric energy produced by transforming other forms of energy, commonly expressed in kilowatt-hours (kWh) or megawatt hours (MWh).
Energy charge: That portion of the charge for electric service based upon the electric energy (kWh) consumed or billed.

Energy efficiency: A ratio of service provided to energy input (e.g., lumens to watts in the case of light bulbs). Services provided can include buildings-sector end uses such as lighting, refrigeration, and heating: industrial processes; or vehicle transportation. Unlike conservation, which involves some reduction of service, energy efficiency provides energy reductions without sacrifice of service. May also refer to the use of technology to reduce the energy needed for a given purpose or service.
Energy source: Any substance or natural phenomenon that can be consumed or transformed to supply heat or power. Examples include petroleum, coal, natural gas, biomass, electricity, wind, sunlight, geothermal, and water movement.
Fast-start generator: Generating units that have fast-start capability. In general, fast-start capability refers to generating units that can be available for load within a 30-minute period. fast-start gas turbine peaking units.
Forced outage: The shutdown of a generating unit, transmission line, or other facility for emergency reasons or a condition in which the generating equipment is unavailable for load due to unanticipated breakdown.
Gas turbine plant: A plant in which the prime mover is a gas turbine. A gas turbine consists typically of an axial-flow air compressor and one or more combustion chambers where liquid or gaseous fuel is burned and the hot gases are passed to the turbine and where the hot gases expand drive the generator and are then used to run the compressor.
Generating unit: Any combination of physically connected generators, reactors, boilers, combustion turbines, and other prime movers operated together to produce electric power.
Generation: The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in kilowatt-hours.
Geothermal energy: Hot water or steam extracted from geothermal reservoirs in the earth's crust. Water or steam extracted from geothermal reservoirs can be used for geothermal heat pumps, water heating, or electricity generation.
Geothermal plant: A plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in the ground.
Gigawatt (GW): One billion watts or one thousand megawatts.
Gigawatt hour (GWh): One billion watthours.
Greenhouse effect: The result of water vapour, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent.
Hedge contracts: Contracts which establish future prices and quantities of electricity independent of the short-term market. Derivatives may be used for this purpose.
Hydroelectric power: The use of flowing water to produce electrical energy.
Impedance: The impedance of the power system inhibits current flow, that being both normal load current and fault current. Impedance has two components, resistance and reactance, but the dominant factor determining the impedance of the line (i.e. inhibiting the flow of current) is the reactance and not the resistance. The power sharing across two different transmission paths is determined by the overall reactance of each path and more will flow over the lower impedance path, even though it may be the longest physical route.
Interruptible load: This Demand-Side Management category represents the consumer load that, in accordance with contractual arrangements, can be interrupted at the time of

annual peak load by the action of the consumer at the direct request of the system operator. This type of control usually involves large-volume commercial and industrial consumers. Interruptible Load does not include Direct Load Control.

Kilovolt (kV): One thousand volts.

Kilowatt (kW): One thousand watts.

Kilowatt-hour (kWh): A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000watts) of power expended for 1 hour.

Load An end-use device or customer that receives power from the electrical transmission and/or distribution system

Maximum demand: The greatest of all demands of the load that has occurred within a specified period of time.

Megawatt (MW): One million watts of electricity.

Megawatt-hour (MWh): One thousand kilowatt-hours or 1million watt-hours.

Ohm: A measure of the electrical resistance of a material equal to the resistance of a circuit in which the potential difference of 1 volt produces a current of 1 ampere.

Open cycle gas turbine (OCGT): The gas turbine is connected to the generator and the waste heat is just vented to the atmosphere. The efficiency of open cycle gas turbine generation is typically only 34-44 % compared to CCGTs with efficiencies of 50-60%, and CHP plants which can have efficiencies up to 75%. The higher fuel cost per MW, are partially offset by the lower capital cost but are still relatively expensive to operate, so tend to be used as fast start peaking plants and tend to operated for a relatively small number of hours per year compared to other generation technologies.

Outage: The period during which a generating unit, transmission line, or other facility is out of service.

Peak demand: The maximum load during a specified period of time.

Plant: A term commonly used either as a synonym for an industrial establishment or a generating facility or to refer to a particular process within an establishment.

Power: The rate of producing, transferring, or using energy, most commonly associated with electricity. Power is measured in watts and often expressed in kilowatts (kW) or megawatts (MW). Also known as "real" or "active" power. See Active Power, Apparent Power, Reactive Power, Real Power.

Pumped-storage hydroelectric plant: A plant that usually generates electric energy during peak load periods by using water previously pumped into an elevated storage reservoir during off-peak periods when excess generating capacity is available to do so. When additional generating capacity is needed, the water can be released from the reservoir through a conduit to turbine generators located in a power plant at a lower level

Reactive power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. Reactive power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. It is a derived value equal to the vector difference between the apparent power and the real power. It is usually expressed as kilovolt-amperes reactive (KVAR) or megavolt-ampere reactive (MVAR). See Apparent Power, Power, Real Power.

Real power: The component of electric power that performs work, typically measured in kilowatts (kW) or megawatts (MW)--sometimes referred to as Active Power. The terms "real" or "active" are often used to modify the base term "power" to differentiate it from Reactive Power and Apparent Power. See Apparent Power, Power, Reactive Power.

Resistivity (Resistance): The conducting ability of a material. The resistivity of a material is dependent upon the material's electronic structure and its temperature.
Retail sales: Sales made directly to the customer that consumes the energy product.
Revenue: The total amount of money received by an entity from sales of its products and/or services; gains from the sales or exchanges of assets, interest, and dividends earned on investments; and other increases in the owner's equity, except those arising from capital adjustments.
Scheduled outage: The shutdown of a generating unit, transmission line, or other facility for inspection, maintenance or replacement, in accordance with an advance schedule.
Solar energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.
Spinning reserve: That reserve generating capacity running at a zero load and synchronized to the electric system.
Stability: The ability of an electric system to maintain a state of equilibrium during normal and abnormal conditions or disturbances.
Stranded assets: Investments which are made, but at some time prior to the end of their economic life (as assumed at the investment decision point), they are no longer able to earn an economic return. This can result from a range of market, regulatory, or environmental changes.
Substation: Facility equipment that switches, or regulates electric voltage, or transforms between different voltage levels.
Supervisory Control and Data Acquisition (SCADA): A system of remote control and telemetry used to monitor and control transmission and distribution systems.
Switching station: Facility equipment used to tie together two or more electric circuits through switches. The switches are selectively arranged to permit a circuit to be disconnected or to change the electric connection between the circuits.
Thermal rating: The maximum amount of electrical current that a transmission line or electrical facility can conduct over a specified time period before it sustains permanent damage by overheating or before it sags to the point that it violates public safety requirements in the case of overhead lines.
Transformer: An electrical device for changing the voltage of alternating current. It is typically used to transform the generator voltage (typically around 11 kV) up at generating stations to the transmission voltage (typically 110 or 220 kV), and down again at substations, to a level that allows it to be used by a distribution (lines) company (typically at voltages 33 kV and below).
Transmission constraint: A limitation on one or more transmission elements that may be reached during normal or contingency system operations. A condition that occurs when insufficient grid transfer capacity is available to implement all of the preferred schedules for electricity transmission simultaneously.
Transmission line: A transmission line is a series of structures carrying overhead one or more transmission circuits from one location to another location. The transmission line is the actual physical asset that can be seen; that is the foundations, structures (towers), conductors, insulators etc.
Transmission grid: An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers or is delivered to other electric systems.

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.
Underground cables: For underground transmission, the conductor is insulated to prevent it coming into contact with the earth.
Vertical integration: The combination within a firm or business enterprise of one or more stages of production or retailing.
Volt: The volt is a measure of electric potential. Electrical potential is a type of potential energy, and refers to the energy that could be released if electric current is allowed to flow. The highest voltages in a power system are used for transporting bulk electricity from generation stations to areas of demand. The voltages used in AC transmission in New Zealand are presently up to 220,000 Volts (220 kV). Higher transmission voltages are progressively transformed down so by the time electricity reaches most New Zealand homes and businesses it provides a single phase 230 V supply (or a three phase 400 V supply).
Watt (W): The unit of electrical power equal to one ampere under a pressure of one volt. A Watt is equal to 1/746 horse power.
Watt-hour (Wh): The electrical energy unit of measure equal to one watt of power supplied to, or taken from, an electric circuit steadily for one hour.

ATTACHMENT B: MBIE DRAFT ELECTRICITY DEMAND AND GENERATION SCENARIOS (EDGS) 2015 - GENERATION BUILD BY SCENARIO

Because of the volume of data only the build schedule out to 2030 is shown below. The full data set out to 2050 can be found on the MBIE website-

http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015/scenario-summary.xlsx

CCGT	Hydro (Run of River)	Geothermal	Gas Cogen	Diesel Recip
Wind	Hydro (Pkr)	Gas Peaker	Diesel Peaker	Decommissioning

	Base Case (Mixed Renewables)	High Geothermal Access	High Gas Availability	Global Low Carbon Emissions	Tiwai 400MW	Tiwai Exit	Low Demand	High Demand
2014	Te_Mihi (114 MW)	Te_Mihi (114 MW)	Te_Mihi (114 MW)	Te_Mihi (114 MW)	Te_Mihi (114 MW)	Te_Mihi (114 MW)	Te_Mihi (114 MW)	Te_Mihi (114 MW)
2015	Mill_Creek (60 MW)	Mill_Creek (60 MW)	Mill_Creek (60 MW)	Mill_Creek (60 MW)	Mill_Creek (60 MW)	Mill_Creek (60 MW)	Mill_Creek (60 MW)	Mill_Creek (60 MW)
	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)	Southdown_E105 (45 MW)
2017				OtahuB_Pkr (250 MW)	OtahuB_Pkr (250 MW)	OtahuB_Pkr (250 MW)		
				Otahuhu_B (380 MW)	Otahuhu_B (380 MW)	Otahuhu_B (380 MW)		
				Huntly_unit_3 (250 MW)	Huntly_unit_3 (250 MW)	Huntly_unit_3 (250 MW)		
						Huntly_unit_4 (250 MW)		
2018	ToddPeaker_npl (100 MW)	ToddPeaker_npl (100 MW)		Tauhara_stage_2 (250 MW)	Tauhara_stage_2 (250 MW)		Huntly_unit_3 (250 MW)	ToddPeaker_npl (100 MW)

	Tauhara_stage_2 (250 MW) Huntly_unit_3 (250 MW)	Tauhara_stage_2 (250 MW) Huntly_unit_3 (250 MW)						Tauhara_stage_2 (250 MW) Huntly_unit_3 (250 MW)
2019		CCGT_Cogen_generic_1 (40 MW)	OCGT_peaker_generic_ (200 MW) ToddPeaker_npl (100 MW) Huntly_unit_3 (250 MW)	CCGT_Cogen_generic_1 (40 MW) Lake_Pukaki (35 MW) Huntly_unit_4 (250 MW)	ToddPeaker_npl (100 MW) Lake_Pukaki (35 MW) Huntly_unit_4 (250 MW)		Tauhara_stage_2 (250 MW)	
2020	Hawea_Control_Gate_R (17 MW) Lake_Pukaki (35 MW) Stockton_Mine (35 MW) Wairau (70 MW) Huntly_unit_4 (250 MW)	Tauhara_generic1 (80 MW) Lake_Pukaki (35 MW) Wairau (70 MW) Huntly_unit_4 (250 MW)		Turitea (183 MW)	Stockton_Mine (35 MW) Wairau (70 MW)		ToddPeaker_npl (100 MW) Lake_Pukaki (35 MW) Wairau (70 MW) Huntly_unit_4 (250 MW)	CCGT_Cogen_generic_1 (40 MW) Turitea (183 MW) Hawea_Control_Gate_R (17 MW) Lake_Pukaki (35 MW) Stockton_Mine (35 MW) Wairau (70 MW) Huntly_unit_4 (250 MW)
2021	Turitea (183 MW)	Hawea_Control_Gate_R (17 MW) Stockton_Mine (35 MW)	Otahuhu_C (400 MW) Huntly_unit_4 (250 MW)	Hawkes_Bay_windfarm_ (225 MW)		CCGT_Cogen_generic_1 (40 MW)	Stockton_Mine (35 MW)	Tikitere_LakeRotoiti (45 MW)
2022	CCGT_Cogen_generic_1 (40 MW)	Rotokawa_generic1 (130 MW)	CCGT_Cogen_generic_1 (40 MW)	OCGT_peaker_generic_ (200 MW) OCGT_peaker_generic_ (200 MW)	CCGT_Cogen_generic_1 (40 MW) Turitea (183 MW)	OCGT_peaker_generic_ (200 MW) Tauhara_stage_2 (250 MW)		Arnold (46 MW)

				CastleHill_stage1 (200 MW) Hawea_Control_Gate_R (17 MW) Stockton_Mine (35 MW) Wairau (70 MW) Taranaki_CC (380 MW)		Lake_Pukaki (35 MW) Taranaki_CC (380 MW)		
2023	Rotokawa_generic1 (130 MW)			Rotokawa_generic1 (130 MW) CastleHill_stage2 (200 MW)	Rotokawa_generic1 (130 MW)	Rotokawa_generic1 (130 MW)	Turitea (183 MW)	Rotokawa_generic1 (130 MW)
2024	Otahuhu_C (400 MW) Taranaki_CC (380 MW)	Otahuhu_C (400 MW) Taranaki_CC (380 MW)	CCGT_generic_1 (475 MW) Taranaki_CC (380 MW)	CastleHill_stage3 (200 MW)	Otahuhu_C (400 MW) Taranaki_CC (380 MW)		CCGT_Cogen_generic_1 (40 MW) OCGT_peaker_generic_ (200 MW) Rotokawa_generic1 (130 MW) Tauhara_generic1 (80 MW) Taranaki_CC (380 MW)	Otahuhu_C (400 MW) Tauhara_generic1 (80 MW) Taranaki_CC (380 MW)
2025	Tauhara_generic1 (80 MW)	OCGT_peaker_generic_ (200 MW) Ngatamariki_generic1 (100 MW) Huntly_unit_6_(P40) (44 MW)		Arnold (46 MW)	Tauhara_generic1 (80 MW)	Tauhara_generic1 (80 MW)		
2026	Arnold (46 MW)	Recip_Diesel_generic (10 MW)	OCGT_peaker_generic_ (200 MW)	Project_CentralWind (120 MW)			OCGT_peaker_generic_ (200 MW)	OCGT_peaker_generic_ (200 MW)

	Stockton_Plateau (25 MW)							Hawkes_Bay_windfarm_ (225 MW) Stockton_Plateau (25 MW)
2027		Turitea (183 MW)		Waitahora (156 MW) Stockton_Plateau (25 MW)	OCGT_peaker_generic_ (200 MW) Hawea_Control_Gate_R (17 MW)			Kawerau_generic2 (30 MW) Ngawha_generic1 (25 MW)
2028	OCGT_peaker_generic_ (200 MW) Hawkes_Bay_windfarm_ (225 MW) Southdown (122 MW)	Arnold (46 MW) Stockton_Plateau (25 MW) Southdown (122 MW)	Tauhara_stage_2 (250 MW) Southdown (122 MW)	OCGT_peaker_generic_ (200 MW) Tikitere_LakeRotoiti (45 MW) Southdown (122 MW)	Rodney_CCGT_stage_1 (240 MW) Southdown (122 MW)	CCGT_generic_1 (475 MW) Southdown (122 MW) Huntly_unit_6_(P40) (44 MW)	Arnold (46 MW) Hawea_Control_Gate_R (17 MW) Stockton_Plateau (25 MW) Southdown (122 MW)	CastleHill_stage1 (200 MW) Southdown (122 MW)
2029	Tikitere_LakeRotoiti (45 MW) Huntly_unit_6_(P40) (44 MW)	Tikitere_LakeRotoiti (45 MW) Lake_Coleridge_2 (70 MW)	Lake_Pukaki (35 MW) Huntly_unit_6_(P40) (44 MW)	GenericMediumWind3_W (200 MW) Huntly_unit_6_(P40) (44 MW)	Tikitere_LakeRotoiti (45 MW) Huntly_unit_6_(P40) (44 MW)		Huntly_unit_6_(P40) (44 MW)	Recip_Diesel_generic (10 MW) Lake_Coleridge_2 (70 MW) Huntly_unit_6_(P40) (44 MW)
2030	Ngatamariki_generic1 (100 MW)			OCGT_peaker_generic_ (200 MW) Ngatamariki_generic1 (100 MW) OtahuBPkr (-250 MW)	OCGT_peaker_generic_ (200 MW) Ngatamariki_generic1 (100 MW) OtahuBPkr (-250 MW)	OCGT_peaker_generic_ (200 MW) OtahuBPkr (-250 MW)	Ngatamariki_generic1 (100 MW)	OCGT_peaker_generic_ (200 MW) Ngatamariki_generic1 (100 MW)

ATTACHMENT C: AUTHOR'S EXPERIENCE

Asset Rock is a Wellington based consultancy that provides specialist advice to the Electrical Industry specialising in power system planning, development, and maintenance of transmission plant, economic evaluation of projects, and business process improvements.

The report was prepared by David Boyle who has over 25 years experience in the Electricity Industry, including power system planning and development, construction and maintenance of AC and HVDC transmission plant, economic evaluations, regulatory submissions and assessments, business improvements, and stakeholder management.

David has a New Zealand Certificate in Engineering, a Bachelor of Electrical Engineering from the University of Canterbury, and is a member of the Institution of Professional Engineers New Zealand.

He has held a number of senior engineering and management positions, constructing and maintaining the New Zealand HVDC link, implementing asset management process and systems, and successfully leading the significant redevelopment and expansion of the New Zealand transmission system. The majority of his roles have been involved with developing and managing efficient and economic solutions to manage and extract the maximum capacity and life out of existing transmission plant and developing the New Zealand electricity transmission system.

David has also been an expert witness in the field of power system planning and development for resource consent hearings and Boards of Enquiries. In this capacity he has represented project proponents, the Crown, and also provided independent advice to Commissioners.

David has worked for Transpower NZ Ltd, the Commerce Commission, and also engineering and project management consultancies.