

# Wholesale Electricity Market and Security of Supply Benefits Kaimai Wind farm

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Review of the New Zealand Wholesale Electricity Markets security of supply settings and transmission planning reports to find the potential benefits of the Kaimai Wind farm development

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| Revision                                 | Date       |
|--|------------|
| Final draft                              | 15/11/2017 |
| Final                                    | 30/11/2017 |
| Revised Final for new turbine definition | 24/05/2018 |

## Executive Summary

Kaimai Wind Farm Ltd is proposing to build a wind farm comprising of 24 \* 4.2MW Vetas or similar GE or Gamesa/Siemens turbines that will inject into Transpower's 110KV Valley Spur circuit between Hamilton and Kopu. It will have an installed capacity of circa 100MW and expected annual output of 400GWh.

Electricity Risk Solutions Ltd (ERS) has been asked to evaluate the proposed wind farm development to determine the economic and physical benefits it provides to the New Zealand Wholesale Electricity Market and how it would help meet both Local and National Security of Supply requirements.

## Summary of Benefits

The Kaimai Wind farm will provide benefits to:

- The New Zealand Wholesale Electricity Market by aiding competition,
- It will support national security of supply challenges by bringing new supply to the market,
- While helping with local transmission thermal and voltage issues, and
- Reducing overall losses in the transmission system by providing electricity close to local demand in a high demand growth area.

## New Zealand Wholesale Electricity Market

The New Zealand electricity market is based on a model of economically constrained dispatch to ensure that the least cost providers of electricity are always dispatched to meet demand. This is a highly competitive market and new supply will aid that competition as it brings another seller to the market which puts downward pressure on price.

There are also benefits to the financial contracts market, where buyers and sellers reach agreement of financial contracts to set a fixed price for electricity in the future. Once again new supply into this market will be a benefit to buyers of contracts as there is more choice of sellers.

## Kaimai Wind farm

With an installed capacity of circa 100MW to put down would pressures on the wholesale price in real time and an expected annual production level of circa 400GWh which ERS expects would be mostly sold forward into the contracts market the Kaimai Wind farm will aid competition in the New Zealand Wholesale Electricity Markets. This will result in lower overall electricity prices for consumers in New Zealand.

## Security of Supply Balance

There are both National and Local benefits from a security of supply perspective to having the Kaimai Wind farm consented and built.

## National Security of Supply

There has been a decline in the supply and demand balance between 2010 and 2016 both from an installed capacity and an annual output or energy perspective. There has been more thermal plant retired than new plant built between 2010 and 2016.

Financial contract of sufficient value to keep the remaining two Huntly coal units in the market until 2022 where executed against this backdrop of changing supply and demand risk.

### System Operators Reports

The System Operator’s short term (Hydro Risk Curves) and medium to long term (security of supply assessment) security of supply reports show declining supply and demand balances and the need to build modest level of new generation from 2020, while more significant investments are needed from 2023.

The Security of Supply Assessment report “base case scenario” shows a need for 1,174MW of new capacity and new annual energy volumes of 8,877GWh by 2026. Wind is expected to provide 21% of new capacity and 32% of the annual energy capability based on this scenario.

While there are parties with generation investments on their books there are no actual committed projects. New Zealand needs new generation assets to be built to meet the expected growth in electrical demand.

### EDGS Scenarios

Based on the outcomes of the Ministry of Business, Innovation, and Employment(MBIE), Electricity Demand and Generation Scenarios (EDGS<sup>1</sup>).

Wind generation is expected to play an important role in meeting the challenge of new supply at least cost and will make up circa 43% of all new installed capacity and provide circa 46% of all new generation output in 2040 based on the average across the EDGS scenarios.

Table 1: Summary of EDGS

| Issue                                    | Total     | Wind Contribution |
|--|-----------|-------------------|
| New Installed Capacity 2040              | 3,680MW   | 1,583 or 43%      |
| Difference in annual output 2016 to 2040 | 11,063GWh | 5,100 or 46%      |

Another way of looking at these numbers is over the 24 years between 2016 and 2040 New Zealand would need to install 154MW of new capacity each year that can produce 460GWh per year.

### Kaimai Wind Farm

ERS understands that Kaimai Wind Ltd is committed to consenting and building the Kaimai wind farm and it is committed new build in generation assets that New Zealand needs to meet its National Security of Supply challenges. By consenting and therefore allowing this wind farm to be build it will be able to meet a part of New Zealand renewable future while reducing our national security of supply risk.

### Local Security of Supply

Both Transpower and Powerco in their respective transmission planning documents have noted that there is a forecast thermal constraint and present voltage issues associated with the 110KV Valley Spur circuit. Also, Powerco reports strong demand growth both historically and forecasted in their AMP in the areas that are feed from the Valley Spur circuit.

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<sup>1</sup> This is an economic model that builds generation on a least cost LRMC basis.

## Kaimai Wind Farm

The injection of Kaimai Wind farms generation into the middle of the valley Spur circuit will add another option for management of these thermal constraint and voltage issues.

Peak output of the Kaimai Wind farm would be able to cover over 60% of the expected future demand peaks. While the annual output of 400GWh from the Kaimai Wind farm would have provided 55% of the total demand on the Valley Spur circuit in 2016. This injection of generation close to the local load will also reduce national transmission losses.

## Report Outline

The remainder of the report is set out to cover the following topics:

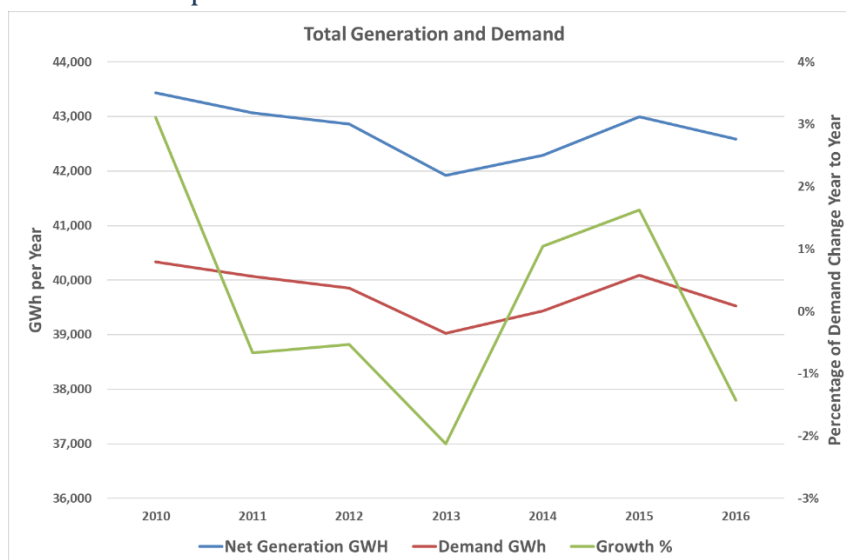
1. Overview of New Zealand electrical demand and generation from 2010 to 2016, including a review of thermal plant that has been de-commissioned, and public retirement plans for generation assets. To identify whether the actual supply and demand balance is improving or declining.
2. Review of the Ministry of Business Innovation and Employment (MBIE) Electricity Demand and Generation Scenarios (EDGS) and the generation build required to meet their demand growth forecasts. To find the economic level of wind generation over different futures.
3. Review of local security of supply in the Waikato region to identify any local transmission issues and review electrical demand forecasts to identify demand growth close to the generation site. To identify where the Kaimai Wind farm can aid local security of supply.
4. Overview of security of supply in New Zealand to identify how the wind farm proposal can help to meet the security of supply challenges.

## New Zealand Demand and Generation Build

### Demand Information

This section of the report outlines the demand changes in New Zealand's total demand post 2010 to show, recent demand trends and sectors of the market that are causing either growth or decline of demand.

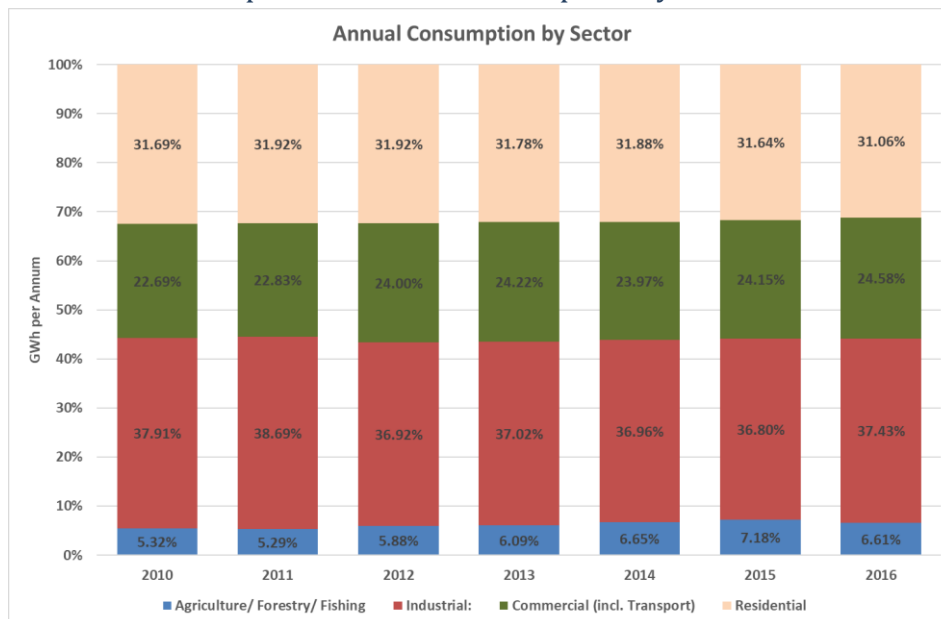
Graphic 1: Annual Generation and Demand



Graphic 1 above shows total generation and demand for New Zealand from 2010<sup>2</sup> on the left-hand side axis and the change in demand year to year as a percentage on the right-hand axis.

The difference between total generation and total demand in Graphic 1 is losses, which are made up of Transmission and Distribution losses. With transmission contributing 44% of losses and distribution 56% losses. On average, total losses account for 7% of annual generation or circa 3,000GWh.

Graphic 2: Annual Consumption by Sector



Graphic 2: show the annual consumption by the sectors of the electricity industry.

While demand in Graphic 2 will fluctuates year to year due to climatic and macroeconomic factors there is two trends visible:

1. Lower demand from 2011 to 2013. This reduction is mostly in residential demand where the increased efficiency of new appliances, lighting solutions, heating solutions and handheld devices has reduced household average consumption. Over the 7 year period being analysed national residential demand fell on average 83GWh each year. And
2. From 2013 demand has generally increased with average year on year demand growth of 0.4%. With average GWh increases over that time in the following sectors:
  - Agriculture/ Forestry/ Fishing 66GWh,
  - Industrial 42GWh, and
  - Commercial (incl. Transport) 39Gwh

A growth rate of 0.4% would require circa 178GWh of extra generation each year. This could be provided by:

- 51MW of wind at a load factor of 40%,

<sup>2</sup> From MBIE spreadsheet titled "electricity.xlsx" at <http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity>

- 22MW of Geothermal at a load factor of 50%,
- 41MW of Hydro at a load factor of 50%, or
- 146MW of solar at a load factor of 14%.

### Summary of Demand

Losses account for 7% of annual generation or circa 3,000GWh.

Prior to 2014 the decline in residential demand outstripped the growth in industrial demand. From 2014 onwards, growth in industrial demand has been greater than the continued decline in residential demand leading to 0.4% or 178.5GWh year on year growth in demand. Average growth from 2010 to 2016 was 0.15% or 64.6GWh per year.

If new generation was required to meet the post 2014 growth of 0.4% annually, then the industry would need to install each year:

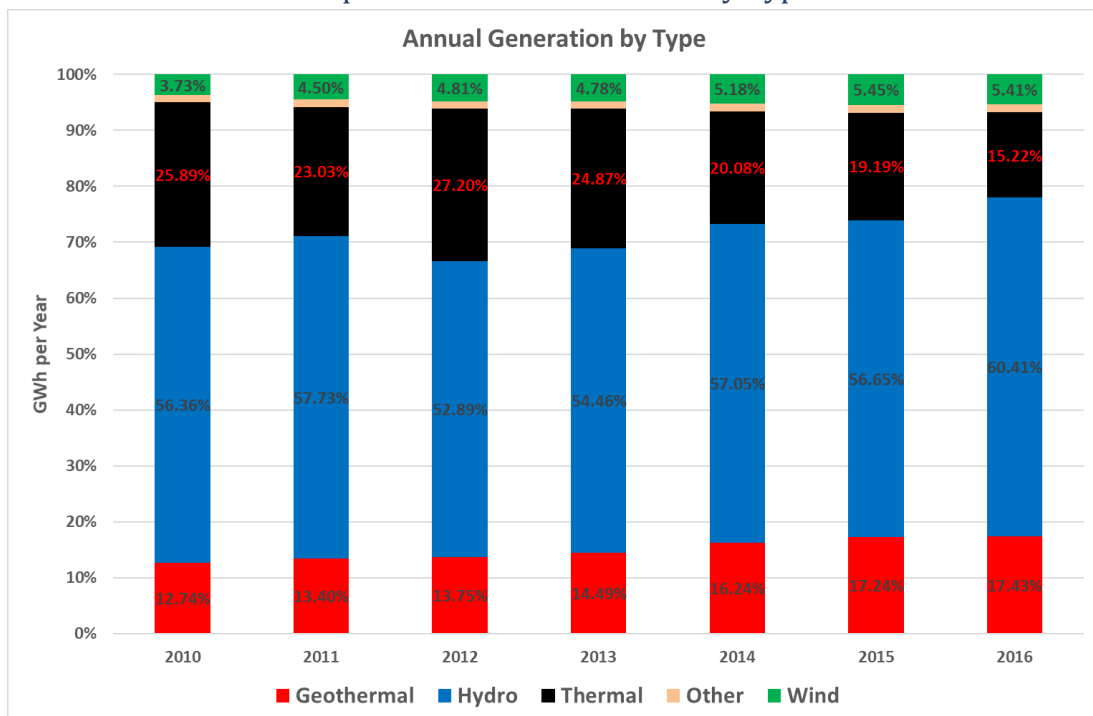
- 51MW of wind at a load factor of 40%, or
- 22MW of Geothermal at a load factor of 50%, or
- 41MW of Hydro at a load factor of 50%, or
- 146MW of solar at a load factor of 14%.

To maintain the present energy balance between electrical supply and demand.

### Generation Information

This section outlines the generation changes post 2010 to show, generation trends, the makeup of the generation fleet, the amount and type on new installed capacity that has been commissioned and the level of thermal plant that has retired.

Graphic 3: Annual Generation by Type

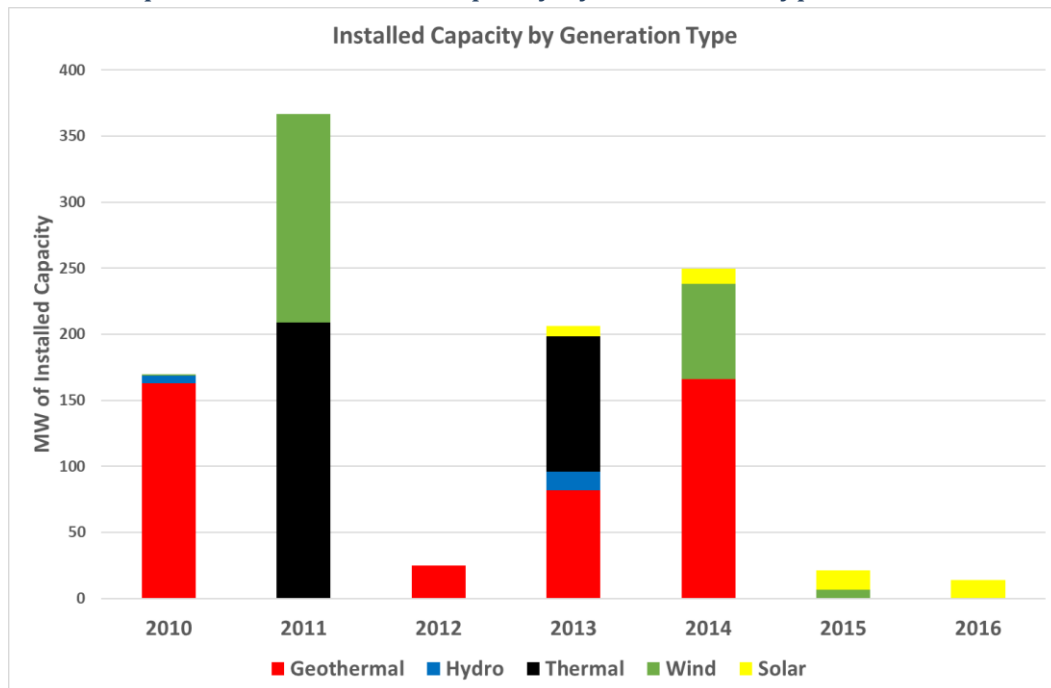




The breakdown of annual generation by fuel type for each year is shown in Graphic 3<sup>3</sup> above. As geothermal and wind volumes have increased with plant been commissioned over time, the thermal volume has reduced.

Collectively the grouping of Geothermal, Hydro, Other, and Wind make up the renewable generator fleet, on average from 2010 this group has produced 78% of annual generation.

Graphic 4: Installed New Capacity by Generation Type Post 2010



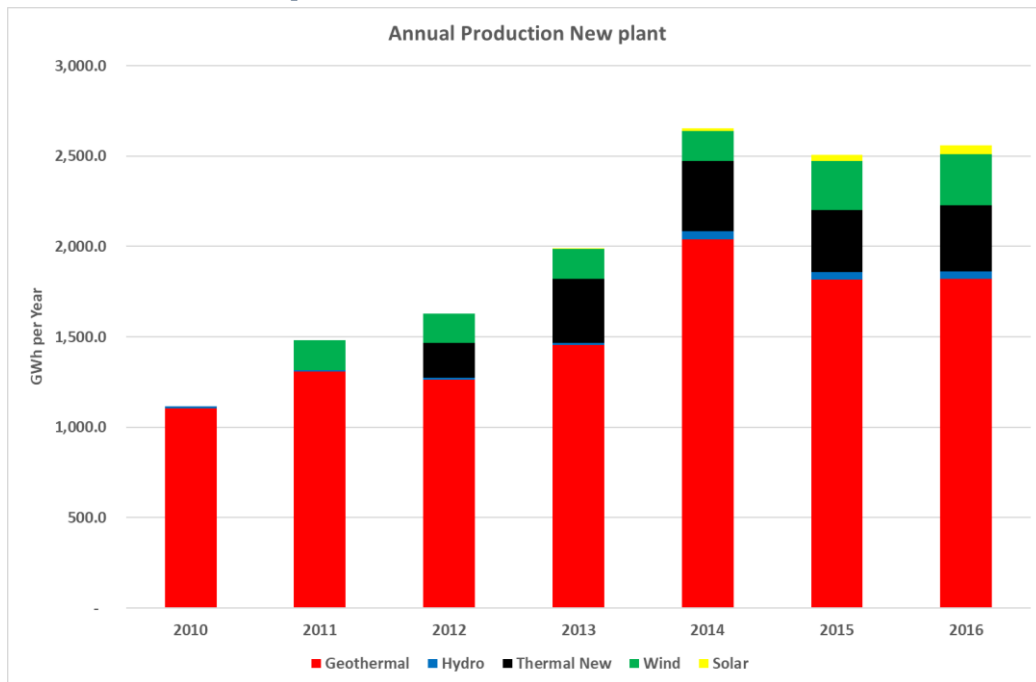
Graphic 4 above shows the installed capacity of new generation by fuel type from 2010<sup>4</sup>. Wind contributes 24% of the combined capacity built. When Wind is combined with, hydro, solar and geothermal the renewable build over this period is 70% of all new installed capacity. The thermal assets built in 2011 and 2013 were open cycle gas turbine peakers (OCGT) which are needed to support the variability of renewable generation output in the wholesale electricity market.

There is a table in appendix A that above provides more detail to the information in the Graphic above.

<sup>3</sup> From MBIE spreadsheet titled “electricity.xlsx” at <http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity>

<sup>4</sup> Based on information in the spreadsheet titled “20151030\_Existing\_generating\_plant” hosted at [https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation\\_fleet/Existing](https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_fleet/Existing)

Graphic 5: New Installed Plant Production



The above Graphic shows the annual production by the plant that has been installed post 2010.

### Thermal Retirement

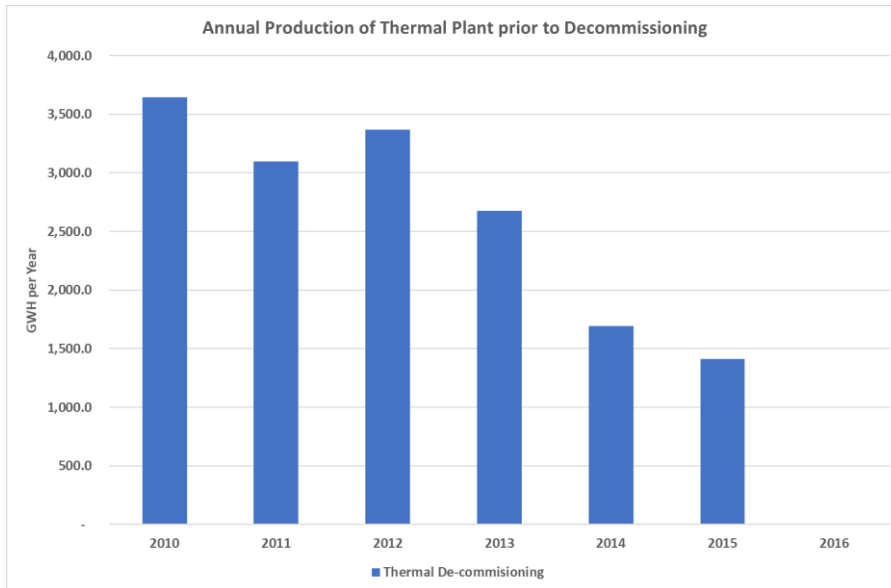
There have been 4 thermal power stations and 2 thermal units de-commissioned post 2010.

These assets had operated as mid merit plant and as new renewable baseload generation was installed, their load factor and therefore revenue declined against the fixed and variable costs to make the plant available each year. They were ultimately shut down for a range of economic and engineering reasons.

Table 2: De-commissioned Thermal Assets

| Station Name | Decommissioned | Installed capacity | Fuel Type | Commissioned |
|--------------|----------------|--------------------|-----------|--------------|
| New Plymouth | 2011           | 360                | Gas       | 1974         |
| Huntly Unit  | 2012           | 250                | Gas/Coal  | 1983         |
| Huntly Unit  | 2013           | 250                | Gas/Coal  | 1983         |
| Southdown    | 2015           | 175                | Gas       | 1996         |
| Otahuhu B    | 2015           | 380                | Gas       | 2000         |
| Total MW     |                | 1415               |           |              |

Graphic 6: Production of the Thermal Plant that was Retired



Prior to the shutdown of the First Huntly unit the combined annual production<sup>5</sup> from the plant that would be all retired by 2015 was 3,643GWh, this had declined to 1,413GWh for the last year prior to the retirement of the Otahuhu station.

Genesis Energy Ltd<sup>6</sup> announced in 2016 that had entered into commercial contracts that would allow the remaining two Huntly Coal/Gas units to remain in the market until 2022. They had previously planned to retire the units in 2018. The reasons given for the new contracts were market changes including:

- The time required to develop new generation,
- Continued uncertainty over the future of the electricity-intensive smelter at Tiwai Point, and
- Increased dry year risk resulting from other recent thermal plant retirements

### Summary of Generation

Production from the presently installed renewable generation assets produced 78%<sup>7</sup> of annual generation over the period from 2010 to 2016.

Table 3: Total Installed Generation Post 2010

| Fuel type  | Total Installed Capacity MW |
|------------|-----------------------------|
| Geothermal | 436.0                       |
| Hydro      | 19.6                        |
| Thermal    | 311.0                       |
| Wind       | 237.5                       |
| Total      | 1004.1                      |

<sup>5</sup> Combination of Central dataset and EA reconciliation data.

<sup>6</sup> [Genesis 28/04/22016 market announcement](#)

<sup>7</sup> From MBIE spreadsheet titled "electricity.xlsx" at <http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity>

Annual production from these new assets in 2016 was 2,561GWh<sup>8</sup>.

There haven't been any significant generation assets built since Te Mihi and Mill Creek in 2014.

1,469MW of thermal plant has been de-commissioned post 2010.

More than one market participant<sup>9</sup> was sufficiently incentivised by the apparent change in wholesale market price risk caused by, a lack of firm generation development, uncertainty of Tiwai demand and increased dry year risk from thermal retirement, that they contracted to cover the operational and capital cost of keeping the Huntly coal units in the market for four years.

## Supply & Demand Balance 2017

While it is easy to see the shortfall of 411MW between the installed capacity of new generation assets (1004.1MW) and that of de-commissioned thermal assets of (1415MW) and draw the conclusion that the balance between supply and demand is 465MW worse in 2017 than it was in 2010.

The comparison of installed capacity doesn't tell the full picture as the annual output of the plant is also important. Prior to the shutdown of the first Huntly unit, the combined annual production from the thermal plant that would be retired by 2016 was 3,643GWh, while the annual production from the new installed plant was 2,561GWh in 2016. Leaving a shut fall of 1,082GWh between retired and new generation output.

This means, that there has been a reduction in both installed capacity and combined annual output when the new installed generation assets are compared to the retired thermal assets.

With annual demand growth from 2013 of 0.4% requiring additional generation output of 178.5GWh annually and a short fall between retired thermal and new build generation annual production of 1,082GWh. ERS draws the conclusion that the electrical supply & demand balance in 2017 is worse off than it was in 2010.

## Forecast Demand

### Electricity Demand and Generation Scenarios

The Ministry of Business, Innovation, and Employment(MBIE) are responsible for publishing the Electricity Demand and Generation Scenarios (EDGS). They are created to be used by Transpower and the Commerce Commission to assess future proposals for planning for capital investment in the transmission grid. The scenario form part of the grid investment test which is applied to Transpower's capital investments. They were last updated in 2016.

Appendix 2 has descriptions of each of the five scenarios.

They are also a very useful resource for the wider electrical industry as the scenarios are designed to investigate key uncertainties in the electricity sector including:

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<sup>8</sup> Combination of EA reconciliation data and some estimates for small embedded sites.

<sup>9</sup> [Genesis 28/04/22016 market announcement](#)

- The type and location of electricity generation supply, considering:
  - Technology costs (for existing and emerging generation technologies),
  - Resource availability and cost (particularly for natural gas), and
  - The global response to climate change (particularly the price of carbon emissions).
- The characteristics and location of electricity demand, considering:
  - The size and structure of the economy,
  - The future of heavy industry in New Zealand, particularly New Zealand's,
  - Aluminium Smelter at Tiwai Point,
  - The size and structure of the population,
  - The price of electricity compared with alternative energy sources,
  - Energy efficiency and demand side participation in the electricity market, and
  - Uptake rate of new technology such as electric vehicles and Solar PV

## Key Results from EDGS

The following are MBIE key outtakes from the scenario modelling for EDGS 2016.

Both peak and total electricity demand is expected to grow out to 2050:

- Total electricity demand growth averages between 0.4% and 1.3% each year in our scenarios out to 2050.
- Peak electricity demand is expected to grow, reaching between 6,560 MW and 8,060 MW by 2040 in our scenarios.
- The possible closure of New Zealand's Aluminium Smelter at Tiwai Point is a key uncertainty to the future of electricity demand. Total electricity demand would not return to current levels until the late 2020s in our modelling if the smelter closed in 2018.

The percentage of electricity generated from renewable sources is expected to increase:

- Renewable electricity supply is expected to grow to meet increasing demand.
- More geothermal and wind generation capacity is built in all our scenarios and these technologies are the lowest cost options to meet additional new baseload demand in most scenarios.
- Up to 2,530 MW and 790 MW of new wind and geothermal capacity is built respectively between 2016 and 2040.
- In all our scenarios remaining large coal fired generation capacity is retired between 2020 and 2026.
- In a scenario with low cost and abundant gas supply and low carbon prices long term, the percentage of renewable electricity generation remains at a similar level as it is today. This is due to a mixture of renewable and gas fired baseload generation capacity being built to meet growing demand.

High uptake of electric vehicles and in-home batteries can lead to increased renewable generation and reduced reliance on flexible gas fired generation:

- Investment in solar PV systems with batteries could reach around 390,000 by 2040, in a scenario in which solar PV capital costs fall to NZD 3.16/W for a 3kW system and battery costs fall to NZD 167/kWh.
- Charging electric vehicles predominately overnight, means little additional demand is added to peaks periods, as transport electricity demand increases with high electric vehicle uptake.

- Investment in residential solar panels with batteries can maximize household use of solar generation and shift household demand away from peak periods.
- Additional transport electricity demand from a high uptake of electric vehicles can be met by new geothermal, solar PV with batteries, and wind generation. There is less need for flexible gas fired peaking generation if the daily residential demand profile has lower peaks.

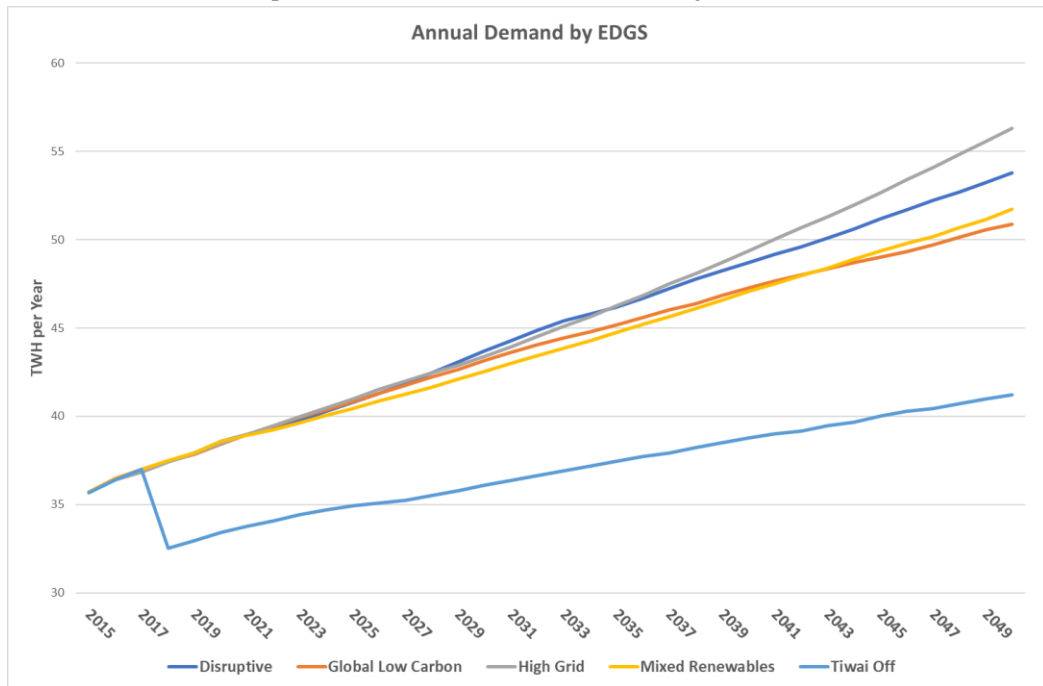
MBIE is using robust modelling methods with a set of assumption that have been consulted on with the wider electricity industry. Energy demand is modelled by sector, using a combination of econometric models, production-based forecasts for high energy intensive industry and a vehicle fleet model for transport demand. For these reasons, ERS will be using the EDGS generation forecasts as a reference in this section of the report.

### EDGS Demand Forecast

EBIE have demand growth ranging between 0.4% p.a. in their *Tiwai Off* scenario and 1.3% p.a. in their *High Grid* scenario out to 2040. Demand growth is 1.0% p.a. in the *Mixed Renewable* scenario. Grid demand is higher in the *Disruptive* scenario than all other scenarios except the *High Grid* scenario. This is due to charging of the 1.77 million vehicles in this scenario by 2040.

Demand is expected to grow over time as the population, the economy, and household incomes grow.

Graphic 7: EDGS Annual Demand by Scenario



The Tiwai off scenario sees Tiwai shutdown completely in 2018, which causes demand to fall and it does not return to 2017 levels until 2033.

This scenario assumes that there is no new industrial demand uplift from the closure of Tiwai despite lower wholesale prices for some years. ERS believes, that should Tiwai close; Industry in the South Island that uses coal for thermal process heat will move quickly to take advantage of the lower

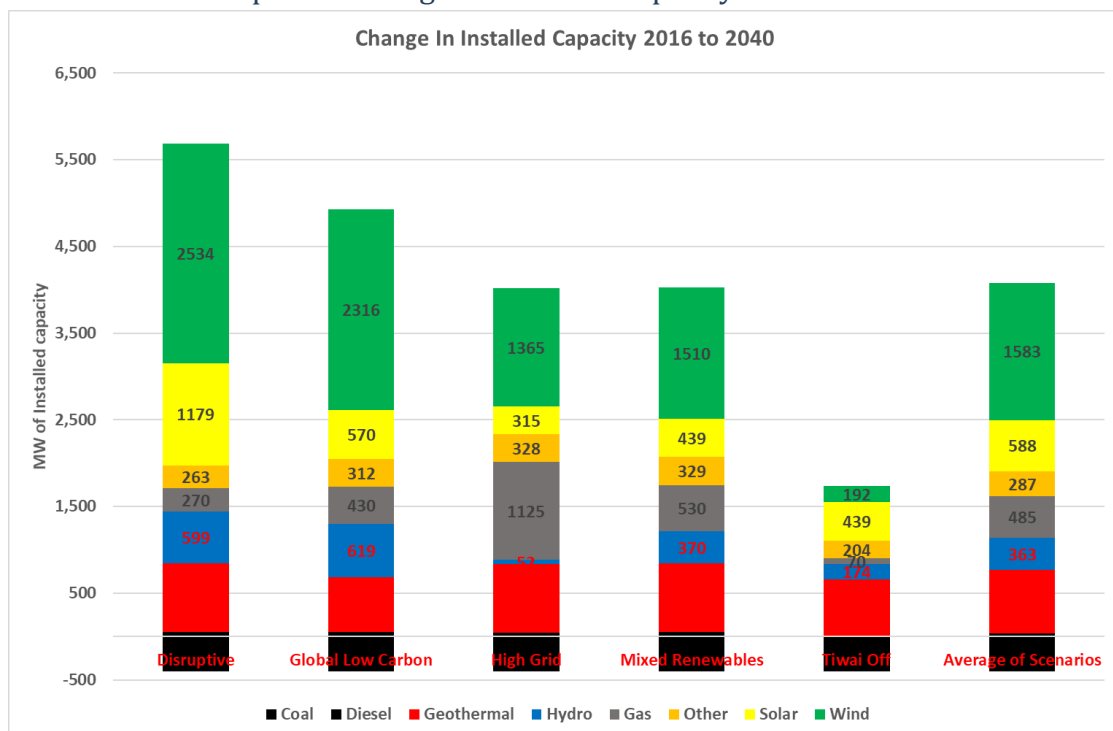
contract electricity prices on offer to electrify process heat, while also reducing their carbon footprint.

## New Generation Capacity Required

The Graphic below outlined the amount of new generation capacity by type that will need to be installed to maintain the balance between supply and demand across the scenarios.

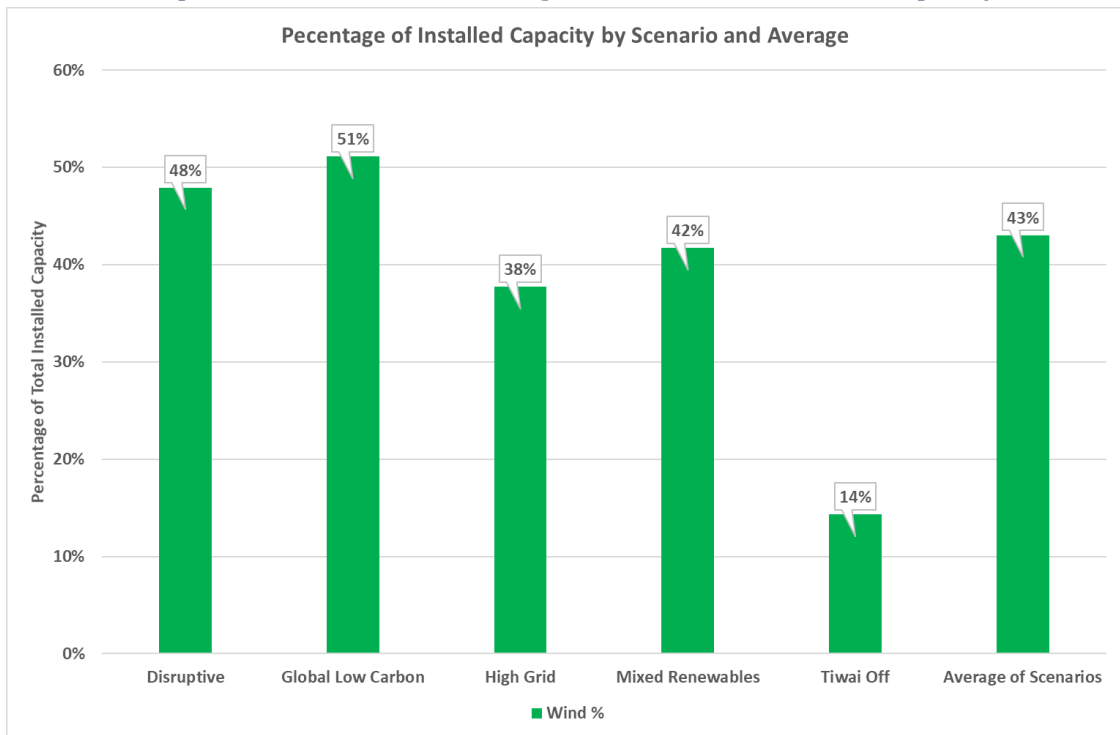
MBIE make a point to say that that no one scenario is more likely than any other to actual transpire. Therefore, when looking at the Graphic the thing to consider is the type and sort of volumes of new generation that is required across all scenarios. ERS has included an average of the scenarios to help illustrate this point.

Graphic 8: Change in Installed Capacity 2016 to 2040



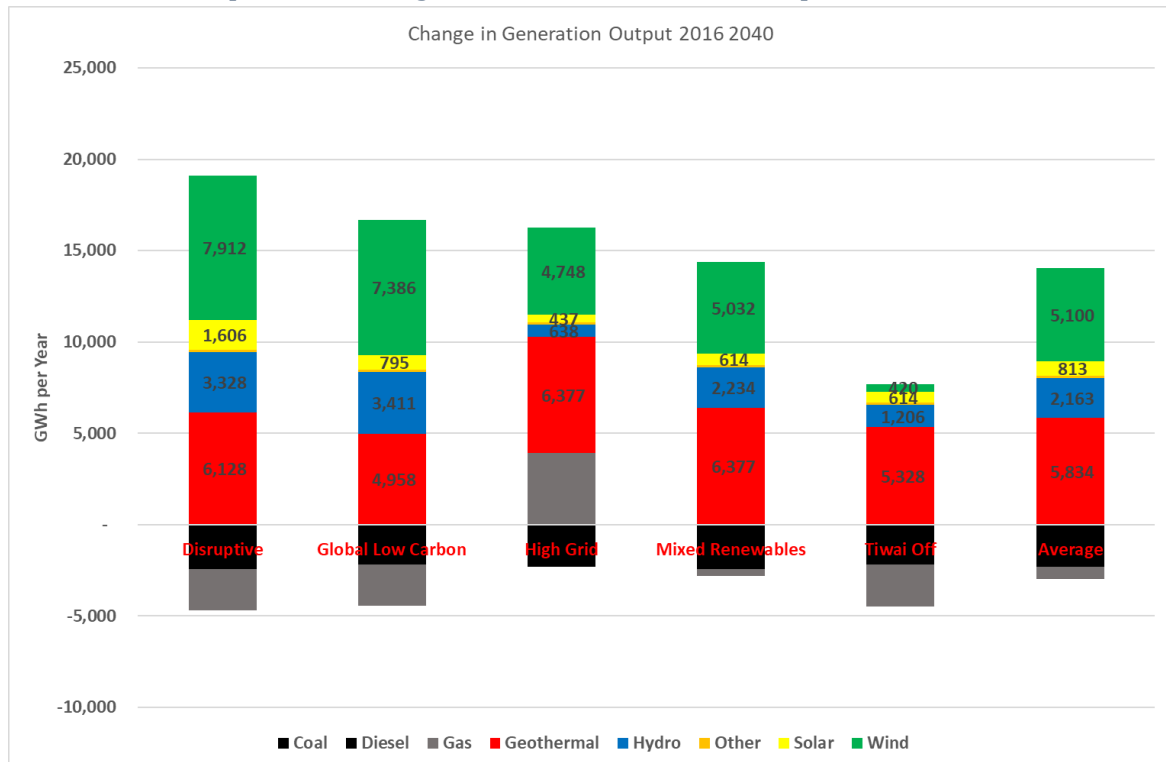
Geothermal and wind capacity increases in all scenarios between 2016 and 2040. In most of the scenarios, geothermal and wind plant are the cheapest to build, with a long run marginal cost (LRMC) ranging from \$80 to \$100 per MW.

Graphic 9: Wind as a Percentage of Total Installed New Capacity



Across the range of scenarios winds penetration was between 14% and 51% with the average across all scenarios being 43% of new installed capacity being wind.

Graphic 10: Change in Generation Annual Output 2016 2040

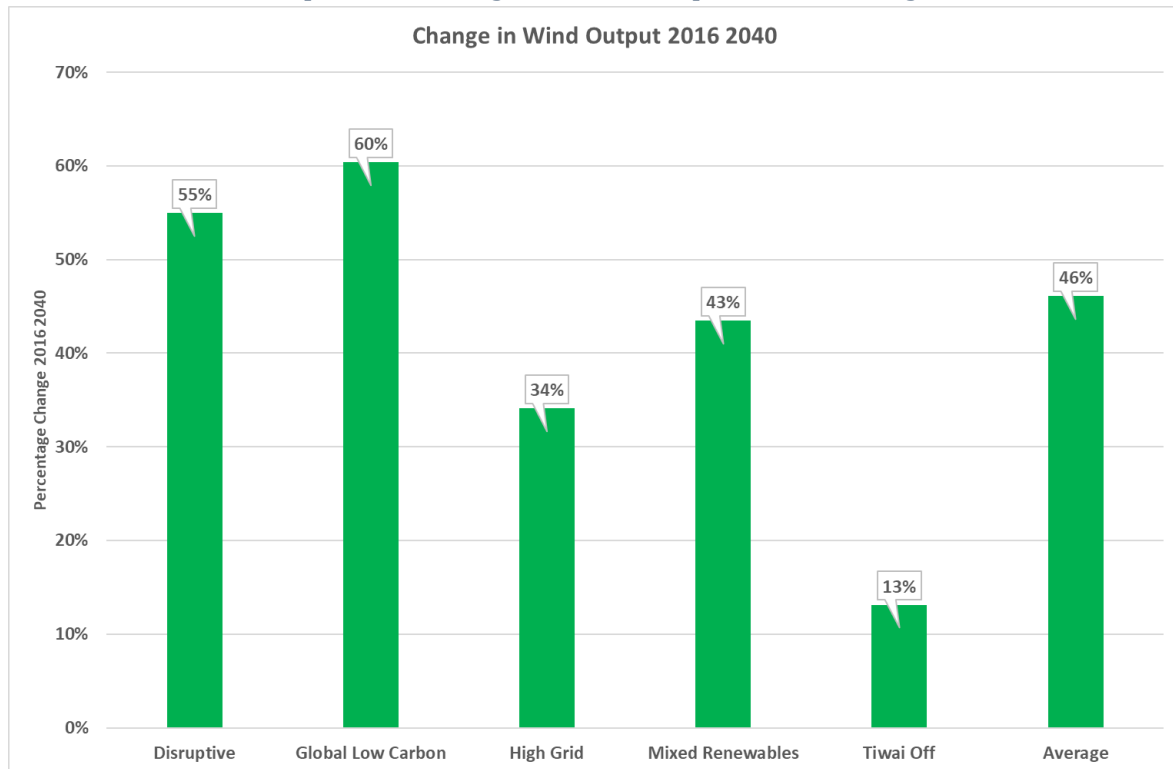


Graphic 10 above shows the difference in annual output by fuel type between 2016 and 2040 for each EDGS scenario. There has been a marked shift away from Coal and Gas as a generation fuel and



a move towards renewables backed by wind and geothermal. Across all scenarios wind is a strong contributor to the total volumes required.

Graphic 11: Change in Wind Output as Percentage



This Graphic shows how much of the total generation difference between 2016 and 2020 is made up of wind generation as a percentage under each EDGS scenario. Wind contributed between 13% and 60% depending on scenario while the average across all scenarios has wind producing 46% of total new generation output.

GEM<sup>10</sup> which is used in the EDGS modelling optimises for least cost of the LRMC<sup>11</sup> of new capacity. The information presented in the EDGS scenarios indicates that the least cost solution for new generation in New Zealand between 2007 and 2040 is to have 43% of the new installed capacity and 46% of new generation output as wind generation.

### Summary of EDGS Generation Forecast

Looking at the average outcome across the EDGS scenarios ERS draws the following conclusions.

Wind generation is expected to play an important role in meeting the challenge of new supply at least cost and will make up circa 43% of all new installed capacity and provide circa 46% of all new generation output in 2040 based on the average across the EDGS scenarios.

<sup>10</sup> Generation Expansion Model use by MBIE is a long-term planning model used to study capacity expansion in the New Zealand electricity sector

<sup>11</sup> Long Run Marginal Cost

Table 4: Summary of EDGS

| Issue                             | Total     | Wind Contribution |
|-----------------------------------|-----------|-------------------|
| New Installed Capacity 2040       | 3,680MW   | 1,583 or 43%      |
| Difference in output 2016 to 2040 | 11,063GWh | 5,100 or 46%      |

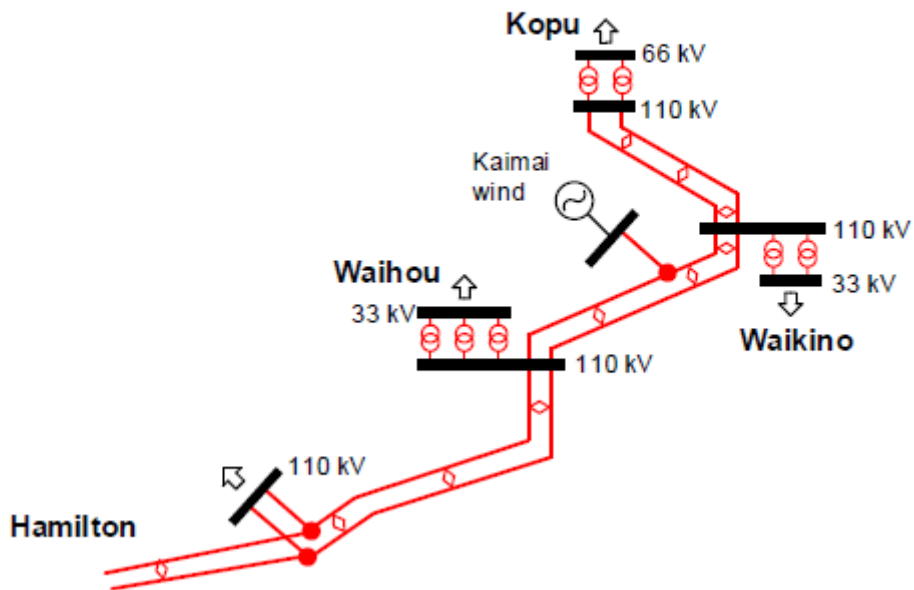
Another way of looking at these numbers is over the 24 years between 2016 and 2040 New Zealand would need to install 154MW of new capacity each year that can produce 460GWh per year.

## Local Security of Supply

### Transpower

Transpower the National grid owner produces the Transmission Planning Report (TPR) that describes how they assess the adequacy of the transmission network to meet the future needs of users, and identifies investments to address demand needs or alleviate expected constraints. The TPR also identifies investment opportunities in the interconnected grid that may improve operation of the grid, reduce losses, or enhance market operation.

Graphic 12: Valley Spur Circuit



The diagram above show where the Kaimai Wind farm will connect between Waihou and Waikino.

Transpower in the TPR<sup>12</sup> has identified an issue on the Valley spur circuit that the Kaimai Wind farm will connect to. The Valley Spur’s summer and winter peak loads have become very similar, such that transmission issues that previously occurred only in winter now also occur in summer. From 2018 the strong demand on the Valley Spur is expected to cause thermal issues on the Hamilton–

<sup>12</sup> Transpower TPR chapter 9, 9.4.2.4

Morrinsville Tee section of the Hamilton–Piako–Waihou circuits following an outage on the parallel circuit.

Also, a Hamilton–Piako–Waihou circuit outage during high load periods will cause the Waihou and Waikino supply bus voltages to drop below acceptable levels

Transpower's Enhancement approach:

- In the short-term they believe that the issue can be managed operationally.
- Longer term they will discuss investment options with Powerco. Installing capacitors at the Waihou and Waikino 33 kV buses will defer the thermal capacity issue by up to five years and will also improve supply voltage quality.

Generally, there are positive benefits from connecting generation into a part of the grid which suffers from both thermal overload constraints and voltage sag issues as:

- Generation injected into the constrained section of the grid will reduce energy flows as it supplies the local load instead of the energy needing to be transferred over the transmission system.
- The generators voltage control equipment can be used to help manage the local voltage sag issues.

ERS notes that all three turbines listed in the turbine definition in appendix 3 claim full grid compliance for power factor control. The new:

- Vetas 4.2MW machines are advertised with “full scale inverters<sup>13</sup>, to provide superior grid performance”.
- GE 4.8-158 platform are advertised as “the most significant onshore turbine advantages: greater reliability, lower losses and, of<sup>14</sup> course, the fulfilment of grid requirements”. And
- Siemens Gamesa 4.2MW unit is advertised as have “0.9<sup>15</sup> CAP-0.9 IND throughout the power range”

Based on these claims it is reasonable to think that the Kaimai wind farm when it is producing energy will be able to assist with the management of voltage and thermal constraints.

While the variable nature of a wind farms energy output doesn't lend itself well to being dispatched to manage a constrained element of the grid in real time. The diurnal generation shape of wind farms, which tends to peak in the late afternoon does align well with the daily load shape so therefore even without being dispatch primarily to help with constraint management by default the Kaimai Wind farms daily generation shape will aid with constraint management.

Should Kaimai Wind Farms Ltd which to provide a firmer solution to deferring the need for Transpower or Powerco to invest in either voltage control equipment or in upgrading the Valley Spur circuit then they could add battery storage to the wind farm development with four quadrant

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<sup>13</sup>

<http://nozebra.ipapercms.dk/Vestas/Communication/Productbrochure/4MWbrochure/4MWProductBrochure>

<sup>14</sup> <https://www.ge.com/renewableenergy/wind-energy/turbines/4mw-platform>

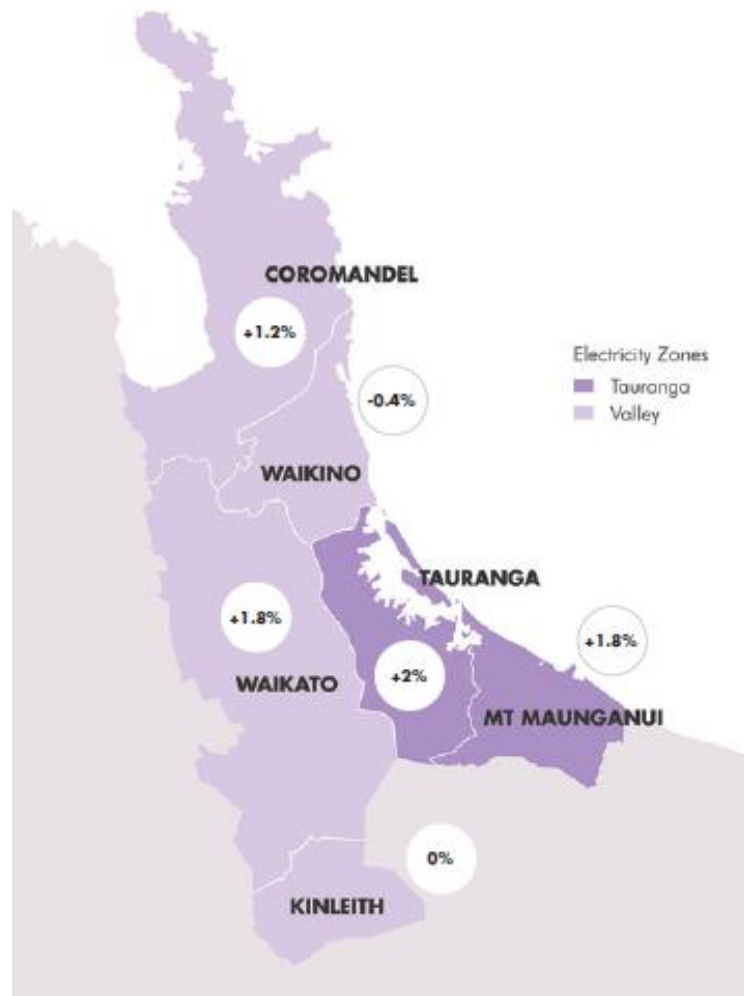
<sup>15</sup> <https://www.siemensgamesa.com/en-int/products-and-services/onshore/wind-turbine-sg-4-2-145>

inverters. They would be charged by the wind farm generation and would be dispatched by the System Operator to manage the thermal or voltage issues at peak.

## Powerco

Transpower's valley Spur circuit provides electricity to the eastern Waikato and Coromandel areas and Powerco is the distributor that connects to that circuit and is responsible for management on the distribution assets in those areas.

Graphic 13: Powerco Growth Eastern Region.



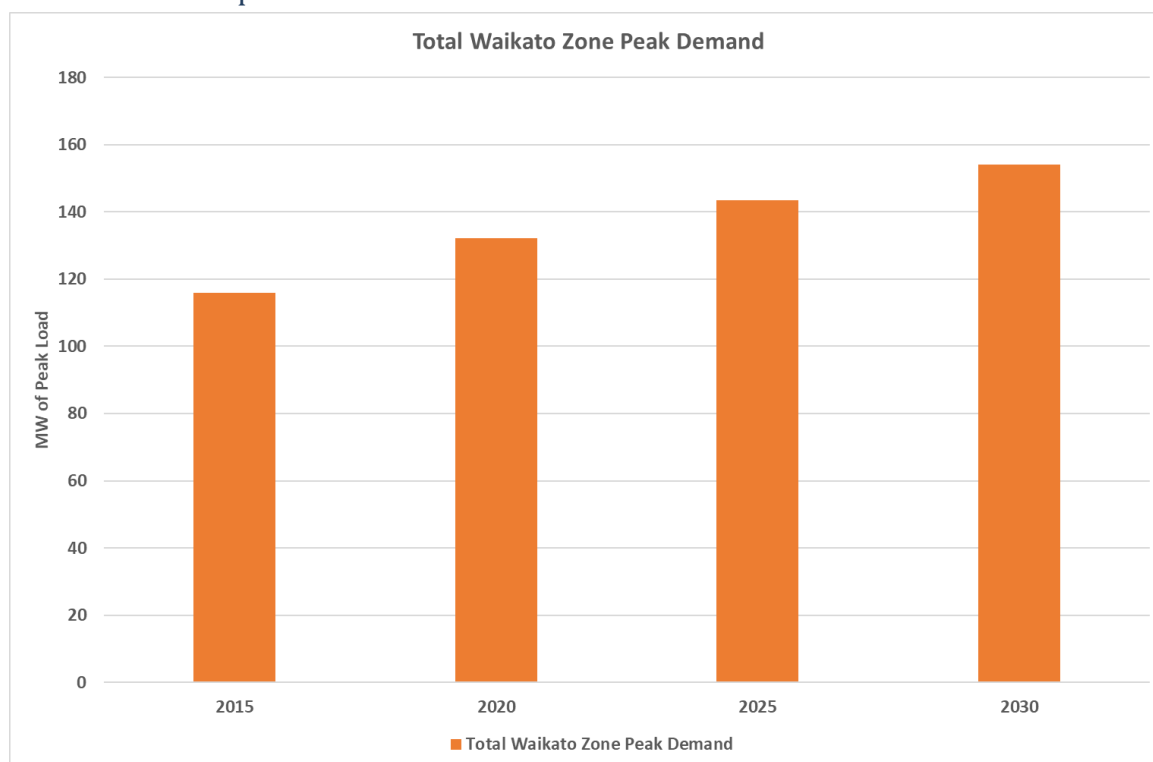
In Powerco's Asset Management Plan<sup>16</sup> (AMP) they report good historical growth in their Waikato and Coromandel areas.

The growth in the Waikato is a combination of dairy, residential new house build, and commercial and industrial, while Coromandel has been more residential/Holiday Home driven.

Powerco note that in their AMP, the Piako and Waihou GXPs, along with Kopu and Waikino, are supplied from Transpower's dual 110kV circuits and that the capacity of this circuit impacts the longer-term development in this area and will need to be upgraded in the future.

<sup>16</sup> <https://www.powerco.co.nz/media/1362/powerco-amp16-interactive-pdf.pdf>

Graphic 14: Powerco Peak Demand Forecast Waikato Zone



Distributors are concerned with Peak demand when planning the transmission system as it is the most that the transmission assets will be required to carry. Powerco AMP forecasts very strong peak demand growth with average growth 2020 to 2030 of 7.8%. Total annual demand in the area was 728.8GWh in 2016<sup>17</sup>.

In the context of the Kaimai Wind farm and the benefits it provides to New Zealand Inc with its maximum output expected to be 100MW and annual production of 400GWh it will be able to provide over 60% of the future peak demand or 55% of the total consumption in the distribution area it connects to. This will reduce the overall losses to supply this load.

### Summary of Local Security of Supply

Both Transpower and Powerco in their respective transmission planning documents have noted the thermal constraint and voltage issues associated with the 110KV Valley Spur circuit. The injection of Kaimai Wind farms generation into the middle of this circuit will add another option for management of these issues.

Powerco reports strong demand growth both historically and forecasted in their AMP. Peak output of the Kaimai Wind farm would be able to cover over 60% of the expected future demand peaks. While the annual output of 400GWh from the Kaimai Wind farm would provide 55% of the 2016 total demand on the Valley Spur circuit. This injection of generation close to the local load will also reduce transmission losses.

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<sup>17</sup> EA reconciliation data for 2016

## National Security of Supply

Transpower, as system operator, has specific duties to monitor, analyse and, if required, manage dry winter situations. They also oversee the administration of policies which govern how New Zealand security of supply is managed.

They use several policies to manage the Security of Supply process:

1. Emergency Management Policy<sup>18</sup>: The Emergency Management Policy (EMP) sets out the steps that they will take, as a reasonable and prudent system operator, during an extended emergency.
2. Rolling Outage Plans<sup>19</sup>: They have prepared and published a Rolling Outage Plan and provided links to all approved participant plans.
3. Security of Supply Forecasting and Information Policy<sup>20</sup>: The Security of Supply Forecasting and Information Policy sets out their functions in relation to the provision of information and short to medium term forecasting.
4. Security of Supply Annual Assessment<sup>21</sup>: Their Security of Supply Annual Assessments provide an assessment of the power system's ability to meet prudent winter energy and peak requirements over the next seven years.

It is the Security of Supply Forecasting and Information and Security of Supply Assessment policies that ERS will be discussing in this section of the report in the context of how can, the Kaimai Wind farm help with the management of National Security of Supply.

## Hydro Risk Curves

One of the major pieces of forecasting and information provided by the System Operator is the Hydro Risk Curves. They are published on both Transpower's<sup>22</sup> and the EA's web site<sup>23</sup>.

The Hydro Risk Curves are generated from detailed market modelling of supply and demand to indicate the probability of energy shortage to the electricity system without using any contingent hydro storage. Each risk curve shows either the New Zealand or South Island hydro storage level over a calendar year that represents a specific, quantified level of risk of future shortage. The 1% risk curve shows the storage level at which there is a 1% risk of supply shortage.

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<sup>18</sup> Emergency Management Policy Link

<sup>19</sup> [Rolling Outage Plans Link](#)

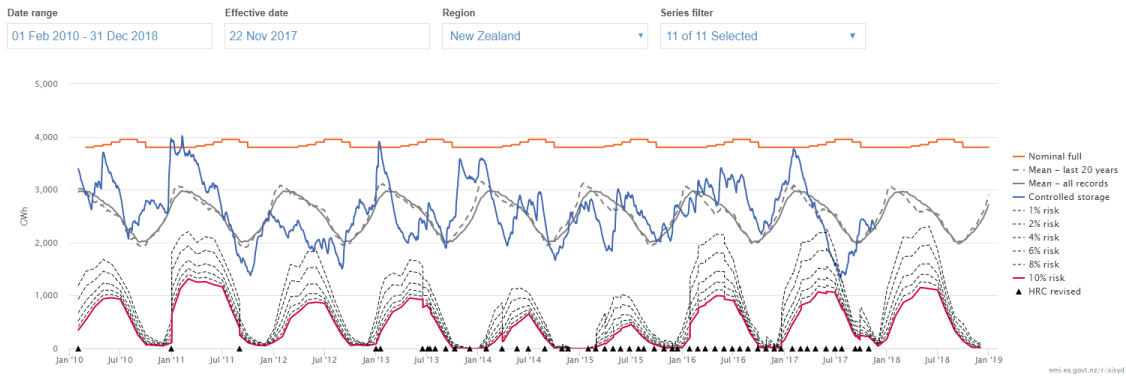
<sup>20</sup> [Security of Supply Forecasting and Information Policy Link](#)

<sup>21</sup> [Security of Supply Annual Assessment link](#)

<sup>22</sup> <https://www.transpower.co.nz/system-operator/security-supply/hydro-risk-curves>

<sup>23</sup> [https://www.emi.ea.govt.nz/Environment/Reports/3UN1KD?\\_si=v|3,p|0](https://www.emi.ea.govt.nz/Environment/Reports/3UN1KD?_si=v|3,p|0)

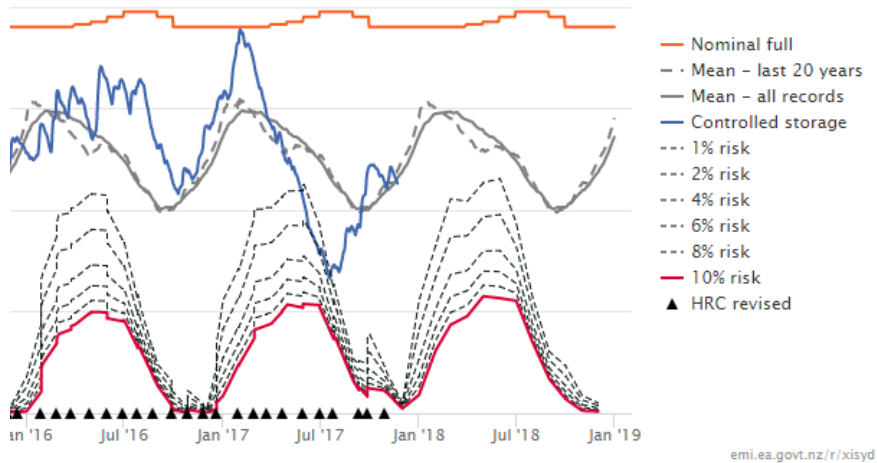
Graphic 15: Full Set of Published Risk Curves New Zealand.



The chart shows at the bottom the risk curves for 1% to 10% risk, above that in the black colour is the average controlled storage of New Zealand Hydro lakes and the blue line was the actual hydro storage. As can be seen the actual storage line is quite variable and is driven by a combination of inflows into storage lake and usage from them.

ERS would draw your attention to the changing level of the risk curves at the bottom of the chart. They reduce from 2011 as new generation was installed and security of supply was improved until their lowest levels is reached over 2014 and 2015. They then increase again as thermal plant continued to be retired and no new plant is commissioned.

Graphic 16: 2016 to 2018 Set of Published Risk Curves New Zealand.



This chart zooms in on the 2016 to 2018 risk curves, to show 2 things:

1. Post winter 2017 the System Operator updated the risk curves to take account of the information they learned during the 2017 dry winter and the risk curves are now at historic high levels.
2. To show that the actual storage can and does cross the risk curves which occurred during the winter of 2017. This resulted in elevated wholesale electricity market prices and the use of thermal plant including mid merit OCGT gas plant, mid merit CCGT gas plant and the use of Genesis Energy reserve plant the Huntly coal units.

The hydro risk curves react to new installed generation plant by reducing and they increase when more generation plant is retired than commissioned.

## Security of Supply Assessment

Transpower publishes an annual, medium to long-term security of supply assessment. This assessment provides a ten-year view (2017 to 2026) of security of supply metrics for a range of supply and demand scenarios. These metrics enable industry stakeholders to compare the risk of supply shortages both between scenarios and over time to inform risk management and investment decisions.

The set of metrics include three measures the;

1. New Zealand Winter Energy Margins (WEM NZ) and
2. South Island Winter Energy Margins (WEM SI) and
3. North Island Winter Capacity Margins (WCM NI).

The energy margin looks at the ability to provide energy in MWh and assess whether it is likely there will be an adequate level of generation supply and south flow HVDC transmission capacity to meet expected electricity demand at either New Zealand or South Island level for extended dry periods. The capacity margin assesses in MW whether it is likely there will be adequate generation and north flow HVDC transmission capacity to meet peak North Island demand.

The 2017 base-case assumptions are based on Transpower's demand forecast, including continued demand from New Zealand Aluminium Smelter (NZAS), Huntly Rankine units being decommissioned at the end of 2022, and investor (generator) advice of new generation options under consideration.

In the base-case, the security of supply measures remains above or within their respective security standards until at least 2018. From 2018, some modest investment in generation will need to commence, with significant investment required after 2022 to maintain the security standards throughout the assessment period.

Current security of supply standards are:

- a WEM of 14-16% for New Zealand.
- a WEM of 25.5-30% for the South Island.
- a WCM of 630-780 MW for the North Island.

Assumptions about generation were largely based on information received from the major generators on a confidential basis. Some publicly available information is also used. All existing generation is expected to remain operationally available throughout the assessment period except for generation with a publicly notified decommissioning date<sup>24</sup>.

Information provided by generators about new generation development has been aggregated for publication to preserve confidentiality. There are currently no projects classified as committed.

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<sup>24</sup> For example, in the Base-case Transpower assume two coal-fired Huntly Rankine units are available for the derivation of the WEMs and WCMs up to, and including, winter 2022. From winter 2023 onwards, it is assumed no Huntly Rankine units will be available



New generation development options under consideration by investors may or may not proceed for a variety of reasons. Transpower have asked potential investors to indicate the likelihood of the investment proceeding. New generation projects have been allocated to four categories: committed, high probability, medium probability, and low probability.

Each scenario includes four cases:

- Existing and committed generation only
- Existing, committed and high likelihood generation
- Existing, committed, high and medium likelihood generation
- Existing, committed, high, medium and low likelihood generation.

Broadly speaking each classification represents a 75%, 50% or 25% likelihood of generation projects going ahead respectively. However, it should be noted that a number of factors influence generation investment decisions and therefore these numbers are a guideline only.

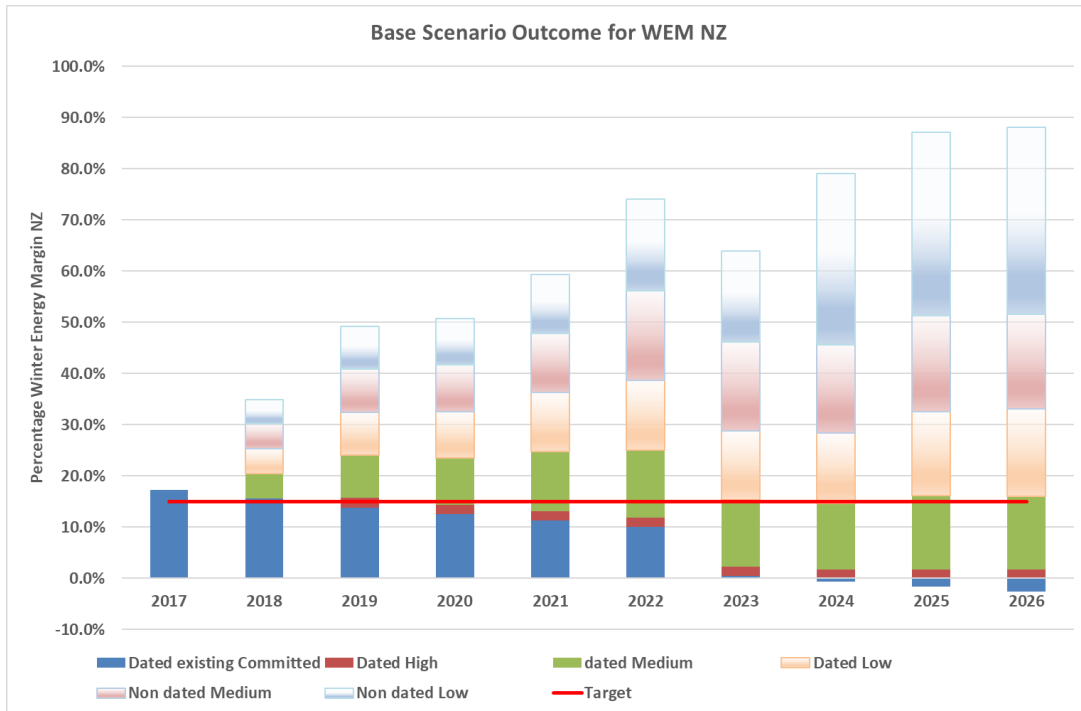
Transpower reported that several Investors did not indicate expected commissioning dates for some new generation projects. Their assessment has adopted a twofold classification system:

1. where generation has a planned commissioning date, this date is used, and generation is treated as a *dated project*
2. where generation does not have a planned commissioning date, then assumed commissioning dates of 2022 and 2024 for medium and low likelihood projects are used respectively, and the generation is treated as a *non-dated project*.

While there are several scenarios in the System Operator's security of supply assessment ERS has concentrated on the base case scenario as it is the business as usual scenario with both the Tiwai Point aluminium smelter staying in operation and Genesis Energy's Huntly coal units staying in service until 2022 and then retiring.

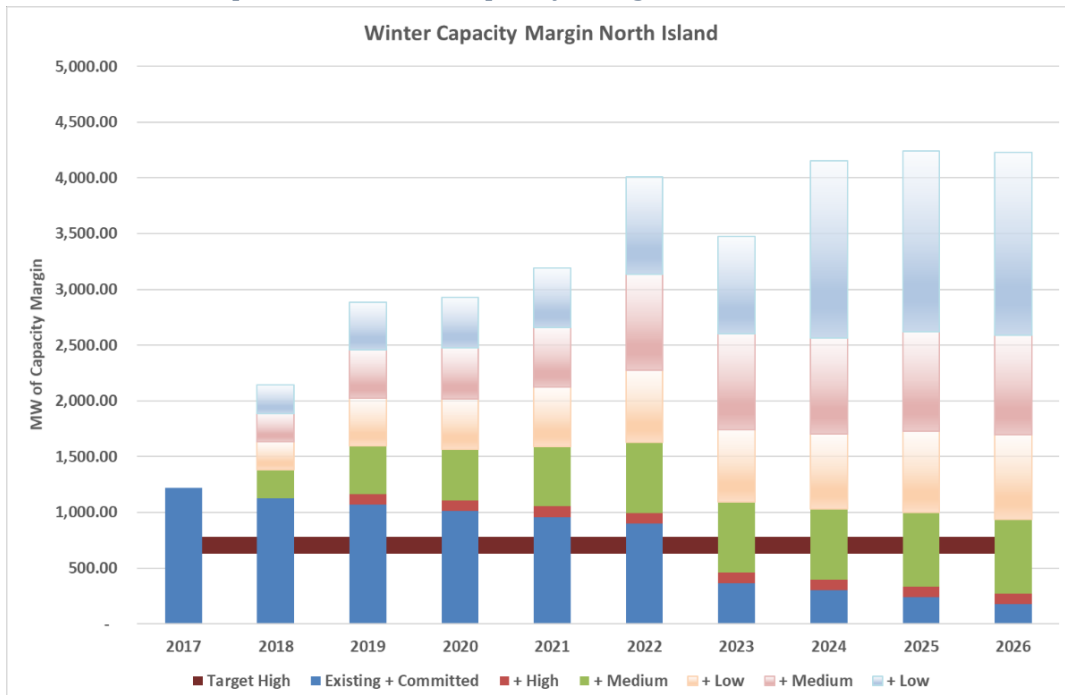
The results of the base case scenarios metrics for the Winter Energy Margin New Zealand and Winter Capacity Margin North Island are below.

Graphic 17: Winter Energy Margin for New Zealand



The red line is the target of 15%. There are no committed generation projects to add supply to the energy margin while demand grows over time meaning that the existing generation + committed projects ability to maintain the energy margin is eroded over time and by 2019 it passes through the target level. At this point dated high likelihood of proceeding projects are added and the target is met until 2020. Adding in the dated medium likelihood projects the target line is maintained until 2023. By 2024 all generation that makes up the WEM's 15% energy margin target, need to come from new installed generation projects.

Graphic 18: Winter Capacity Margin for North Island



The capacity margin target is to have between 630 and 780MW of capacity above the prudent peak demand for North Island. The target is met by exciting generation until 2022, in 2023 both high and medium likelihood of proceeding projects are needed to reach the target. By 2026 nearly most of the medium likelihood of proceeding projects will be needed to meet the capacity target.

### **Summary of National Security of Supply**

Both the short-term Hydro risk curves and the medium to longer term security of supply assessment show a need for investment in new generation capacity and energy production capability.

For the security of supply assessment there is a strong need for new levels of energy capability or MWhs of production from 2023 onwards when all the present high and medium likelihood of proceeding generation will be needed in an extended dry year situation.

The North Island Capacity measure will need new installed capacity by 2023 with projects from both the high and medium likelihood of proceeding projects being required to meet the target from there until the end of the report period, 2026.

In the context of the Kaimai Wind farm it is well placed to help with both measures. Its energy produce of 400GWh annually will contribute to that needed to meet the Winter Energy Margins and the installed capacity of 100MW will contribute to the Winter Capacity Margin in the North Island.

Yours



Ashley Wall  
Principal Consultant

Date 24/05/2018

## Appendix A: Generation Build Post 2010

| Generation Type | Station Name     | Capacity MW | Year | Island Name  | Owner Name                     |
|-----------------|------------------|-------------|------|--------------|--------------------------------|
| Geothermal      | Kawerau - TOPP 1 | 25          | 2012 | North Island | Norske Skog Tasman             |
| Geothermal      | Nga Awa Purua    | 140         | 2010 | North Island | Mighty River Power             |
| Geothermal      | Ngatamariki      | 82          | 2013 | North Island | Mighty River Power             |
| Geothermal      | Te Huka          | 23          | 2010 | North Island | Contact Energy                 |
| Geothermal      | Te Mihi          | 166         | 2014 | North Island | Contact Energy                 |
| Hydro           | Amethyst         | 6           | 2013 | South Island | Westpower                      |
| Hydro           | Cleardale        | 0.9         | 2010 | South Island | MainPower                      |
| Hydro           | Esk              | 4           | 2013 | North Island | Trustpower                     |
| Hydro           | Kowhai           | 1.9         | 2010 | South Island | Pioneer Generation             |
| Hydro           | Rochfort         | 4.2         | 2013 | South Island | Kawatiri Energy                |
| Hydro           | Talla Burn       | 2.6         | 2010 | South Island | Talla Burn Generation          |
| Thermal         | Marsden Diesel   | 9           | 2011 | North Island | Trustpower                     |
| Thermal         | McKee            | 102         | 2013 | North Island | Todd Energy                    |
| Thermal         | Stratford Peaker | 200         | 2011 | North Island | Contact Energy                 |
| Wind            | Chathams Wind    | 0.45        | 2010 | OT - Other   | CBD Energy                     |
| Wind            | Flat Hill        | 6.8         | 2015 | South Island | Pioneer Generation             |
| Wind            | Lake Grassmere   | 0.66        | 2014 | South Island | Energy3                        |
| Wind            | Lulworth Wind    | 1           | 2011 | South Island | Energy3                        |
| Wind            | Mahinerangi      | 36          | 2011 | South Island | Trustpower                     |
| Wind            | Mill Creek       | 71.3        | 2014 | North Island | Meridian Energy                |
| Wind            | Mount Stuart     | 7.65        | 2011 | South Island | Pioneer Generation             |
| Wind            | Te Rere Hau      | 48.5        | 2011 | North Island | New Zealand Wind Farms         |
| Wind            | Te Uku           | 64.4        | 2011 | North Island | WEL Networks / Meridian Energy |
| Wind            | Weld Cone Wind   | 0.75        | 2010 | South Island | Energy3                        |
|                 | Total MW         | 1004.11     |      |              |                                |

## Appendix 2: EDGS Scenarios

**Mixed Renewables** scenario has a mixture of geothermal and wind plant built, starting in 2020. This scenario assumes an average of 1% annual electricity demand growth, reflecting moderate GDP and population growth, and current views on relative technology cost and expected fuel and carbon prices.

**High Grid** scenario assumes higher GDP and population growth rates leading to higher electricity demand across all sectors; with 1.3% per year growth in grid connected electricity demand. Higher as exploration effort results in higher domestic gas supply with a flat wholesale gas price of around \$6/PJ to 2040<sub>1</sub>.

**Global Low Carbon** scenario assumes a high carbon price and lower cost renewable technology (wind and solar) which leads to more renewable build. This scenario assumes high uptake of petrol hybrid vehicles and solar PV systems, and flat electricity demand per household due to efficiency measures.

**Disruptive** scenario a reduction in technology costs leads to high uptake of Solar PV with batteries and electric vehicles. Both total electricity demand and grid connected demand increases as the additional electric vehicle demand is only partially offset by solar generation. Peak and off-peak retail electricity price signals lead to flattening of demand, with a lower peak demand through battery load shifting and off peak EV charging.

**Tiwai Off** scenario Tiwai shuts at the start of 2018 and lower GDP growth leads to lower electricity demand across all sectors, averaging 0.4% p.a. Some existing thermal generation retires due to the drop-in energy demand in the short term. With less capacity on the system more flexible North Island generation is built in the early years to meet peak requirements.

## Appendix 3: New turbine definition

Attached is the revised turbine definition for the Kaimai Wind farm.

### Title: Kaimai Wind Turbine Definition

Date: 21 May 2018

| Specialty              | Company and Expert                    | Email                           |
|------------------------|---------------------------------------|---------------------------------|
| AEE                    | Enspire, Sue Ruston                   | sue@enspire.co.nz               |
| Archaeological;        | Andrew Hoffman                        | ajarchaeology@gmail.com         |
| Aviation;              | Peet Aviation, Brian Whelan           | brian@rft.aero                  |
| Civil Drawings         | Tektus, Jack Turner                   | jack.turner@tektus.nz           |
| Civil Peer Review      | TBA                                   |                                 |
| Construction           | Energy3, Tom Cameron                  | tom@energy3.co.nz               |
| Ecology - Site         | Kessels and Associates; Gerry Kessels | Gerry@kessels-ecology.co.nz     |
| Ecology - Environs     | Ecology NZ; Simon Chapman             | simon.chapman@ecologynz.nz      |
| Electricity Market     | ERS; Ashley Wall                      | ashley.wall@xtra.co.nz          |
| Geotechnical;          | KGA, Jacqui McCord                    | Jacqui@kga.co.nz                |
| Turbine Transportation | Tranzcarr; Warwick Bell               | warwick.bell@macmove.co.nz      |
| Landscape              | Mike Moore                            | mike@mmla.co.nz                 |
| Landscape Peer Review  | Boffa Miskel; Boyden Evans            | Boyden.Evans@boffamiskell.co.nz |
| Project Rationale      | Energy3, Tom Cameron                  | tom@energy3.co.nz               |
| Radio Communications   | Lambda; Stephen Aitkinson             | stephen@lambda.co.nz            |
| Shadow Flicker         | Energy3, Tom Cameron                  | tom@energy3.co.nz               |
| Siltation              | CES, Murray Preston                   | office@ces94.co.nz              |
| Stormwater             | CES, Murray Preston                   | office@ces94.co.nz              |
| Tourism                | TRC; Donna Graf                       | donna@trctourism.com            |
| Traffic                | Gray Matters, Alasdair Gray           | alasdair.gray@graymatter.co.nz  |

1. The purpose of this memorandum is to re-define the turbines that we wish to install at the Kaimai Wind Farm. However, within that definition we must allow a measure of flexibility to allow for competition in the turbine procurement process – that is – we don't wish to be constrained into using an obsolete turbine or a turbine from a single manufacturer.
2. Previously the turbines we defined as:
  - a. Upper Ridgeline: 112m Hub Height, 136m rotor diameter, 180m tip height
  - b. Lower Ridgeline: 132m Hub Height, 150m rotor diameter, 207m tip height
3. The previous definition was based upon the Vestas 3.6/4.2MW platform. However other manufacturers are now surpassing Vestas – notably GE and Gamesa/Siemens so we need to include for them also and not all future configurations are known.
4. Our new dimension scenarios are as follows
  - a. Upper Ridge(18-24):

- i. (i) 112m Hub Height, 136m rotor diameter, 180m tip height (as before)
- ii. (ii) 107m Hub Height, 146m rotor diameter, 180m tip height
- iii. (iii) 98m Hub Height, 146m rotor diameter, 171m tip height
- iv.
- v.

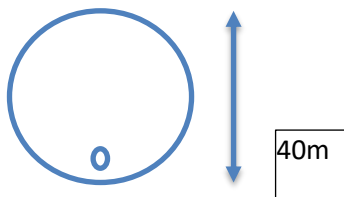
b. Lower Ridge(1-17):

- i. (i) 132m Hub Height, 150m rotor diameter, 207m tip height (as before)
- ii. (ii) 128m Hub Height, 160m rotor diameter, 207m tip height
- iii. (iii) 110m Hub Height, 160m rotor diameter, 190m tip height
- iv.

Obviously, there is a lower practical limit in terms of for tip clearance above the ground, for this we have allowed 30m, which defines scenario (iii).

Clearly not all scenarios will need special mention for all of your studies.

5. Please clearly state in the summary/intro/front page of your documents the above dimension scenarios have been considered.
6. No changes are proposed to the location of turbines nor to the base arrangements.
7. The nacelle shapes have also changed recently, most notably with the GE turbine which has a large box structure under the Nacelle. Please note this if on relevance.
8. With respect to the maximum mass - my information at this stage is that the maximum weight remains as per the Vestas option of 90t. The maximum blade length becomes 78m.
9. Please revise your reports accordingly and email a revised updated version with an appropriate revision number included ASAP. This will allow us to complete the AEE.
10. Allow a locational flexibility (in the horizontal plane) of 20m. Which means the centre of the turbine tower could move 20m in any direction. For the avoidance of doubt the complete range of movement is therefore a circle of 40m diameter.
11. With respect to 10 above, please note if increased environmental effects would result for any particular turbine from moving the turbine by 20m in any direction. And either 1. assess those effects or 2. recommend that the movement in any particular direction is reduced or prohibited.
12. Images of Nacelles that should be allowed for are attached - dimensions available.









# Onshore Wind Turbine

### Pitch System

Independent blade pitch angle adjustment combined with generator torque enables rotor to regulate speed depending on wind conditions

### Hub

Mounted on main shaft - can be entered through hatches located on the nacelle to simplify up-tower repairs

### Blades

158 meter rotor diameter with blades from LM Wind Power

### Tower

Hub heights available at 101m, 120.9m with tubular tower & 149m, 161m with hybrid concrete tower

### Nacelle

Larger nacelle platform brings more comfort to Service personnel and facilitates up-tower repairs

### Generator & Gearbox

Based on a proven doubly-fed induction generator (DFIG) electrical system, available at 50 Hz & 60 Hz

### Control System

Control system and digital integration including WindSCADA control system, Asset Performance Management (APM) and cybersecurity modules

### Electrical System

High power density electrical system for performance and grid integration



## Ideal for low to medium wind speed sites

- GE's 4.8-158 can power the equivalent of up to 5,000 residential homes in Europe  
- It is GE's largest, high efficiency onshore wind turbine to date with a 30% higher annual energy production compared to GE's 3.6-137

