Before the Hearings Commissioners
at Christchurch

in the matter of:	a submission and further submission on the proposed Canterbury Land and Water Regional Plan under the Resource Management Act 1991
to:	**Environment Canterbury**
submitter	**Meridian Energy Limited**

Statement of evidence of James Thomas Truesdale

Date: 4 February 2013

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STATEMENT OF EVIDENCE OF JAMES THOMAS TRUESDALE

INTRODUCTION

1 My name is James Truesdale. I hold a Bachelor of Electrical Engineering degree (honours, 1979) and a Master of Electrical Engineering degree (1981), both from the University of Canterbury.

2 I am an energy sector consultant specialising in electricity generation and market issues. Since 1999, I have advised a range of energy sector clients, including policy makers and regulatory bodies in New Zealand and overseas. Prior to then I held technical and management roles in the New Zealand electricity sector over approximately twenty years.

3 Experience of particular relevance to my statement includes:

3.1 Design of electricity markets, including system operation and security of supply arrangements;

3.2 Analysis of electricity markets, including supply and demand projections and security of supply assessments;

3.3 Coordination of ECNZ's[1] generation resources, including hydro storage lakes and thermal fuel;

3.4 Restructuring of ECNZ into competing generation companies; and

3.5 Establishing electricity market trading and risk management capabilities at ECNZ and Genesis Energy.

4 Further details regarding my relevant experience can be found in **Appendix 1**.

5 Although this is a Council hearing, in preparing my evidence I have reviewed the code of conduct for expert witnesses contained in part 5 of the consolidated Environment Court Practice Note 2011. I have complied with it in preparing my evidence. I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

6 In preparing my evidence I have reviewed:

6.1 The Proposed Canterbury Land & Water Regional Plan;

[1] Electricity Corporation of New Zealand.

6.2 The statement of **Mr Ken Smales** of Meridian Energy Limited (*Meridian*).

6.3 The references cited in my evidence.

SCOPE OF EVIDENCE

7 In my evidence I have been asked by Meridian to address the roles and significance of the Waitaki Power Scheme from a New Zealand energy supply perspective.

8 My statement will cover the following:

8.1 An overview of electricity demand and supply in New Zealand;

8.2 A brief outline of how electricity supply and demand are coordinated in the electricity market;

8.3 Discussion of future electricity supply requirements, including government's objectives for climate change and renewable energy;

8.4 An overview of the Waitaki Power Scheme;

8.5 Discussion of the roles of the Waitaki Power Scheme; and

8.6 Discussion of the scheme's importance going forward, from regional and national perspectives.

SUMMARY

9 Maintaining a secure electricity supply system, both regionally and nationally, is critically dependent on flexible and controllable generation technologies that are able to respond to continuously changing electricity demand. Generally speaking, this flexibility can only be provided by hydro generation with storage, thermal power stations with flexible fuel arrangements or by curtailing demand.

10 Given its size, flexibility and energy storage capability, the Waitaki Power Scheme is an instrumental contributor to security of electricity supply, both regionally and nationally.

11 The scheme:

11.1 Provides, on average, around 18% of NZ's annual electricity generation requirements – enough energy to meet all of Canterbury's annual requirements and to help meet demand in other regions;

11.2 Alters its output in order to help meet electricity demand as it changes through-out the day, contributing proportionally more to periods of peak demand – at times up to 30% of national requirements;

11.3 Can also respond quickly to changes in supply, a function that will become increasingly more important in enabling greater levels of inflexible and/or intermittent renewable generation to be added to the electricity system;

11.4 Holds around 60% of national hydro storage capacity, helping to smooth out seasonal variations in hydro inflows, and hence assisting security of supply, reducing thermal generation requirements, and associated emissions, during the winter when demand is higher but inflows lower; and

11.5 Provides ancillary services on which the stable and reliable operation of the electricity system depends.

12 In providing these benefits, the scheme contributes no greenhouse gas emissions in operation, and subject to inflows and lake levels, operates ahead of thermal generation, constraining prices nationally and regionally, and supporting the government's New Zealand Energy Strategy, including the 90% renewable energy target, and the National Policy Statement for Renewable Electricity Generation.

ELECTRICITY DEMAND

13 Electricity impacts on virtually every aspect of modern life. Many of the social and economic benefits enjoyed by New Zealanders stem from technologies relying on electricity, through direct use or indirectly as a productive input for the goods and services we use or export. Often there are simply no economic alternatives to electricity.

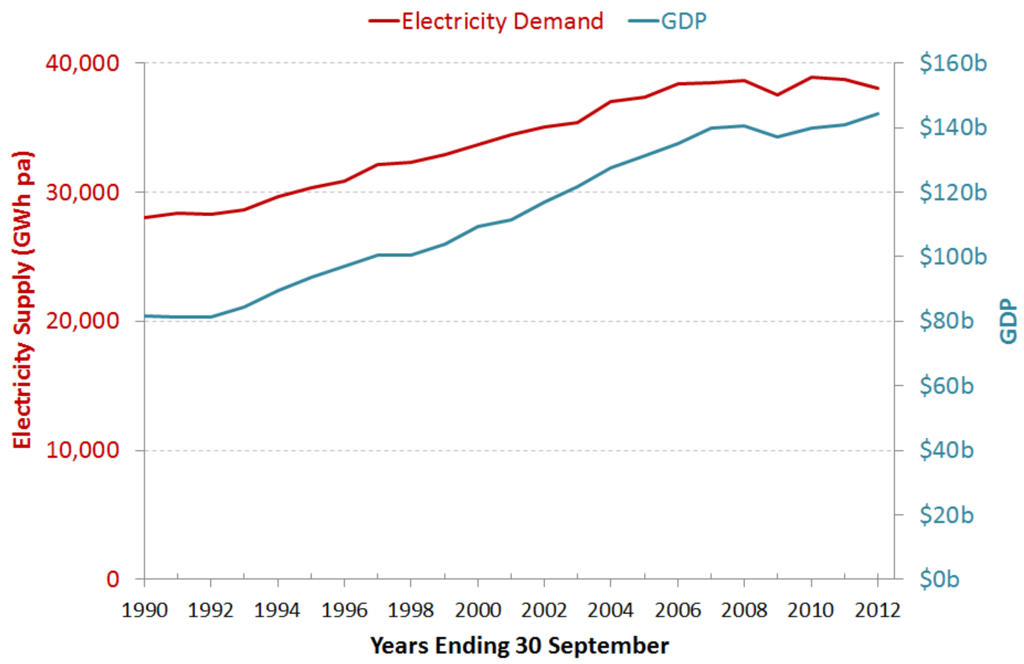
14 The demand for electricity can be measured in terms of the amount of energy needed over time and the amount of electricity required at any instant in time. For example, New Zealand currently uses around 40,000 GWh of electricity annually (energy demand) with a peak use of around 6,700 MW (peak demand). The electricity supply system must be capable of meeting both of these requirements.

15 In energy terms, electricity demand growth over the last twenty years has averaged around 1.6%[2] per annum. A number of factors contribute to demand growth (population growth, technology advances etc). However, as shown in **FIGURE 1** there is a strong relationship between economic growth and annual electricity

[2] Compound growth rate from 1990 to 2011. Derived from MBIE 2011 Energy Data File June 2012.

demand growth[3]. Many of the technologies underpinning economic development rely on electricity. Conversely, a secure and cost-competitive electricity system can help encourage investment and promote economic growth.

FIGURE 1: GDP (PRODUCTION) AND ELECTRICITY DEMAND (YEARS ENDING SEP 1990 TO 2012) [4]

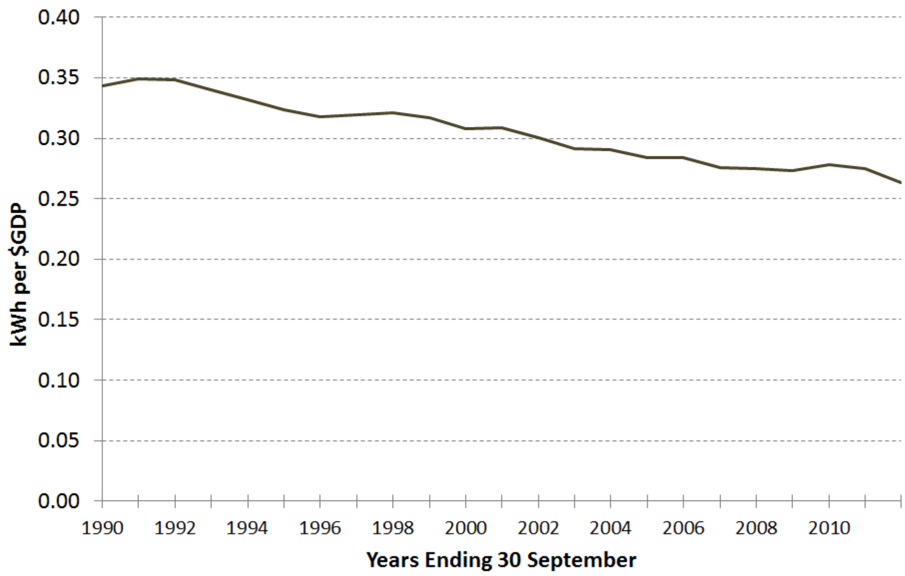


16 **FIGURE 1** also shows that electricity requirements have grown at a lesser rate than economic growth, highlighting increasing levels of energy efficiency. This trend can be seen more clearly in Figure 2 which shows how annual electricity demand per dollar of GDP (real) has reduced over time.

[3] Note that electricity demand has been affected by one-off factors in recent years, in particular the Canterbury earthquakes and reductions in production at the Tiwai aluminium smelter, in part due to equipment failure.

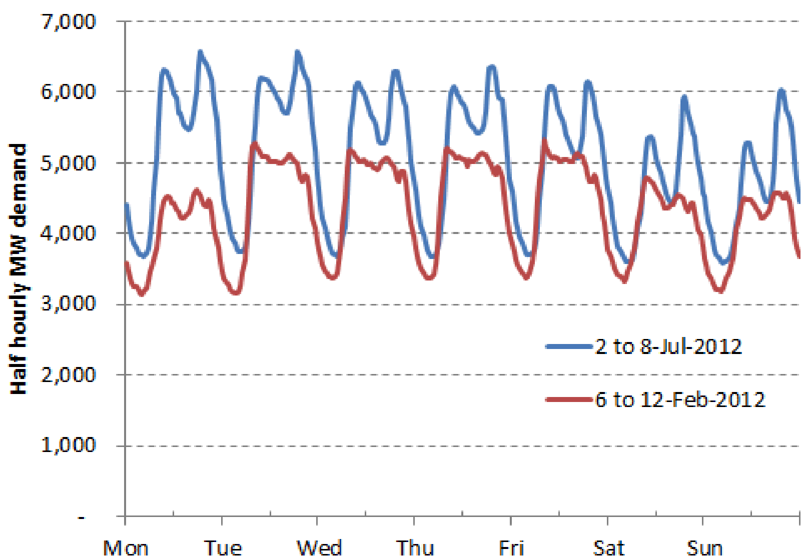
[4] GDP data sourced from NZ Treasury and Statistics New Zealand constant price time series data. Demand data sourced from MBIE Quarterly Electricity Generation Data.

FIGURE 2: CHANGE IN ENERGY INTENSITY OVER TIME[5]



17 From a MW demand perspective, electricity demand changes significantly over the course of a day and across the year. For example, Figure 3 shows half hourly New Zealand MW demand patterns for summer and winter weeks in 2012.

FIGURE 3: EXAMPLES OF NATIONAL HALF HOURLY DEMAND IN SUMMER AND WINTER WEEKS[6]



18 Peak demand periods during the day are largely due to domestic cooking and heating needs on top of the daytime electricity

[5] Electricity demand/ GDP (constant prices).

[6] Derived from Electricity Authority Centralised Dataset.

requirements of business and commerce. The pattern is more pronounced in winter than summer because of increased heating and lighting requirements. These patterns can also alter significantly from one day to the next due to prevailing weather conditions. The electricity supply system must be capable of responding continuously to these changes.

19 I will describe later how the Waitaki Power Scheme fills an important role in this regard because of its inherent short term flexibility, and also how this will become more important with increasing levels of wind and geothermal generation development. These technologies make a valuable contribution to energy supply requirements over time but are intermittent (wind) or tend to operate at constant output (geothermal) on a day to basis. In the longer term, other renewable technologies, such as solar, wave and tidal generation may also be developed, further increasing intermittency.

20 How the electricity system operates on a day to day basis is also relevant to that discussion.

COORDINATING SUPPLY AND DEMAND

21 The electricity supply system must be capable of meeting electricity demand at any instant in time (MW) and over time (GWh). The former requires flexible and controllable generation technologies that are able to respond to continuously changing demand along the lines illustrated in **Figure 3**. For example, hydro power stations with water storage capacity and thermal power stations with flexible fuel supply arrangements. As noted previously, other generation technologies contribute to energy supply requirements over time but on a day to day basis tend to be largely uncontrolled.

22 On a moment to moment basis, electricity generation must be continuously matched to demand, nationally and regionally, to ensure that the security of electricity supply to consumers can be maintained. A mismatch in demand and supply will cause the power system frequency to rise or fall and unless corrected can quickly lead to supply black-outs. Many power stations can provide a level of automatic short term response to system frequency[7] variations but generation around the country must be adjusted (dispatched) in a coordinated manner to match the trend in demand.

23 This important coordination role is undertaken within the electricity market by Transpower as the System Operator. The System operator instructs (dispatches) generators in accordance with offers

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[7] The electricity system operates at a nominal frequency of 50Hz. The Cook Strait cable system means that the frequency in the South Island can differ from the frequency in the North Island but within an island the frequency is the same throughout the electricity system. When demand exceeds generation, the frequency will fall as generators slow down and vice versa.

they submit to the market indicating the quantities of electricity they are prepared to sell at specified prices[8]. Dispatch instructions are issued as often as every 5 minutes and a wholesale 'spot' price established every half hour reflecting the price of the last offer dispatched to meet demand[9].

24 These arrangements mean that, subject to availability of primary energy, generation with lower variable (marginal) operating costs, such as renewable technologies which have no direct fuel costs, will operate in the market ahead of comparatively more expensive thermal generation, helping to minimise greenhouse gas emissions.

25 In practice, the market also takes into account where generation is located – dispatching the lowest cost combination of generator offers to meet demand taking into account transmission system losses and constraints – with corresponding spot prices being established at over 200 locations through-out the country. In addition to minimising the day to day cost of dispatching generation to meet demand around the country, locational spot prices also signal over time the relative need to invest in generation and/ or transmission in different locations.

GENERATION MIX

26 New Zealand's demand for electricity is currently met by a mixture of generation resources as shown in Figure 4.

27 Generation in the South Island is almost entirely from renewable energy resources, and comprises a significant proportion of total generation. Generation in the North Island is more varied, including a large amount of thermal generation.

28 Over recent years there has been a notable increase in generation from geothermal and wind sources. For example, from 2002 to 2011[10]:

28.1 geothermal generation capacity increased from 365 MW to 725 MW;

28.2 wind generation increased from 65 MW to 615 MW; and

28.3 the capacity of all other generation sources combined increased by approximately 310 MW.

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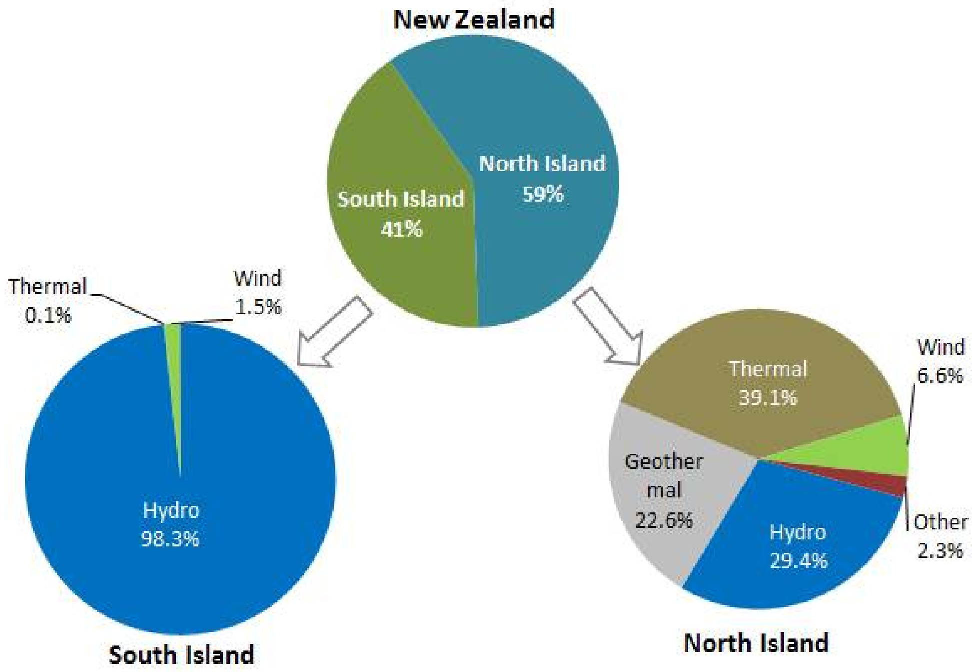
[8] Wind generation is typically not dispatched as such and is required to be offered into the electricity market at $0.01/MWh.

[9] In practice pricing and dispatch are more complex than portrayed here but the principles are similar.

[10] MBIE 2011 Energy Data File, June 2012 (Table G.3a).

FIGURE 4: ELECTRICITY GENERATION BY FUEL TYPE IN 2011[11]



29 Different types of generation have different performance characteristics. The most prominent forms of generation in New Zealand operate as follows:

29.1 geothermal plants generally operate at a consistently high level of output;

29.2 thermal plants can operate at a relatively constant rate of output or, depending on the individual plant design and fuel arrangements, provide flexible generation;

29.3 hydro generators with storage can provide flexible generation, subject to availability of water; and

29.4 wind and run-of-river[12] hydro generators contribute energy over time but on a day to day basis fluctuate largely independent of demand (i.e. they are uncontrolled).

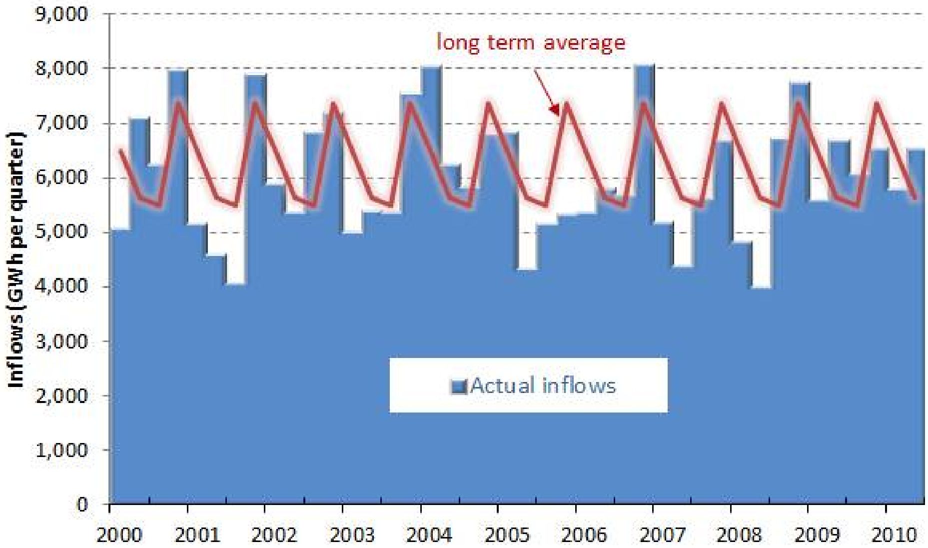
30 In order to keep demand and generation in balance continuously, the output of generators that can be controlled must be regulated to follow the pattern of demand and to compensate for fluctuations in uncontrollable generation. Hydro generation is able to take on a large portion of this role in NZ. However, on a seasonal basis, the availability of hydro energy supply can vary considerably depending on climatic conditions. This can be seen in **Figure 5** which compares

[11] Derived from MBIE 2011 Energy Data, June 2012.

[12] With no appreciable storage capacity.

quarterly hydro inflows, over the period from January 2000 to June 2010, to long term quarterly averages[13].

FIGURE 5: NZ QUARTERLY HYDRO INFLOWS (JAN 2000 TO JUNE 2010)[14]



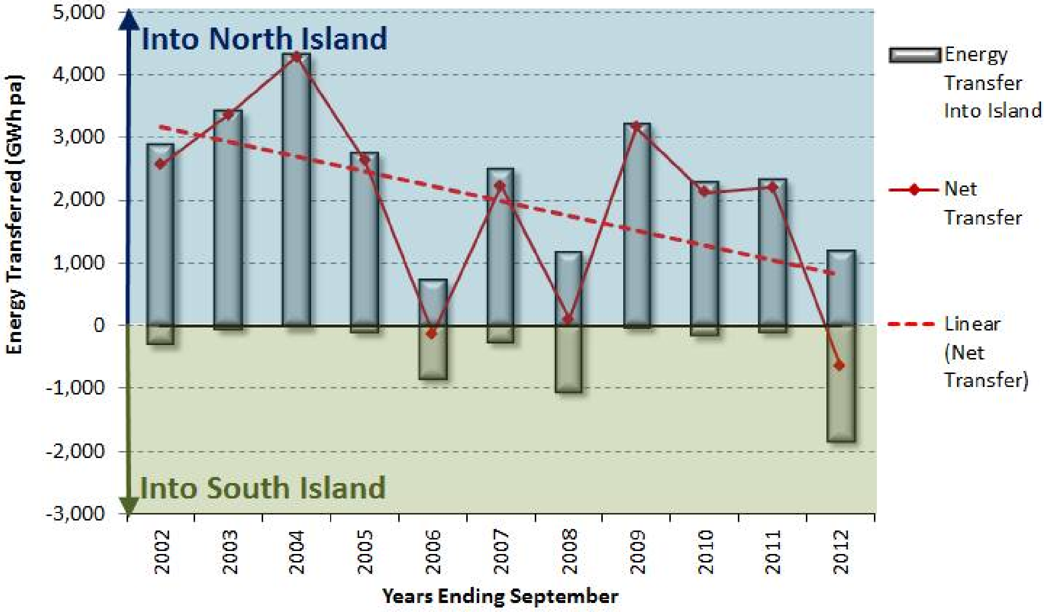
31 The larger hydro storage lakes fill an important role in smoothing out seasonal inflow fluctuations, better matching hydro generation to seasonal demand. However, hydro storage capacity in NZ is limited and compensating thermal generation is also required to ensure security of supply, particularly in dry years.

32 The majority of New Zealand's hydro generation and storage is in the South Island, where on average electricity generation typically exceeds demand. However, although electricity typically flows from the South Island to the North Island through the Cook Strait cables, increasingly, as illustrated in **Figure 6**, electricity flows in the opposite direction and during hydro droughts in substantial amounts. This capability is particularly important, enabling South Island hydro storage lake levels to be regulated within their consented operating ranges so as to manage the risk of hydro spill if lake levels get too high, and electricity supply shortage risks if lake levels get too low.

[13] Hydro inflows are expressed in potential energy (GWh) terms although some of the potential energy cannot be utilised. e.g. during high inflow periods, inflows exceeding the capacity of schemes to store water and/or generate has to be 'spilled' past power stations.

[14] Derived from Electricity Authority Hydro inflows - Spectra Update Issue 8. Long term averages calculated over the period 1932 to June 2010.

FIGURE 6: INTERISLAND ENERGY TRANSFERS (YEARS ENDING SEPTEMBER 2002 TO 2012)



33 **Figure 6** also highlights that while energy transfers between the islands vary considerably from year to year reflecting hydrological conditions, there is a trend towards lower net northward transfers. That is because in the South Island there has been minimal new generation development but on-going demand growth.

34 The discussion in the preceding sections provides important context for discussing the role and significance of the Waitaki Power Scheme. Before doing so, I will discuss the future outlook for electricity supply generally in NZ as it is also highly relevant to the role of the Waitaki Power Scheme.

FUTURE OUTLOOK

35 In recent years, as can be seen in **FIGURE 1**, electricity demand growth has been low or negative reflecting general economic conditions and one-off effects such as the Canterbury earthquakes. However, longer term average annual demand growth rates prior to the economic downturn were of the order of 2%. For example, the average annual growth rate between 1990 and 2007 was approximately 2%. The corresponding rate between 2000 and 2007 was 1.85%.

36 There is a reasonable consensus that over the longer term electricity demand will continue to increase, albeit at a lower rate than observed historically given increased levels of energy efficiency within the economy. For example, reference forecasts developed by

the Ministry of Business, Innovation and Employment (MBIE)[15] indicate average annual growth rates to 2030 of approximately 1.14%[16]. The Electricity Authority's (EA) baseline forecast[17] indicates an average annual rate of growth to 2030 of approximately 1.6%. By comparison, historical annual growth rates from 2000 to 2007 (excluding the economic downturn) and from 2000 to 2011 (including the economic downturn) were around 1.85% and 1.13% respectively[18].

37 Given a number of competing factors, there are varying views of the future rate of electricity demand growth. Different potential scenarios have also been developed according to a range of input assumptions. For example, in addition to its reference scenario, MED projections include 9 scenarios (within the low-high range outlined below) reflecting assumptions about GDP growth, international carbon prices, oil prices and exchange rates.

38 **Figure 7** shows the range of electricity demand growth that would occur under the MBIE forecasts[19] and the EA's baseline forecast. For comparison, the chart also indicates annual demand in 2030 under average historical growth rates between 2000 and 2007 (excluding the economic downturn) and between 2000 and 2010 (including the economic downturn).

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[15] 2011 Energy Outlook, MED/ MBIE. Average growth rates to 2030 have been derived from generation forecasts (demand plus losses).

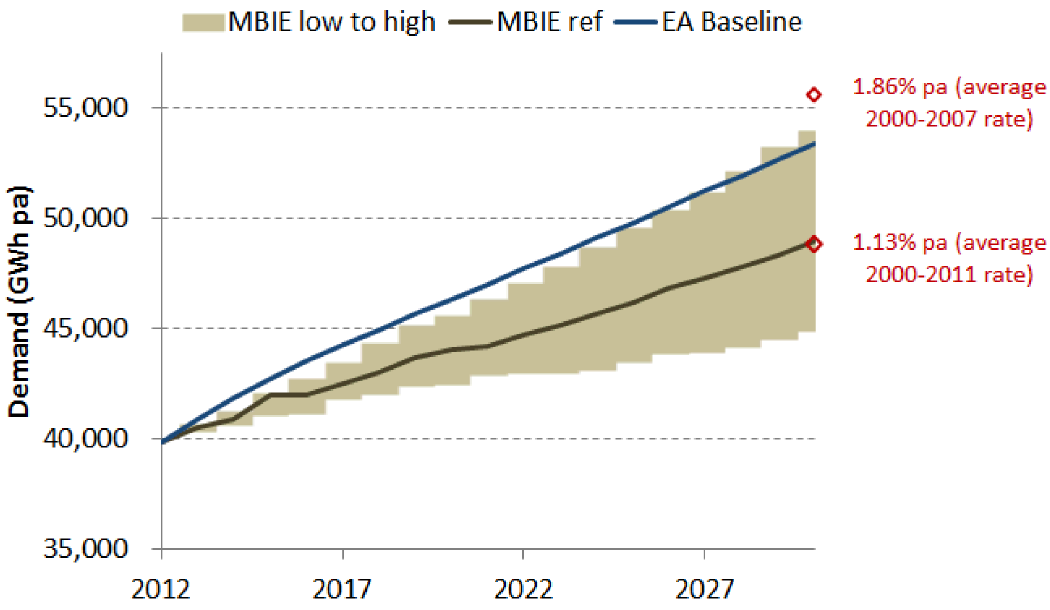
[16] Derived from growth rates for each year from 2012 to 2030, for each forecast scenario.

[17] Electricity Authority National and Regional Energy Forecasts (http://www.ea.govt.nz/industry/modelling/demand-forecasting/).

[18] Derived from MBIE 2011 Energy Data File, June 2012.

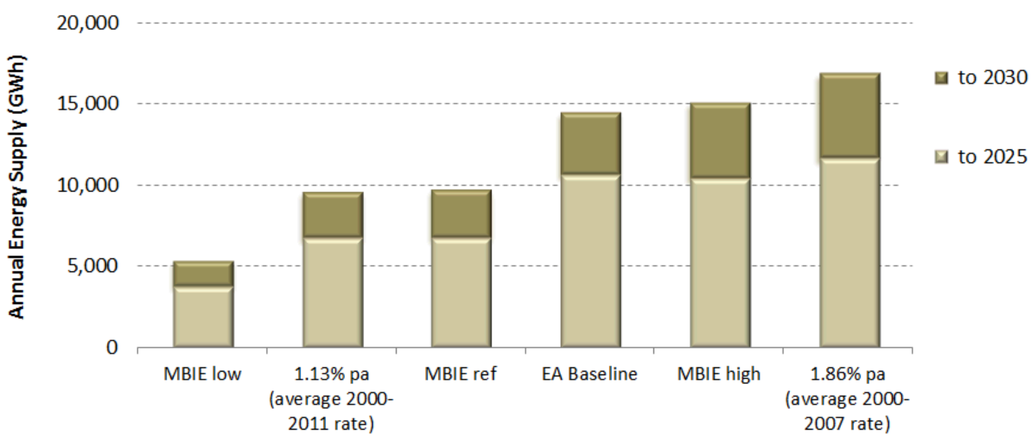
[19] MBIE forecasts represent annual energy generation requirements (including transmission and distribution losses). The EA's nominal forecasts represent energy demand at the national grid level. For consistency, the EA's estimates of embedded generation have been added onto its grid demand estimates. The growth rates in each year of the respective forecasts have been used to grow the estimated total demand for 2012.

FIGURE 7: ELECTRICITY DEMAND GROWTH SCENARIOS TO 2030



39 The amount of new generation that will be needed to meet demand growth under these forecasts (allowing for transmission and distribution losses[20]) is shown in **Figure 8**.

FIGURE 8: ESTIMATED NEW SUPPLY REQUIREMENTS



40 Under any realistic scenario, a substantial amount of new electricity supply will need to be developed over the next 15 -20 years to meet expected demand growth. Loss of existing generation capability,

[20] Based on the current proportion of transmission and distribution losses derived from the Electricity Authority Centralised Dataset.

through retirement of generation capacity[21] or through adverse re-consenting outcomes will increase these requirements.

Government Objectives

41 There is also an increasing focus on renewable energy supply options to avoid greenhouse gas emissions, as reflected in the New Zealand Energy Strategy (NZES)[22]. A key NZES objective is that by 2025, on average, 90% of electricity supply will be from renewable energy sources, subject to security of supply requirements. In support of its objectives, Government has introduced the Emission Trading Scheme (ETS) whereby since July 2010 thermal electricity generators have faced a cost for greenhouse gas emissions. To the extent thermal power stations endeavour to recover increased operating costs, the resulting higher electricity prices make renewable generation investments more economic. Once built, renewable generation, with its low operating costs, will generally operate ahead of thermal generation as I have noted previously.

42 On average, existing renewable generation is currently capable of generating around 75% of New Zealand's electricity supply requirements. Some new renewable generation projects are being developed[23] and the retirement of some geothermal generation[24] has been announced. Taking this and the above demand growth scenarios into account, Figure 9 indicates the level of additional new renewable generation projects that would need to be developed by 2025 and 2030 to achieve the 90% target in 2025 and to sustain it through to 2030. To provide some context, the average annual contribution from the Waitaki Power Scheme is also shown.

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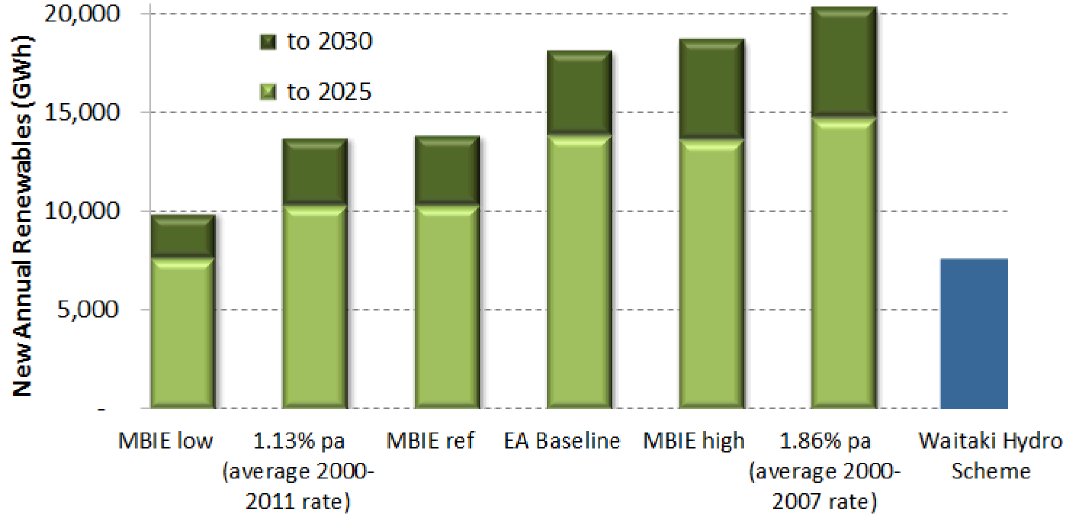
[21] For example, in December 2012 Genesis Energy placed one of its four 250 MW coal-fired generating units at Huntly Power Station into long-term storage and has indicated it plans to place a second unit into long-term storage in December 2014. (Genesis Energy Statement of Corporate Intent 2012/3- 2015.

[22] "New Zealand Energy Strategy 2011-2021; Developing Our Energy Potential"; August 2011.

[23] Projects which are under construction or for which firm commercial commitments have been made to proceed. Amethyst hydro (7MW, 2013), Mill Creek wind (60 MW 2014), Te Mihi geothermal (220 MW, 2013 - replacing some existing Wairakei geothermal capacity), Ngatamariki geothermal (82 MW, 2013) and Kawerau (Norske Skog) geothermal (20 MW, 2013).

[24] Te Mihi will initially replace part of Wairakei power station in 2013 (as noted in footnote 23 above) and Contact Energy has indicated that from 2027 overall generation from the field will be similar to current levels.

FIGURE 9: ESTIMATED NEW RENEWABLE GENERATION REQUIREMENTS TO MEET 90% RENEWABLE SUPPLY TARGET



43 Under the MBIE reference scenario, additional renewable generation capable of generating on average approximately 10,400 GWh and 13,900 GWh annually would need to be developed by 2025 and 2030 respectively.

44 Clearly the achievement of the 90% renewable supply target represents a substantial undertaking. To support its achievement, the government has put in place a National Policy Statement (NPS) for Renewable Electricity Generation, the stated objective being:

> *"To recognise the national significance of renewable electricity generation activities by providing for the development, operation, maintenance and upgrading of new and existing renewable electricity generation activities, such that the proportion of New Zealand's electricity generated from renewable energy sources increases to a level that meets or exceeds the New Zealand Government's national target for renewable electricity generation."*

45 The NPS recognises the difficulty inherent in the government's 90% renewable target, and encourages decision makers to have particular regard to the importance of maintaining the renewable generation that currently exists. It requires Regional Policy Statements to include objectives, policies and methods that provide for the development and maintenance of various forms of renewable generation[25].

[25] Hydro, geothermal, wind, tidal, solar biomass, wave and ocean resources.

46 The last decade has seen a notable increase in geothermal and wind resources. Government policies, an uncertain future gas supply, higher fuel prices, and the ability to gain resource consents have all helped to encourage this outcome.

47 Looking forward, the trend of rising renewable generation appears likely to continue, especially from geothermal and wind generation[26]. This will increase the importance of generation that can provide flexible supply to meet daily and seasonal peak demands, and respond to short term variations in demand, noting that it will also be necessary to compensate for increasing levels of intermittent generation. I will discuss later how in this regard NZ is fortunate in that it has a relatively large amount of hydro generation, of which the Waitaki Power Scheme is a significant portion (on average, around 30% of annual hydro supply).

WAITAKI POWER SCHEME OVERVIEW

48 The Waikato Power Scheme consists of eight power stations inter-connected by a network of rivers and canals and storage lakes. It is supplied by a number of natural inflows (largely from the Southern Alps and the Ahuriri River).

49 The scheme is the largest hydro system in NZ. It has a generating capacity of 1,723 MW - around 18%[27] of NZ's total generating capacity – and on average contributes around 7,600 GWh[28] annually - around 18% of total generation requirements.

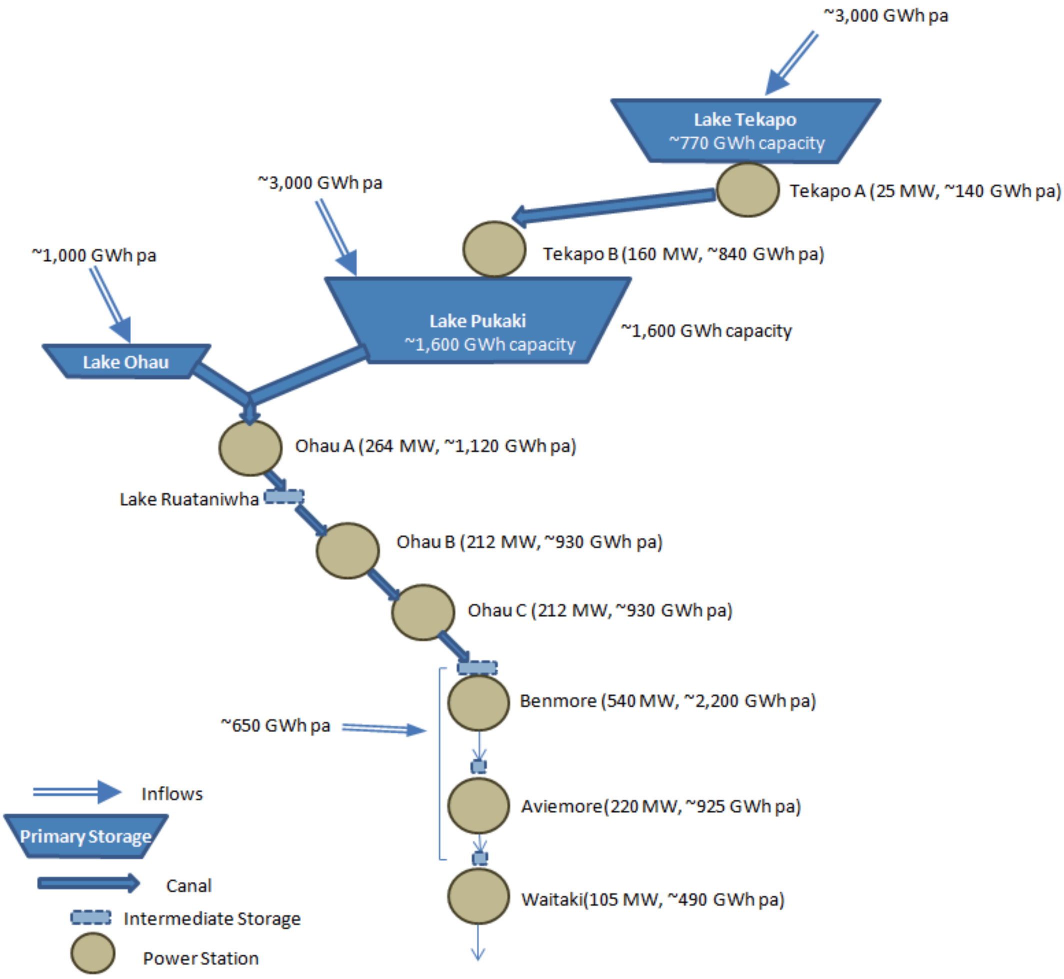
50 A schematic of the Waitaki Power Scheme is shown in **Figure 10**. The Tekapo A and B power stations are operated by Genesis Energy. The remainder of the scheme is operated by Meridian Energy.

[26] Other generation forms are also likely to be developed, such as expanded hydro generation from existing or new sources. However, it appears likely that geothermal and wind generation will account for most of the generation growth from renewables for the next decade or so.

[27] Derived from MBIE 2011 Energy Data File, June 2012 (Table G.3a).

[28] Average annual generation over the period 1998 to 2011 inclusive. Derived from the Electricity Authority Centralised Data Set.

FIGURE 10: SCHEMATIC OF WAITAKI POWER SYSTEM



51 Together, Lake Tekapo and Lake Pukaki comprise almost 60% of NZ's controllable hydro storage capacity.

52 The HVDC[29] link, which includes the Cook Straight cables, is connected to the South Island transmission network at Benmore Power Station. This enables electricity to be transferred in either direction between the South Island and North Island.

53 The scheme was developed in stages, first generating up to 60 MW from the Waitaki Power Station in 1935, and reaching its current capacity in 1985 when Ohau C power station was commissioned. The Waitaki Power Station and dam were initially developed in order to accommodate increasing demand for electricity in Christchurch.

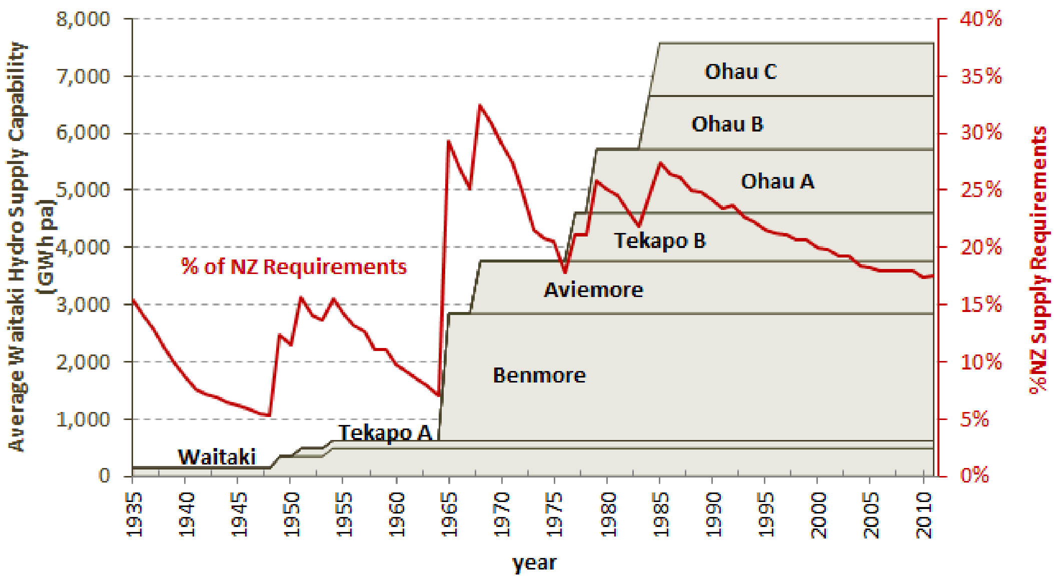
[29] High Voltage Direct Current.

54 Hydro development on the Waitaki River was favoured for a number of reasons. It was a good fit, given its location, with the government's plans to develop an integrated South Island electricity supply network and was seen as having much greater possibilities for expansion than elsewhere. The river's flow rates were also higher and less variable than other rivers, and Lakes Tekapo, Pukaki and Ohau acted as natural flow controls.

55 Control structures at Lakes Tekapo and Pukaki were constructed in the 1940s. This work was considered essential because the inflows to the Waitaki River were not well correlated with high winter demand. By providing upstream storage and control, high spring/summer inflows could be captured so that river flows and electricity generation could be better co-ordinated with electricity demand. The operating range of Lake Pukaki was further extended when the Pukaki high dam was commissioned in 1976.

56 A timeline of the construction of the various stages of the Waitaki Power Scheme is summarised in Figure 11. The scheme's contribution to total NZ supply is also shown on the right hand axis. Also, the evidence of **Mr Kenneth Smales** provides a more detailed explanation of the history of the Waitaki Power Scheme.

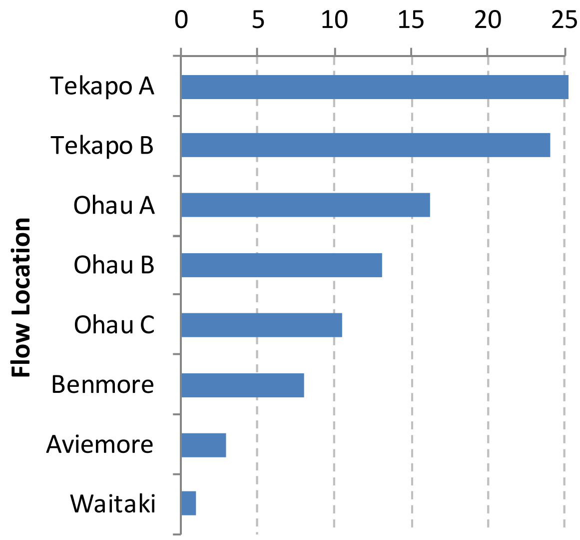
FIGURE 11: CONSTRUCTION TIMELINE OF WAITAKI POWER SCHEME AND CONTRIBUTION TO TOTAL SUPPLY



57 It is important to note that water entering upper parts of the scheme passes through more power stations and therefore generates proportionally more energy than water that enters lower in the scheme. This is illustrated in Figure 12. For example, water that enters upstream of Tekapo A has approximately 25 times more potential energy supply than water entering at Waitaki. It is also important to note that the majority of inflows enter the upper

reaches of the scheme (see **Figure 10**) via Lakes Tekapo, Pukaki and Ohau.

FIGURE 12: RELATIVE ENERGY PER VOLUME OF INFLOW



ROLE OF WAITAKI POWER SCHEME

58 I shall now outline the key features of the Waitaki Power Scheme and its roles within the electricity market to explain its contribution to national and regional electricity requirements.

Contribution to energy supply requirements

59 The Waitaki Power Scheme contributes on average around 7,600 GWh of electricity to NZ's annual requirements[30]. To put this in perspective, that represents;

59.1 around 18% of total annual supply requirements[31]; or

59.2 more than half of the entire South Island's annual electricity demand[32].

60 **Figure 13** illustrates that over the course of a year, because of the Waitaki Power Scheme, the wider Canterbury region on average generates more electricity than it uses, and is able to help meet the requirements of other regions where supply is insufficient to meet demand.

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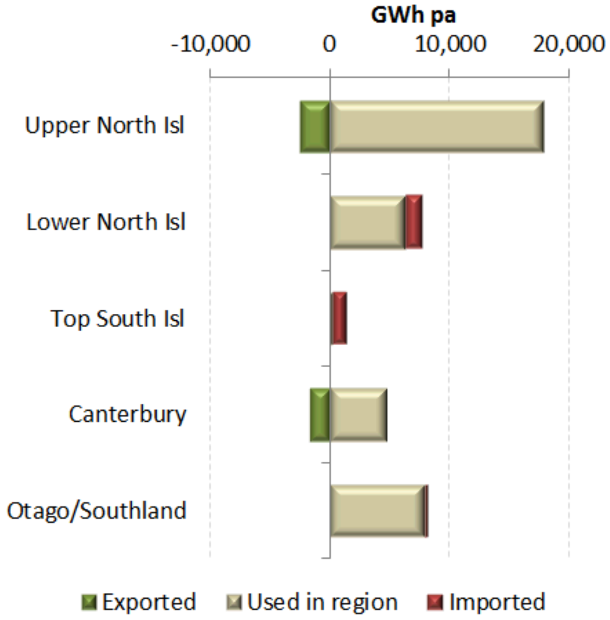
[30] Average annual generation from the Waitaki Hydro scheme from 1998 to 2011 inclusive derived from Electricity Authority Centralised Data Set.

[31] Based on generation for the year ended September 2012 derived from Electricity Authority Centralised Data Set.

[32] Based on demand for the year ended September 2012 derived from Electricity Authority Centralised Data Set.

FIGURE 13: REGIONAL SUPPLY AND DEMAND BALANCE YEAR ENDED SEP 2012[33]



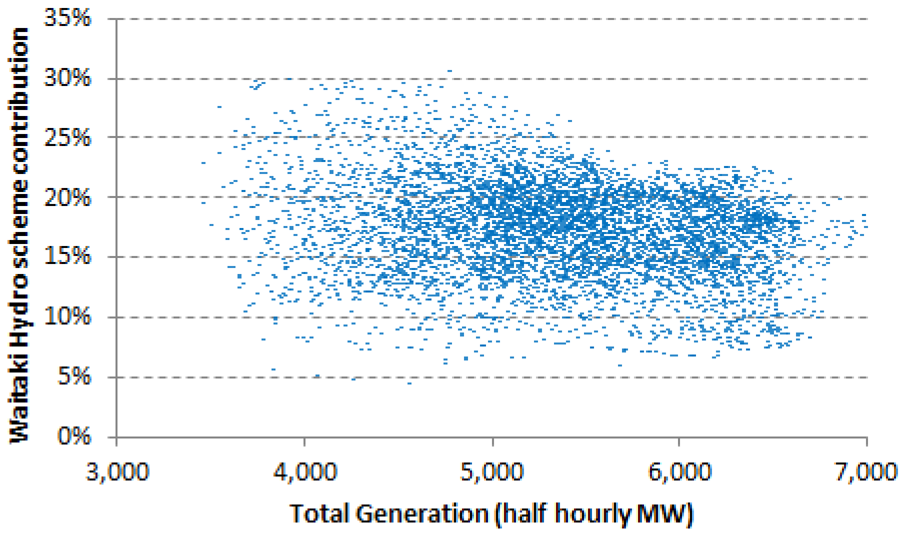
Flexibility and peaking ability

61 The Waitaki Power Scheme is a controllable and very flexible generation source. This means that it is able to respond to electricity market requirements, increasing and decreasing output to follow daily variations in demand. This important contribution is generally only able to be provided by hydro schemes with storage and thermal power stations with flexible fuel supply arrangements.

62 Because the output of the Waitaki Power Scheme can be increased to generate comparatively more at times of peak demand, it is able to make a substantial contribution to peak generation requirements as illustrated in **FIGURE 14**.

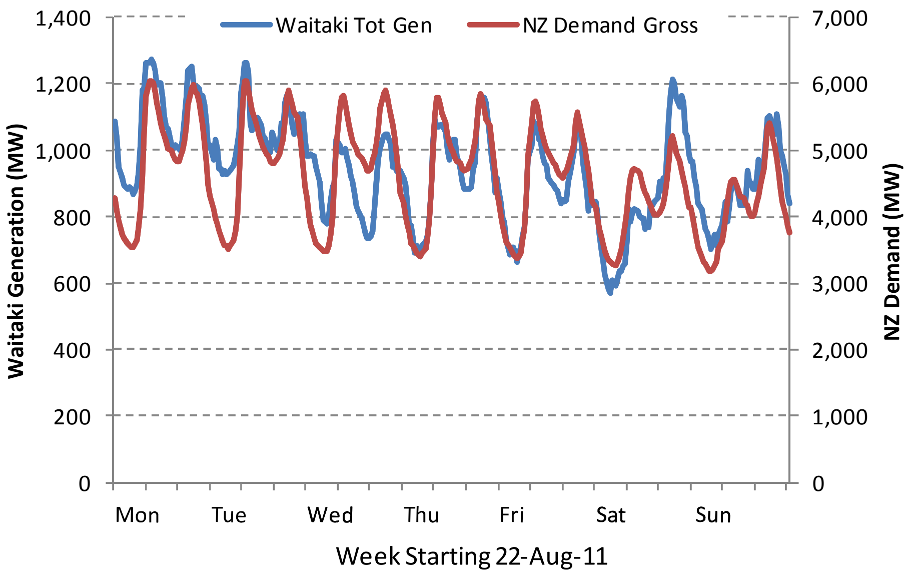
[33] Derived from Electricity Authority Centralised Data Set.

FIGURE 14: WAITAKI HYDRO DAILY PEAK CONTRIBUTIONS OCT 2010 TO SEP 2012[34]



63 **Figure 15** demonstrates how generation from the Waitaki Power Scheme follows the daily variations in demand (noting that its output will also be changing to offset fluctuations in other sources of generation).

FIGURE 15: WAITAKI GENERATION AND NZ DEMAND (WEEK STARTING 22 AUG 2011)

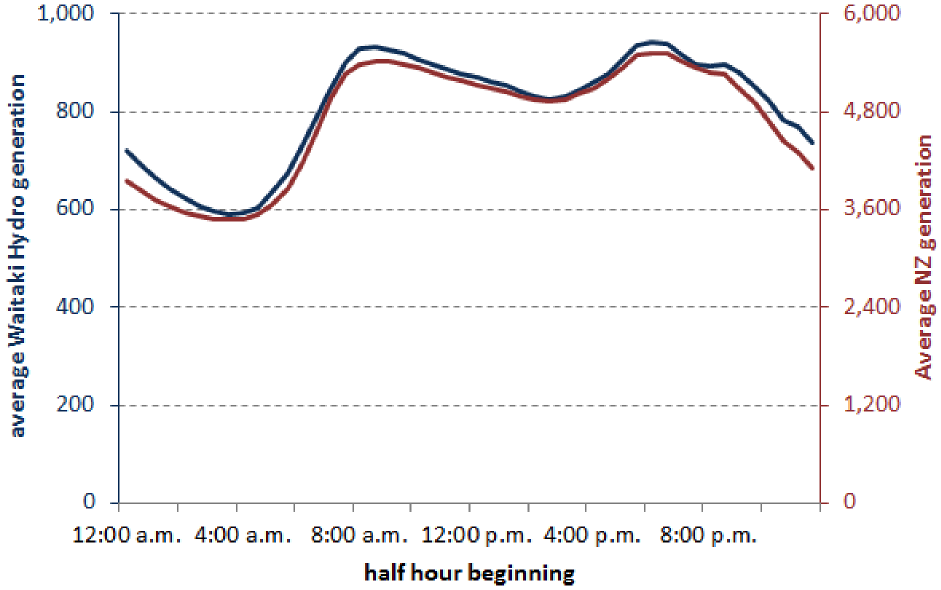


64 This flexibility is emphasised by **Figure 16** and **Figure 17**. **Figure 16** shows the average daily output across the year, against the corresponding average demand for the same period. It can be seen that over time the average output of the Waitaki Power Scheme

[34] Half hours starting 7:00 am to 8:30 am and 5:00 pm to 7:30 pm.

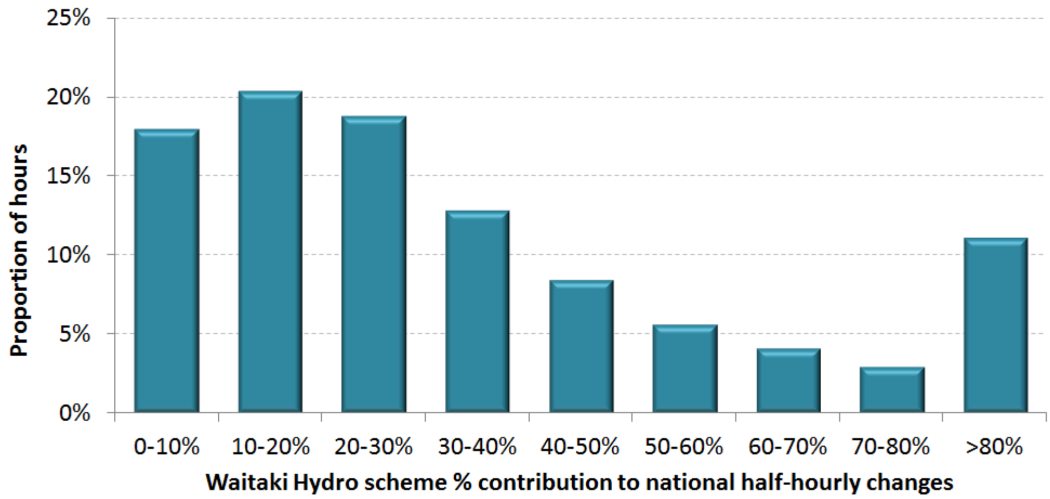
closely correlates with overall demand, illustrating how it provides reliable short term flexibility.

FIGURE 16: AVERAGE HALF HOURLY WAITAKI AND NZ GENERATION REQUIREMENTS (2 YEARS ENDING 30 SEPTEMBER 2012)[35]



65 **Figure 17** shows that on a day to day basis, the Waitaki Power Scheme makes a significant contribution to short term changes in overall generation requirements again emphasising its ability to assist short term reliability.

FIGURE 17: WAITAKI CONTRIBUTIONS TO HALF-HOURLY CHANGES IN NZ GENERATION (2 YEARS ENDING 30 SEPTEMBER 2012)[36]

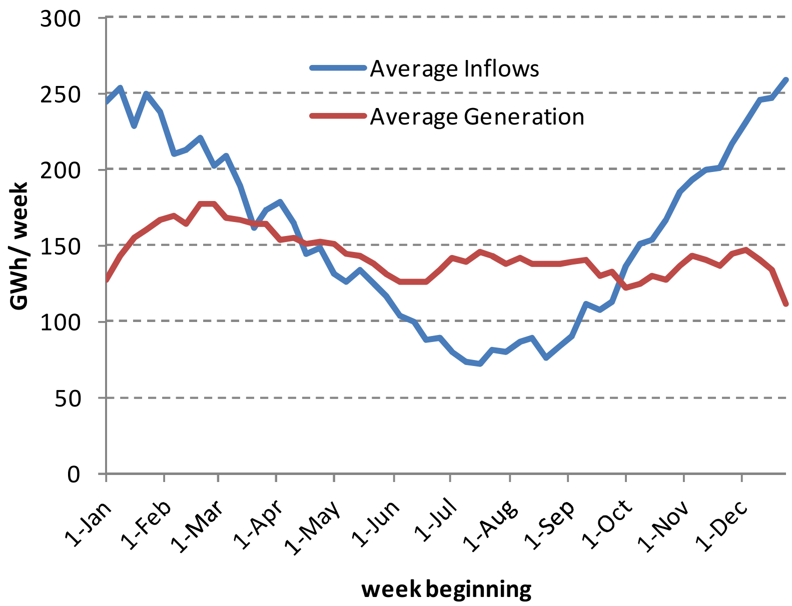


35 Derived from Electricity Authority Centralised Data Set.

36 Derived from Electricity Authority Centralised Data Set.

66 Further, with approximately 2,500 GWh of energy storage capacity in Lakes Tekapo and Pukaki, almost 60% of national storage capacity, the Waitaki Power Scheme is able to store water during periods of higher inflows – e.g. spring/summer - to periods of lower inflows – e.g. winter - when electricity demand is higher. This can be seen in **Figure 18** which compares average weekly generation for the Waitaki Power Scheme over the period 2000 to 2010 to historical weekly average inflows.

FIGURE 18: WAITAKI POWER SCHEME GENERATION (2000 – 2010) AND HISTORICAL AVERAGE INFLOWS (1932 TO 2008)[37]



67 Because overall hydro storage capacity is limited, seasonal storage within the Waitaki Power Scheme fills a particularly important role. Without this capacity, managing the risk of electricity shortages during hydro droughts would require greater levels of thermal generation or energy storage elsewhere.

68 The ability to supply additional electricity over peak demand periods – short term and seasonally – is an especially important contribution that the Waitaki Power Scheme makes to meeting New Zealand's electricity needs.

Price

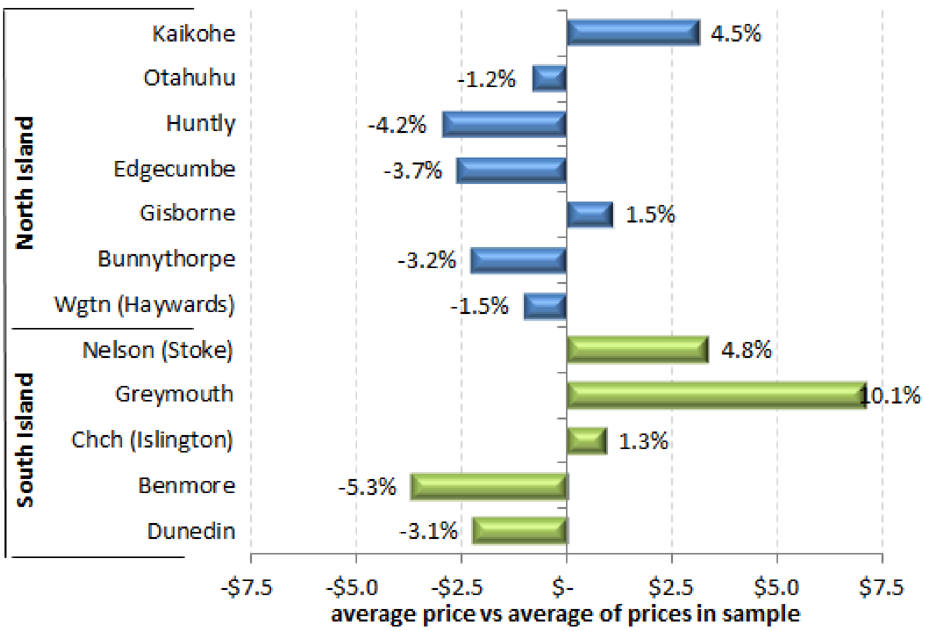
69 Electricity spot market prices rise as more expensive generation is needed to meet consumer demand. This encourages the operators of the Waitaki power stations to generate more at times of peak demand and to maximise the electricity produced from the water available. This means that electricity prices are lower than they

[37] Derived from Electricity Authority Centralised Data Set.

otherwise would be during peak demand periods and generation from the more expensive thermal generators, and associated emissions, are minimised.

70 Furthermore, the Waitaki Power Scheme has a significant effect on local electricity prices. The lower South Island's renewable electricity resources and net generation position typically result in relatively lower spot prices for electricity than in other parts of the country. This is highlighted by **Figure 19**, which compares the average wholesale electricity price for the 10 year period ending September 2012 at 12 representative locations around the country, relative to the overall average of those locations.

FIGURE 19: AVERAGE WHOLESALE PRICES FOR 10 YEARS ENDING SEP 2012[38]



71 The chart shows how the average wholesale electricity price at Benmore is well below average. The pattern is also reflected in the prices that local electricity consumers pay. For example, electricity prices offered by retailers to consumers within the Network Waitaki and Orion (Christchurch and surrounding areas) distribution networks are amongst the lowest in NZ[39].

72 Looking forward, unless significant new generation is developed in the South Island, or the capability of existing generation is restricted, this benefit will tend to erode. That is consistent with the trends in inter-island energy transfers noted previously in paragraph 33.

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[38] Derived from Electricity Authority Centralised Data Set.

[39] Based on average prices offered by retailers in each distribution network. Derived from MBIE's Quarterly Survey of Domestic Electricity Prices To November 2012).

Responsiveness

73 The Waitaki Power Scheme is able to start up and shut down individual generating units in a matter of minutes compared to some thermal power stations which can take hours to start up (or to reinstate following an unplanned shut down). This responsiveness means that the Waitaki Power Scheme is very good at meeting sudden changes in market demand or responding to the failure of power stations elsewhere. If this level of responsiveness was not available, it would be necessary to maintain more generating units in service at partial output to cover the risk of other generating units failing. Fast start thermal power stations are also able to fill this role although they are less efficient.

Contribution to government climate change objectives

74 Being a renewable energy source, the Waitaki Power Scheme contributes to energy supply requirements with very few greenhouse gas emissions. In contrast, **Table 1** shows the greenhouse gas (carbon dioxide equivalent) emission rates for thermal power stations and the annual emissions that each would produce in generating the average amount of generation from the Waitaki Power Scheme in a year.

Table 1: Thermal generation emissions

Tonnes CO_2e	Gas (CCGT[40])	Gas (OCGT[41])	Oil (OCGT[42])	Coal
Per GWh[43]	375	506	688	916
@ 7,600 GWh pa	2,843,900	3,837,400	5,217,700	6,946,800

75 By way of context, that range of emissions would be equivalent to between 40% and 94% respectively of all emissions from electricity generation in the year ending Sep 2012[44].

76 Alternately, to avoid equivalent emissions NZ would need to develop an equivalent amount of new renewable generation with the same

[40] Combined Cycle Gas Turbine. Modern high efficiency gas powered generators like Contact Energy's Otahuhu and Taranaki Combined Cycle Gas Turbine power stations and the e3p power station at Huntly owned by Genesis Energy.

[41] Open Cycle Gas Turbine. Typically used as peaking plants, such as Contact Energy's 200 MW peaking facility at Stratford.

[42] For example, the Whirinaki plant purchased by Government in 2004 for dry year reserve energy purposes (since sold to Contact Energy).

[43] Assuming 53.3, 68.8 and 89.4 tonnes of CO_2 per TJ of natural gas, diesel and sub-bituminous coal respectively ("NZ Energy Greenhouse Gas Emissions", Ministry of Economic Development, 2009); and plant net heats rate of approximately 7,050, 9,500, 10,250 and 10,000 GJ/GWh for CCGT, gas OCGT, coal-steam and diesel OCGT plants respectively.

[44] Based on MBIE Quarterly Electricity and Liquid Fuels Emission Tables, Nov 2012.

capabilities as the Waitaki Power Scheme. Developing an equivalent amount of renewable generation (7,600 GWh pa), without any consideration of the need for flexibility or likelihood of consents, would cost of the order of $5b[45]. The actual cost would be considerably higher given the need to replace lost flexibility from the scheme and to compensate for increased intermittency/ inflexibility from the wind and geothermal developments.

Ancillary services

77 In addition to generating electricity, the Waitaki Power Scheme provides essential ancillary services including:

77.1 Frequency keeping: Many generators are fitted with governor systems which respond automatically to system frequency deviations – an essential part of maintaining supply and demand in balance as discussed previously. The frequency keeping service enables these generators to return to their dispatched/efficient levels and helps to maintain supply and demand in balance between System Operator dispatch instructions.

77.2 Spinning reserves: The scheme has the flexibility to respond automatically to a rapid fall in South Island system frequency due to a sudden loss of a large generating unit or HVDC transmission capacity when importing electricity from the North Island. This service is essential to maintaining the system frequency within acceptable limits, preventing generators disconnecting automatically and risking South Island blackouts.

77.3 Over-frequency reserves: The scheme has the flexibility to respond automatically to a rapid rise in system frequency due to a sudden loss of a large electricity load (for example, at the Tiwai Aluminium smelter) or failure of HVDC transmission capacity when sending electricity to the North Island. This service is essential to maintaining the system frequency within acceptable limits, preventing generators disconnecting automatically and risking South Island blackouts.

77.4 Voltage support: Generators within the Waitaki Power Scheme are fitted with control systems which enable them absorb or produce reactive power, as instructed by the System Operator, to enable the System Operator to maintain grid voltage levels within acceptable levels and maintain the quality/ security of supply. This service has an impact on voltage quality over large areas of the grid.

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[45] Derived from the potential wind and geothermal projects listed, in order of estimated long run marginal cost, in the MBIE Energy Outlook 2011.

WAITAKI SCHEME AND FUTURE OUTLOOK

Increasing intermittency/need for flexibility

78 It appears likely that in the near term a significant portion of new generation developments will be geothermal and wind generation projects as in recent years. While contributing to energy supply requirements, as discussed, and to renewable energy targets, these forms of generation are largely uncontrolled, their operation being largely independent of electricity market demands or prices.

79 This will place an even greater emphasis on plant that can provide flexible generation and increase its output during high-demand periods. In this context, the Waitaki Power Scheme's flexibility will become more valuable to the electricity system over time in maintaining security of supply, both regionally and nationally.

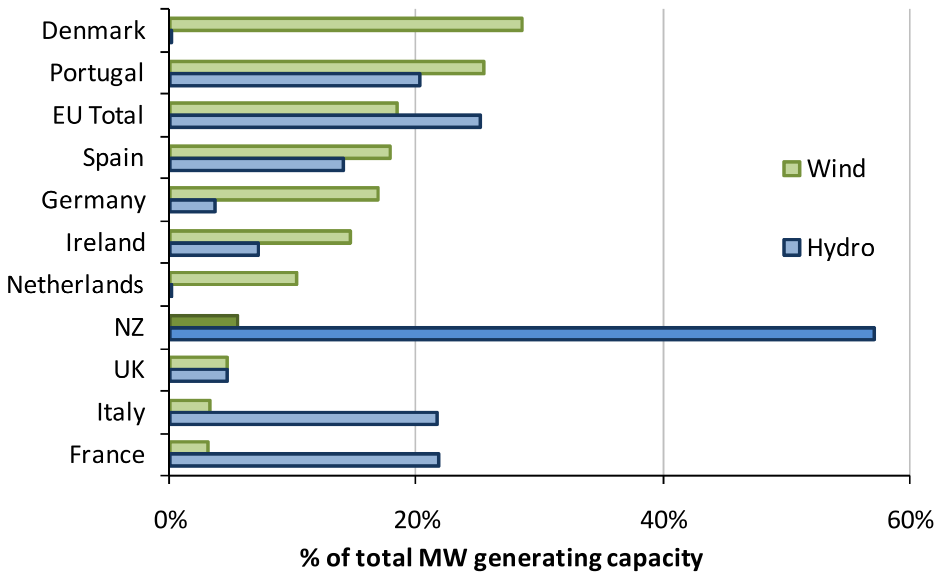
Facilitating increased intermittent generation

80 As discussed, the government has set a target for 90% of electricity generation to be met by renewable sources by 2025, subject to security of supply requirements. With the exception of geothermal and hydro generation backed by storage, renewable generation is typically intermittent in nature as it is dependent on the weather (wind/sun/waves etc).

81 This necessitates flexible, fast-response generation that can offset short term variations in these intermittent renewable sources. NZ benefits from a large portion of flexible generation – particularly hydro such as the Waitaki Power Scheme – that can respond quickly and acts as an effective complement to wind generation.

82 Most countries that have developed large amounts of wind generation have considerably lower proportions of hydro generation, and are much more reliant on thermal and, in some instances, nuclear generation. They therefore tend to rely more on fast start gas turbines to respond to peak demand requirements and to compensate for intermittent wind generation. In this regard, the NZ electricity system is well placed to facilitate renewable generation development compared to many other countries as demonstrated in **Figure 20**.

Figure 20: Proportions of wind and hydro generation[46]



83 Without this foundation of flexible hydro generation, of which the Waitaki Power Scheme is a majority contributor, achieving the 90% renewable target would be an unrealistic undertaking for NZ, at least without significant levels of investment in fast start thermal back up plants.

84 The Waitaki Power Scheme will hence help to facilitate the future development of additional renewable generation and the achievement of the 90% renewable supply target, noting that this target is also subject to the important requirement that security of supply be maintained.

Seasonal flexibility

85 Energy storage within the electricity system is particularly important given high dependence on, and inherent variability of, hydro inflows.

86 The flexible energy storage provided by the Waitaki Power Scheme helps to mitigate security of supply risks in low inflow periods, and hydro spill risks during higher inflow periods.

87 Apart from hydro schemes with seasonal storage, only thermal power stations with flexible fuel supply arrangements are able to compensate for renewable seasonal energy supply, especially hydro and energy demand variations.

[46] European data sourced from http://www2.eurelectric.org/DocShareNoFrame/Docs/1/EOEMOJIBOLMNJHAGAGAIFENFPDBW91GY9DBDW3PDBW91/Eurelectric/docs/DLS/2008-542-0001-2008-542-0001-02-E.pdf and, for the UK, http://www.bwea.com/ukwed/.

Expansion opportunities

88 Options are available to extend the Waitaki Power Scheme and extract further energy from the same quantity of water.

89 Meridian has been granted resource consents for a hydro station between Lake Pukaki and the existing Pukaki-Ohau canal. This would provide an additional 35 MW of capacity. The project is in pre-construction design phase.

90 Meridian also has Stage 1 consents to take, use and discharge water for the purposes of operating a power station downstream of Lake Waitaki - the North Bank Tunnel project. The project would add an additional 280 MW of capacity, capable of generating around 1,400 GWh on average.

91 In energy supply terms, the Pukaki and North Bank Tunnel projects would increase energy storage capacity in the Waitaki Power Scheme - because water released from Lake Tekapo and Lake Pukaki storage would flow through additional stations - and the overall MW capacity of the scheme.

CONCLUSIONS

92 Under any realistic scenario, a substantial amount of new electricity supply will need to be developed over the next 15 -20 years to meet expected demand growth and to achieve the government's target of 90% of electricity being supplied from renewable resources by 2025 and beyond.

93 This will be a significant challenge. Loss of existing generation capability, through retirement of existing generation capacity or through adverse consenting outcomes will further increase these requirements.

94 Different generation technologies have different technical performance characteristics. Generally speaking, only hydro generation with storage and thermal plant with flexible fuel arrangements are capable of providing the flexibility and controllability necessary to meet the daily and seasonal fluctuations in electricity demand, and offset the inflexibility and/ or intermittency of generation that cannot be controlled.

95 Given its size, storage capacity and inherent flexibility, the Waitaki Power Scheme therefore makes substantial contributions to electricity supply and system security requirements both regionally and nationally.

96 As the scheme is able to meet regional electricity supply requirements and export to other regions most of the time, it also provides regional electricity market pricing benefits.

97 In the foreseeable future it is expected that geothermal and wind generation will continue to be developed, with inherent daily and seasonal inflexibility. The flexibility and controllability of the Waitaki Power Scheme will therefore become increasingly more valuable over time.

98 Furthermore, the Waitaki Power Scheme will contribute to government's climate change objectives, not only by supplying a large amount of electricity from renewable resources itself, but also by facilitating increases in other forms of renewable generation which are intermittent and/or uncontrolled. In the longer term this could also include solar, wave and tidal generation developments.

Dated: 4 February 2013

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James Thomas Truesdale

APPENDIX 1 - FURTHER DETAILS OF RELEVANT EXPERIENCE

1 From 1991 to 1998 I was responsible for co-ordinating ECNZ's[47] generation resources, initially as Generation Control Manager and, from 1995, as Wholesale Market Development Manager. In the latter role, I was also responsible for the establishment and operation of ECNZ's electricity trading and risk management functions;

2 At ECNZ, in 1994/5, I established internal market arrangements which, from February 1996, underpinned the interim electricity market established when Contact Energy was separated from ECNZ. I also had a major role in the design of the final wholesale electricity market arrangements established in October 1996;

3 In 1998 I was a member of the Electricity Reform Transition Unit (ERTU) that designed and oversaw the split of ECNZ and establishment of Meridian Energy, Mighty River Power and Genesis Energy. My responsibilities included electricity market analysis in respect of company viability and issues relating to coordination of generation resources, including security of supply and technical efficiency;

4 In 1999, as establishment General Manager Operations and Trading, I was responsible for establishing and overseeing Genesis Energy's trading risk management arrangements and its participation in the wholesale electricity market;

5 In 1999, I co-founded Concept Consulting Group, a Wellington based firm which provides advice to energy sector clients. I was a director of that firm until October 2012 and now have my own consultancy practice. In my consulting roles, I have advised a range of New Zealand and overseas policy makers, regulatory bodies and market participants on issues including:

5.1 analysis of electricity markets (including longer term electricity supply and demand projections), security of supply assessments, power station development options and climate change policy implications;

5.2 providing expert evidence at resource consent hearings;

5.3 advice on wholesale electricity market operation and design issues (including common quality/ system operation/ ancillary services and security of supply policy issues); and

5.4 electricity market design projects in Singapore (1999/2000), Ireland (2004) and Australia (2009-2012).

47 Electricity Corporation of New Zealand.