IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the Proposed Canterbury Land and Water Regional Plan

BEFORE Hearing Commissioners for **Environment Canterbury**

EVIDENCE OF LEE ATHOL WILSON

4 February 2013

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1. INTRODUCTION

Qualifications and Experience

1.1. My name is Lee Athol Wilson. I am a director of Concept Consulting Group Limited, which provides consultancy services to the energy sector primarily in New Zealand and Australia.

1.2. I have the following qualifications:

a) Bachelor of Engineering – Electrical (with honours) from the University of Canterbury awarded in 1976;

b) Master of Engineering – Electrical (with distinction) from the University of Canterbury awarded in 1977.

1.3. I have worked in the energy sector for 35 years in a range of senior executive and business consulting roles. As a consultant for the last 14 years I have specialised in energy policy, energy market design, energy market analysis, and competition issues.

1.4. In 1999 I oversaw the split of the Electricity Corporation of New Zealand (ECNZ) into three competing State Owned Enterprises (Meridian Energy, Mighty River Power and Genesis Energy), and in the role of Interim Chief Executive I assisted with establishing Genesis Energy. Before that I worked for over twenty years in engineering, planning, strategy, and senior executive roles - for the Ministry of Energy, ECNZ and Contact Energy.

1.5. Experience that is relevant to my evidence includes:

a) Undertaking analysis of generation and transmission projects as Corporate Investment Analyst at ECNZ (1987-89);

b) Coordinating generation and transmission planning, and overall strategy, as Corporate Development Manager at ECNZ (1990-95);

c) Advising on electricity market design and development as part of the Wholesale Electricity Market Development Group (1993-94);

d) Analysing wholesale and retail energy markets as Marketing Director at Contact Energy (1996-98);

e) Overseeing the split of ECNZ and establishment of three new SOEs, assessing company viability, examining the coordination of generation resources, and analysing security of supply risks (1998-1999);

f) Assisting the Electricity Technical Advisory Group in providing advice to the Minister of Energy and Resources on a range of measures to increase competition in the electricity sector (2009);

g) Advising the Ministry of Economic Development on issues surrounding the transfer of the Tekapo A and Tekapo B power stations from Meridian Energy to Genesis Energy (2010);

h) Assessing electricity security of supply risks, preparing longer term electricity supply and demand projections, and assessing the implications of climate change policies on electricity supply – for a number of clients in the electricity sector (2000-2013); and

i) Reviewing the economics of electricity generation projects (2004-2010).

1.6. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express. Where I rely on the opinions or conclusions of others, I have specifically identified this.

Scope of Evidence

1.7. In my evidence I will:

a) Outline the current and likely future demand for electricity;

b) Describe the New Zealand electricity supply system;

c) Provide an overview of the New Zealand electricity Market;

d) Describe how the New Zealand electricity system is operated and coordinated, including the role of hydro-electricity; and

e) Describe how the Waitaki Hydro Scheme operates within the electricity system.

2. THE DEMAND FOR ELECTRICITY

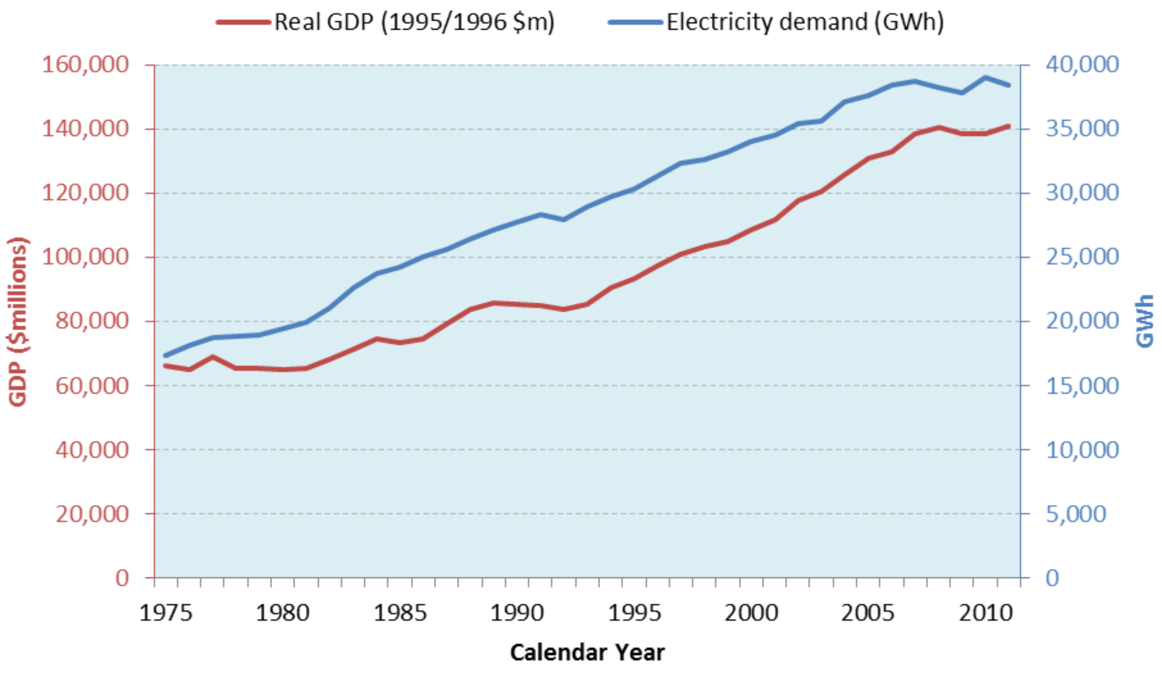
Electricity in the economy

2.1 Electricity is vital to virtually every aspect of modern life, from consumption in the residential setting to a productive input for goods and services. Many of the social and economic benefits enjoyed by New Zealanders stem directly from technologies relying on electricity. In many situations there are no viable alternatives to electricity supply.

2.2 Electricity accounts for over a quarter of annual energy consumption, second only to oil which dominates the transport sector, among sources of energy. Many industrial, commercial and domestic activities are dependent on electricity and, as the economy grows, the demand for electricity grows.

2.3 Figure 1 illustrates that electricity demand (which has been growing at an average rate of 2.2% per annum since 1975) is closely associated with economic growth.

Figure 1: New Zealand economic growth and electricity demand

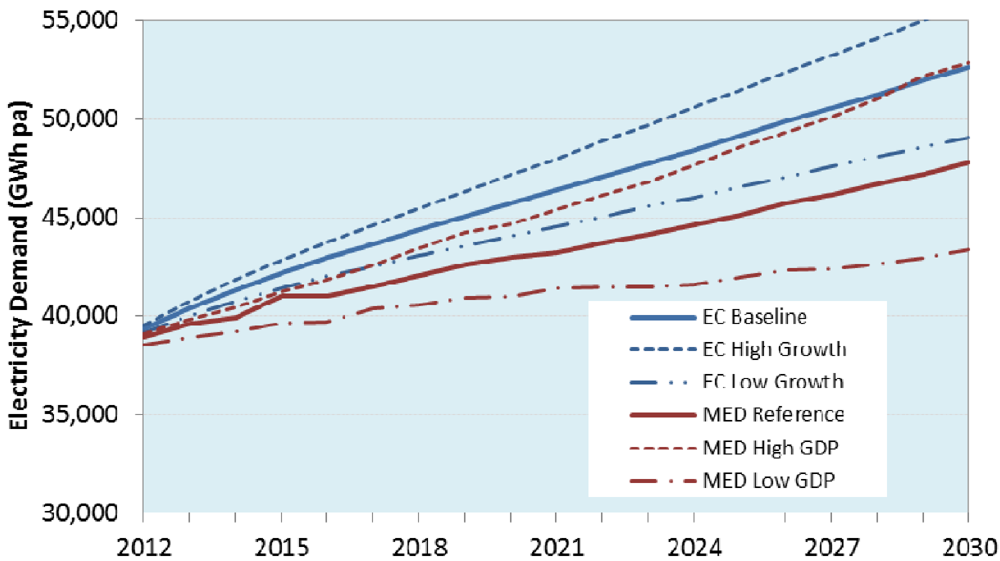


2.4 Of particular note has been the recent slowing of electricity demand growth over the period since 2007. This is a result of a number of factors that have combined over this period including a call for electricity savings during a period of extreme low inflows in 2008, a temporary equipment failure at the Tiwai Point aluminium smelter, the general economic climate arising from the global financial crisis, and the Canterbury earthquakes.

Electricity demand forecasts

2.5 Although the rate of demand growth has slowed gradually (with the average falling to 1.4% per annum over the last 15 years) overall electricity demand is still forecast to grow. Forecasts published by the Electricity Commission (replaced by the Electricity Authority in November 2010) and the Ministry of Economic Development (MED) indicate average annual growth rates of between 1.0% and 2.0% under various scenarios. The impact of these forecasts is illustrated in Figure 2.

Figure 2: Forecasts of New Zealand electricity demand



2.6 Figure 2 highlights the uncertainty about future levels of demand with a large difference in annual demand evident by 2030 between the lowest and highest demand growth scenarios. These demand forecasts show electricity consumption could grow between 3,000 GWh per annum and 12,000 GWh per annum by 2025. Although these forecasts are the latest available, they are now over two years old and may not take into account the full effect of the global financial crisis. I would expect any new forecasts to reflect a slightly lower rate of growth over the next few years.

2.7 There has also been recent publicity about the possibility of the Tiwai Point aluminium smelter being closed. If that were to happen, there would be a significant reduction in national annual electricity demand (approximately 13%) creating an oversupply situation that would last for several years. Although the likelihood of this is low[1] the possibility needs to be acknowledged. In addition, Norske Skog Tasman has halved production at its Kawerau timber paper mill resulting in a reduction in demand of approximately 450GWh per annum (approximately 2.5% of national annual electricity demand).

2.8 Although the electricity demand outlook is uncertain, and there are downside possibilities, any sustained pickup in economic activity would likely lead to a corresponding pickup in electricity demand where new electricity generation projects would be required.

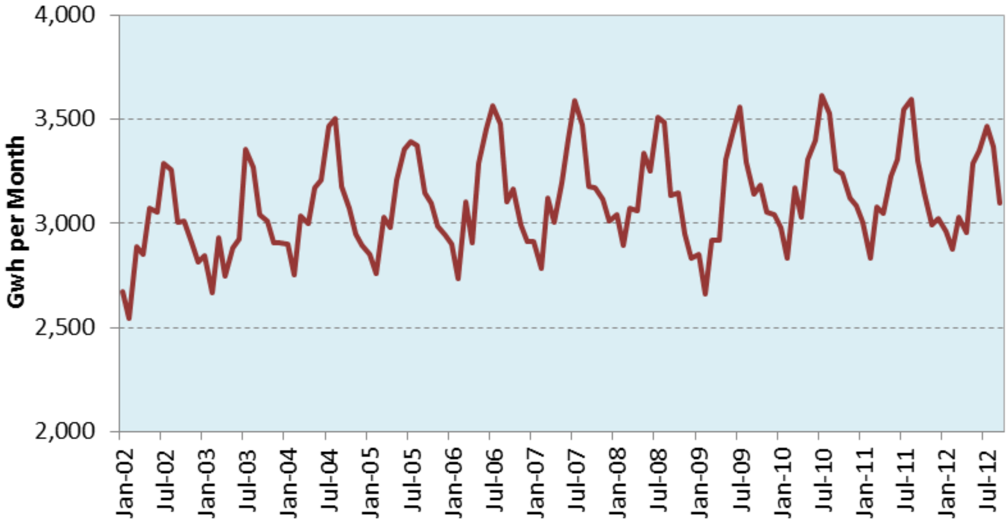
2.9 Any substantive reduction in present electricity supply from closure of power stations or restrictions on electricity generation would accelerate that need.

Variation in Electricity Demand

2.10 Electricity demand varies significantly across the year, as illustrated in Figure 3, in response to several factors, including ambient temperatures and seasonal commercial and industrial activity.

1 The General Manager of the smelter recently stated that “We’re here for the long term but things are tough at this moment”; htt://tvnz.co.nz/business-news/job-cuts-raise-fears-smelter-s-future-5064387.

Figure 3: Monthly New Zealand Demand (2002-2012)



2.11 Figure 3 highlights that:

a) Electricity demand varies significantly across seasons, peaking during the winter months, and reaching a low during summer;

b) Peak monthly demand has approached 3600GWh several times since 2006, but has not exceeded this level;

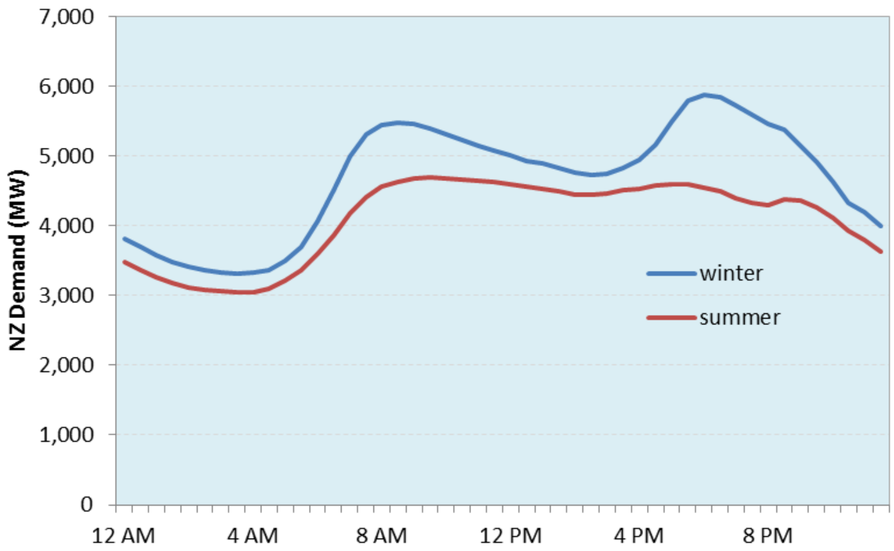
c) The lowest monthly demand during the year is typically 22-24% lower than the peak month.

2.12 Electricity demand also varies significantly over the course of a day. For example, Figure 4 illustrates average within-day summer and winter NZ demand patterns.

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

2.14 The electricity supply system must be capable of responding continuously to these changes in demand throughout the day and from season to season. I address this issue further in my evidence in section 3.

Figure 4: Average national within-day variation in electricity demand



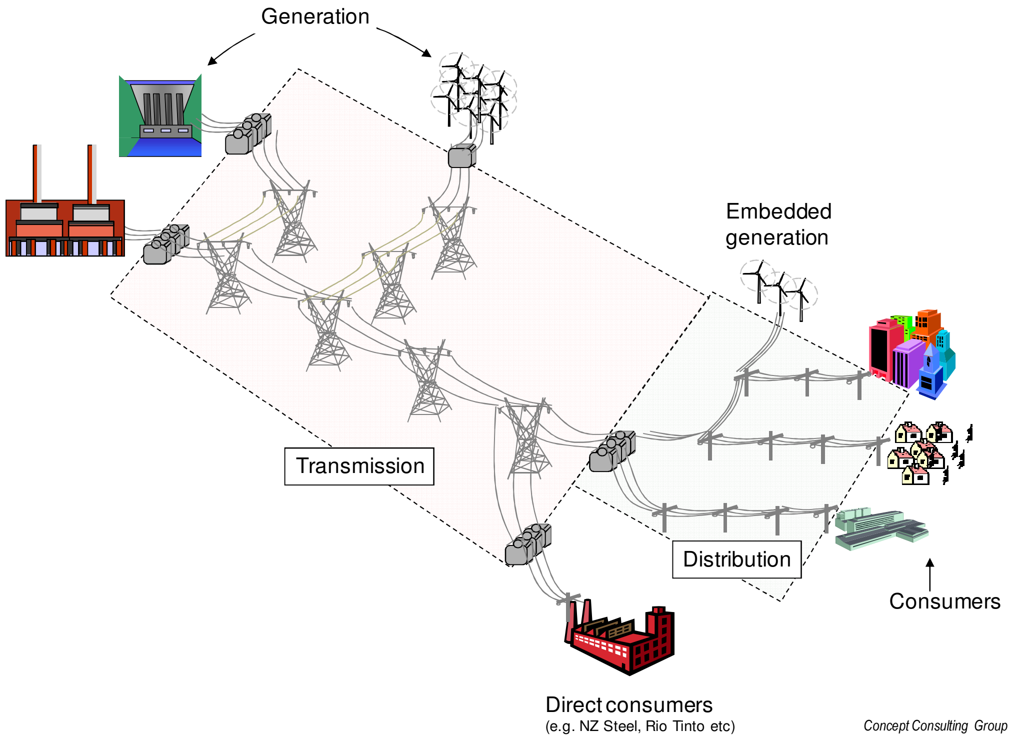
2.15 The Waitaki Hydro system fills an important role in responding to these demand variations because of its inherent flexibility. I address this matter further in my evidence in section 6.

3. THE NEW ZEALAND ELECTRICITY SUPPLY SYSTEM

Physical supply system

3.1 Figure 5 provides an overview of the physical infrastructure through which electricity is generated and delivered to consumers.

Figure 5: Electricity Industry structure



3.2 The national transmission grid, owned and operated by Transpower, is the backbone of the electricity supply system, enabling supply to be matched instantaneously around the country to consumer demand. The majority of electricity generation (approximately 92%) is transported through the grid; the remainder is embedded within distribution company networks or consumer premises.

3.3 Local network companies distribute 66% of the electricity generated, to residential, commercial and industrial users, while 20% is consumed by large industrial users directly from the transmission network.

3.4 Approximately 7% of the electricity generated is lost as heat in the transmission and distribution process.

3.5 The physical characteristics of electricity mean that demand and supply must be matched on a continuous basis because any mismatch of generation and load causes the power system frequency to slow or speed up. A mismatch, if not corrected quickly, can cause the progressive loss of power stations and power black outs.

3.6 In order to keep load and generation in balance, the output from some power stations is automatically raised or lowered to adjust for changes in demand and for fluctuations in generation from sources that vary as a result of unpredictable factors (for example run-of-river hydro or wind farms).

3.7 This coordination of supply and demand is undertaken by Transpower in its role as the System Operator, as it monitors demand and other power system conditions, and makes decisions about the level of generation plant to call into service. This coordination process is part of what is known as the dispatch process.

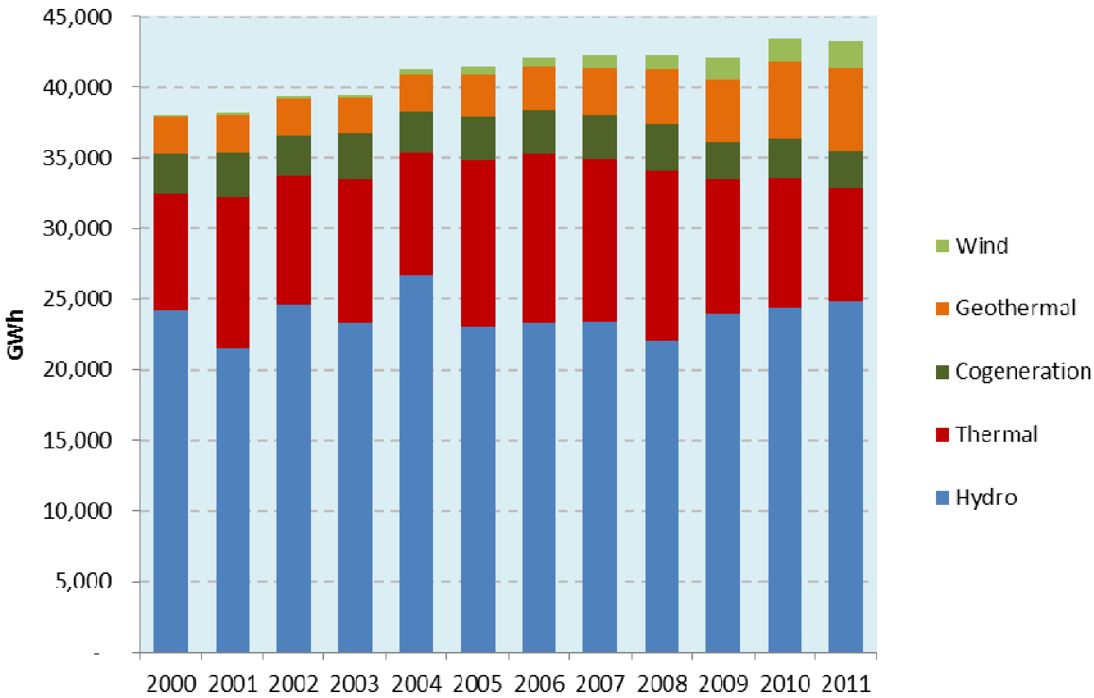
3.8 The requirement to continuously match supply and demand means that generators must make their power stations available to be coordinated by the System Operator in real-time. This poses particular challenges for operating a competitive market in electricity which are discussed later in this evidence.

Current generation mix

3.9 New Zealand's electricity is supplied from a mix of hydro-electric, geothermal, wind, thermal (fossil-fuel fired), and cogeneration power stations.

3.10 Figure 6 shows that hydro generation dominates supply, accounting for over half of New Zealand's electricity needs (a range of 52-65% in the years shown).

Figure 6: Current electricity generation mix



3.11 The renewable component of supply has fluctuated with movements in hydrology, but has averaged 75% over the period from 2000 to 2010.

3.12 A feature of the New Zealand electricity system, and how it is operated, is the complementary role between hydro and thermal generation. Hydro generation can vary greatly from year to year because the supply is vulnerable to periods of low rainfall and low inflows into the hydro lakes. During low inflow periods, output from thermal generation increases to offset the reduced output from hydro generators.

3.13 Hydro generation also provides important short-term flexibility in the New Zealand system because some hydro power stations are designed to quickly vary output in response to fluctuations in the demand for electricity and fluctuations in supply from intermittent generators such as wind farms.

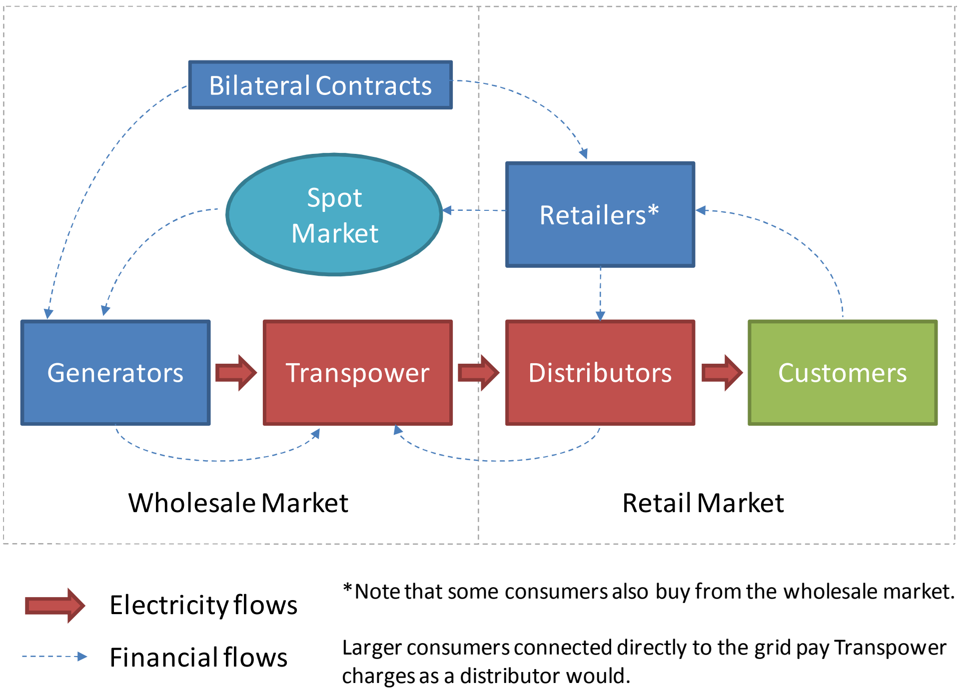
4. ELECTRICITY MARKET ARRANGEMENTS

Commercial arrangements

4.1 The Waitaki Hydro scheme operates within a competitive electricity market and with a particular set of commercial arrangements that recognise the need for electricity supply and demand to be in balance at all times.

4.2 The commercial arrangements are underpinned by a spot electricity market. Figure 7 provides a schematic representation of the physical supply and commercial arrangements within the electricity market.

Figure 7: Commercial arrangements



4.3 The wholesale market operates on the national transmission grid with generators supplying electricity into the transmission system at grid injection points and retailers purchasing electricity at grid exit points. A spot electricity market is used to coordinate supply and determine the wholesale spot price for electricity.

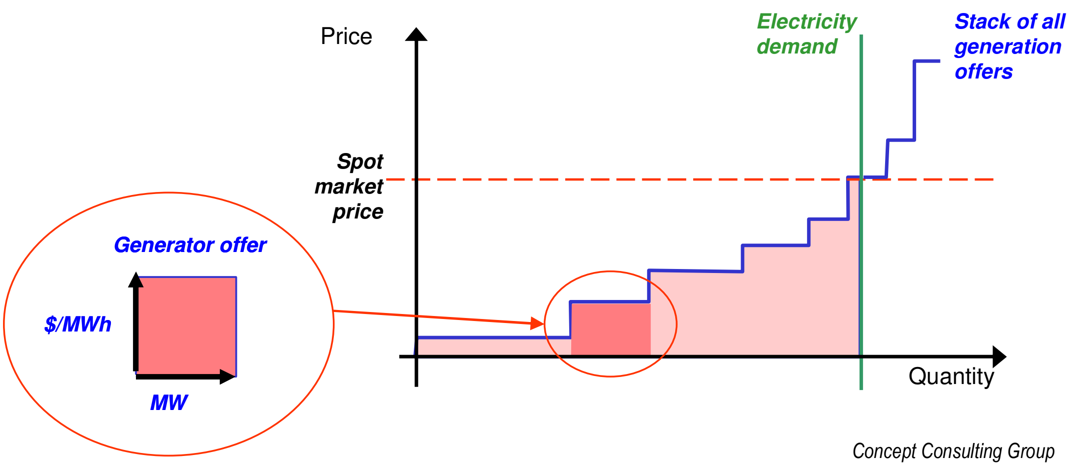
4.4 The retail market operates on the distribution networks with retailers purchasing distribution services, and selling delivered electricity direct to consumers. In order to reduce the risk of purchasing electricity in the spot market and selling to retail customers at fixed prices, retailers typically enter into contracts with generators that insulate both parties from variations in spot prices.

Electricity spot market

4.5 The wholesale electricity market is centred on a spot market, where generators compete by submitting offers to generate electricity on a half-hourly basis. Generators that have their offers to generate accepted are dispatched by the System Operator and receive the spot price for their output in a given half hour (often called a trading period).

4.6 Figure 8 provides a stylised illustration of the spot market, demonstrating how generator offers are stacked in price order to determine which generators will run during the trading period, and how the generation offer that intersects with demand sets the price for the trading period. Using this methodology, a least cost schedule of generators required to run is developed for each trading period, and a spot price is determined. The System Operator coordinates the dispatch of all generators in accordance with the resulting schedule.

Figure 8: Spot market pricing model



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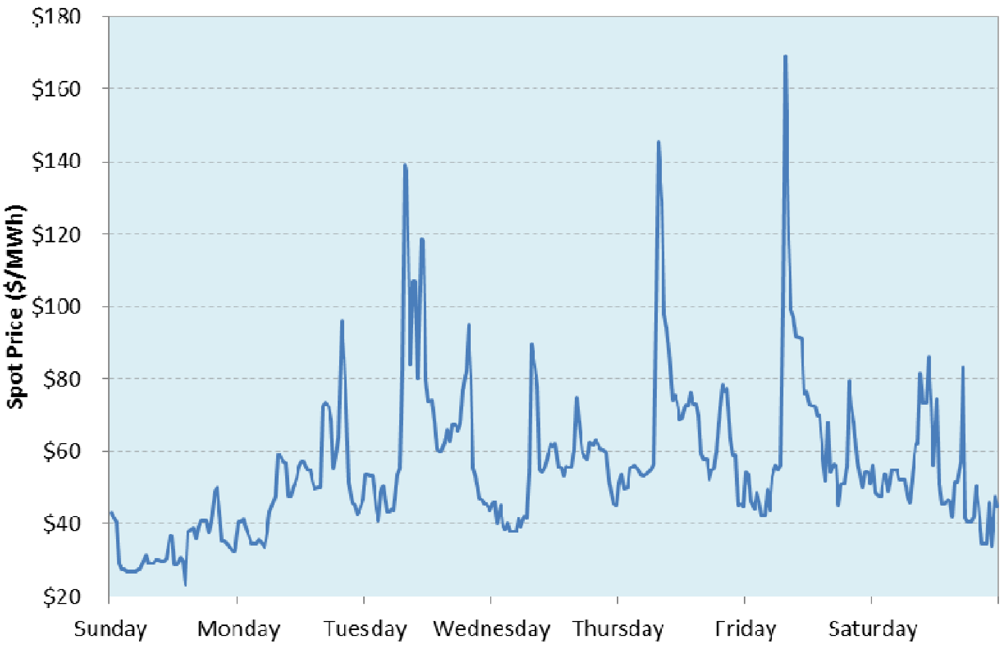
4.7 The spot market arrangements are designed to ensure that generators with low operating costs are able to operate ahead of other generators with higher operating costs.

4.8 Retailers (and some large consumers) purchase electricity through the spot market and pay the spot price for the electricity that their customers consume in each half-hour. Generators are paid the spot price for the electricity that they generate and supply to the spot market in each half-hour.

Spot market prices

4.9 The half-hourly spot prices fluctuate according to demand, generation and grid conditions at the time, resulting in prices which are typically higher at peak demand times and when supply is short, such as during extended periods of low inflows to hydro catchments. A typical variation in spot prices over a week is illustrated in Figure 9.

Figure 9: Spot market prices for a Wellington location – week in March 2009

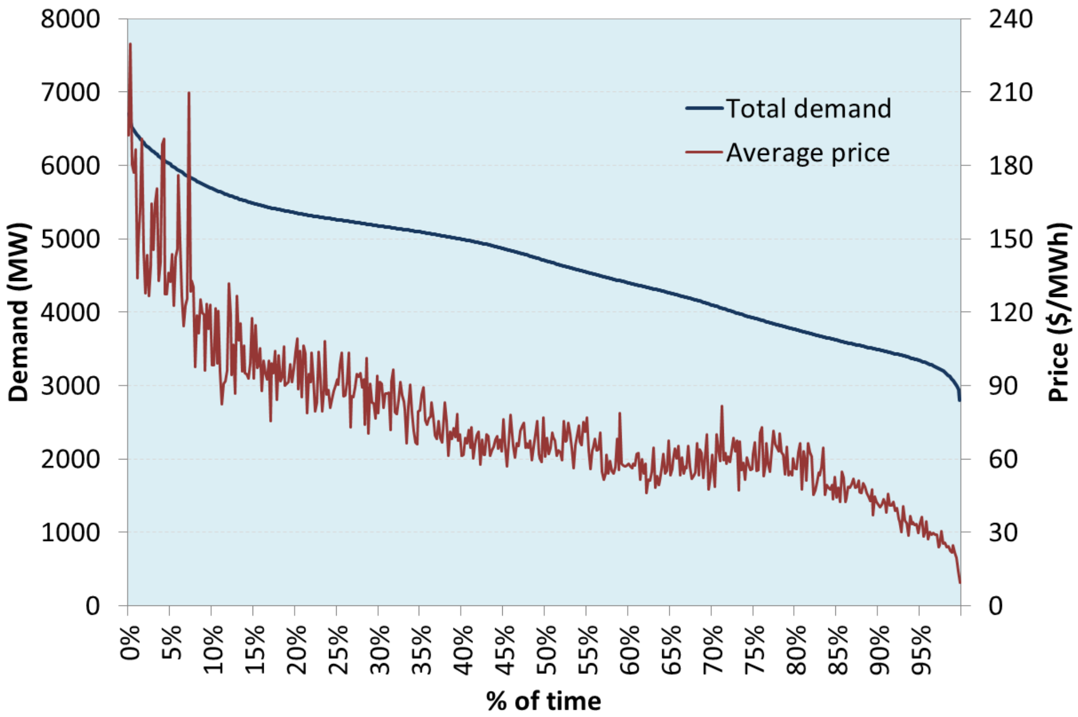


4.10 Generators and retailers/larger consumers also enter into bilateral wholesale contracts to mitigate their exposure to future spot price uncertainty. Contract prices reflect expectations of market conditions/spot market prices, and buyer and seller commercial risks, over time.

4.11 Although spot market prices vary half-hourly, most retail customers are shielded from this volatility, with retail prices typically comprising a fixed fee and a fixed price for each unit of electricity used. Over time, retail prices are influenced by longer term trends in spot market prices.

4.12 The variation in spot prices is strongly correlated with electricity demand. Figure 10 illustrates the national demand for the period 2007 to 2009 (arranged in descending order of magnitude) together with the average spot prices that prevailed at those times, and highlights that spot prices during the highest demand periods are typically orders of magnitude greater than during lowest demand periods.

Figure 10: Relationship between electricity demand and price (2007 to 2009)

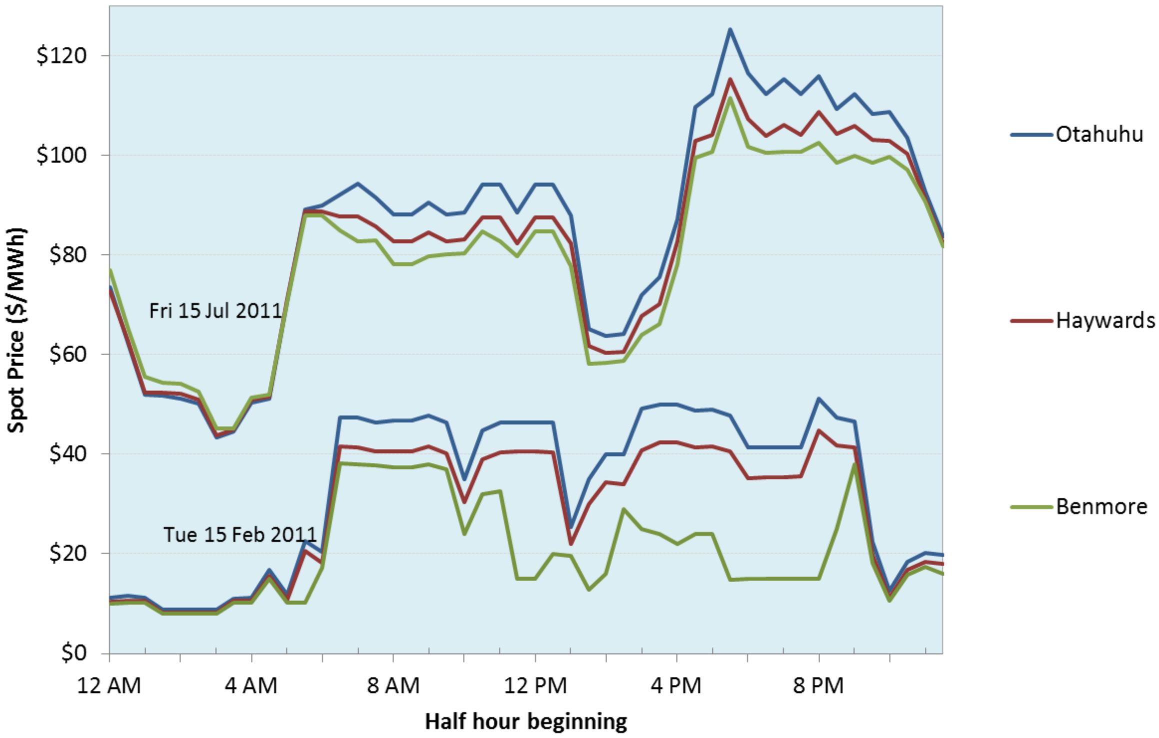


Location specific prices

4.13 Spot market prices are formed for each half-hour trading period, at over 200 locations across the national grid (often described as "nodes" with "nodal prices"). The spot price (or nodal price) varies from location to location (or from node to node) depending upon the pattern of transmission losses and transmission constraints across the national grid. These nodal prices reflect the marginal variable cost of generating and transporting electricity around the country and tend to be high where local demand exceeds local generation and low where local generation exceeds local demand.

4.14 The effect of these arrangements is that electricity spot prices vary significantly across time and by location as illustrated in Figure 11. This highlights that spot prices vary across the day with typical morning and evening peaks, spot prices are typically higher in winter than summer, and spot prices in the north tend to be higher than in the south.

Figure 11: Spot prices on typical days during 2011



4.15 The pattern of prices rising up through the North Island is typical, and reflects the normal balance of generation and demand across the country, with surplus generation from the South Island flowing north to supply higher demand and flowing up through the North Island from Wellington towards Northland.

Ancillary services

4.16 The orderly dispatch of generation to meet demand is supported by a number of important ancillary services that enable the quality and security of electricity supply to be maintained. These services are procured through:

a) **Technical performance obligations on participants** - the market rules require generators to respond automatically to support system frequency (typically achieved through the output of generating units responding automatically through “free governor action” to changes in system frequency);

b) **Ancillary service contracts** - the System Operator contracts with certain generators to support the dispatch process by responding to changes in frequency (due to supply-demand imbalances);

c) **The instantaneous reserves market** - generators and demand-side resources compete to provide reserve capacity to cover the unexpected loss of a large single source of generation or piece of transmission equipment;

d) **Voltage support** – generators provide an important role in helping maintain system voltage at efficient levels around the grid, but where demand is located distant from generation, it is sometimes necessary for additional voltage support equipment to be provided.

5. ELECTRICITY SYSTEM OPERATION

5.1 This section discusses how the mix of hydro, thermal and other power stations, and the electricity transmission network, are collectively operated so as to deliver a secure supply of electricity to consumers. Many of these issues are relevant to the Waitaki Hydro scheme and how it is operated within resource consents and the framework of the proposed Land and Water Regional Plan. These specific issues are addressed in section 6.

Coordinating supply and demand

5.2 The electricity supply system must be capable of meeting electricity demand at any instant in time (normally measured in MW) and the demand for electric energy over time (normally measured in GWh). The former requires flexible and controllable generation technologies that are able to respond to the continuously varying electricity demand as illustrated in Figure 4. The latter requires power stations capable of generating electricity over sustained periods, together with supply and storage of fuel.

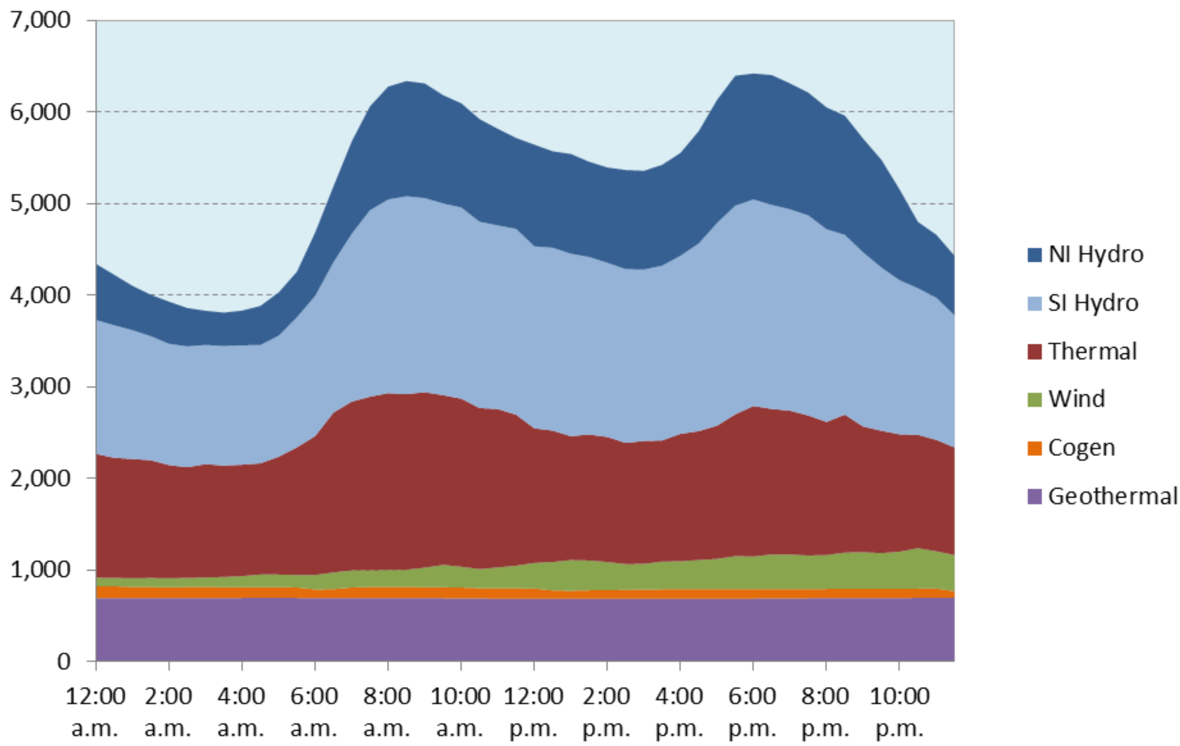
5.3 On a moment to moment basis, electricity generation must be continuously matched to demand, nationally and regionally, to ensure that the security of electricity supply to consumers can be maintained. A mismatch between demand and supply will cause the power system frequency to rise or fall and unless immediately corrected can quickly lead to power system failure and supply black-outs. Some power stations are designed to provide a level of automatic short term response to system frequency variations, while other power stations must be adjusted (dispatched) in a coordinated manner to match electricity demand throughout the day.

5.4 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 they have previously submitted to the wholesale spot market (indicating the quantities of electricity they are prepared to sell at specified prices) and which have been accepted as part of the scheduling process. Dispatch instructions are issued as often as every 5 minutes.

5.5 In practice, the market arrangements also take into account where generation is located – dispatching the lowest cost combination of generator offers to meet electricity demand, while taking into account transmission system losses and constraints, and the need for voltage support at some locations.

5.6 Each type of power station has its own performance characteristics which tend to dictate how it fits into supplying electricity to meet varying demand. For example, Figure 12 illustrates how generation was scheduled to meet demand on 12 July 2012.

Figure 12: Typical Winter Day Generation Profile (July 2012)



5.7 Figure 12 illustrates how on 12 July 2012:

a) Geothermal and cogeneration power stations ran pretty much continuously over the 24 hours;

b) Wind generation followed wind flows across the country, gradually ramping up output across the 24 hours;

c) Thermal power stations provided a large base-load supply, but responded to peak demand periods in the morning and evening;

d) South Island and North Island hydro power stations provided a substantial contribution towards meeting overall demand and provided a large part of the flexibility necessary to respond to varying demand.

5.8 In order to keep demand and generation in balance continuously, the output of generators that can be controlled is adjusted to follow the pattern of demand and to compensate for fluctuations in generation from power stations that are less able to readily control output (such as wind farms, geothermal stations, some thermal stations, and hydro power stations without storage).

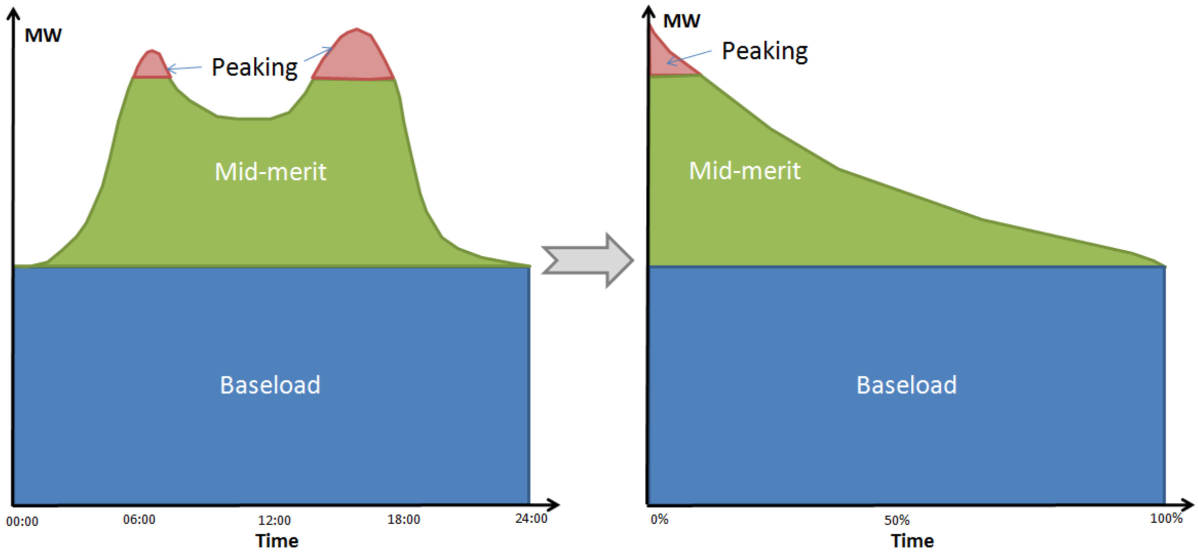
5.9 Figure 13 illustrates three simplified types of power station as:

e) Base-load - designed to supply electricity continuously;

f) Mid-merit - designed to provide some flexibility and to meet intermediate of "mid-merit" demand;

g) Peaking - designed to provide fast response to varying demand and to meet peak demands.

Figure 13: Base-load, mid-merit and peaking stations



5.10 In respect to Figure 13 the chart on the left shows electricity demand and generation in chronological sequence across the day, while the chart on the right presents the same information with demand arranged in descending order of magnitude.

5.11 In New Zealand, hydro generation with storage plays a major role in varying output in response to demand and supply variations, providing a substantial portion of peaking and mid-merit supply.

5.12 This feature of the New Zealand system is discussed within two contexts – short-term coordination and medium-term coordination.

Short-term coordination

5.13 Section 3 of this evidence highlighted that New Zealand has a relatively high proportion of hydro generation. A significant benefit is that, on a day to day basis, hydro power stations with the capability to store hydro inflows are able to respond to short term changes in market demand, providing important peaking and mid-merit capability that the System Operator can rely upon to match supply and demand on a continuous basis.

5.14 Most of New Zealand's hydro power stations incorporate some storage and, subject to resource consent limits, this storage allows hydro generation to be scheduled to match short-term demand patterns. Many hydro generation units are also able to be started and stopped quickly, providing flexibility to respond to short-term movements in electricity demand and compensate for variations in supply from intermittent wind farms.

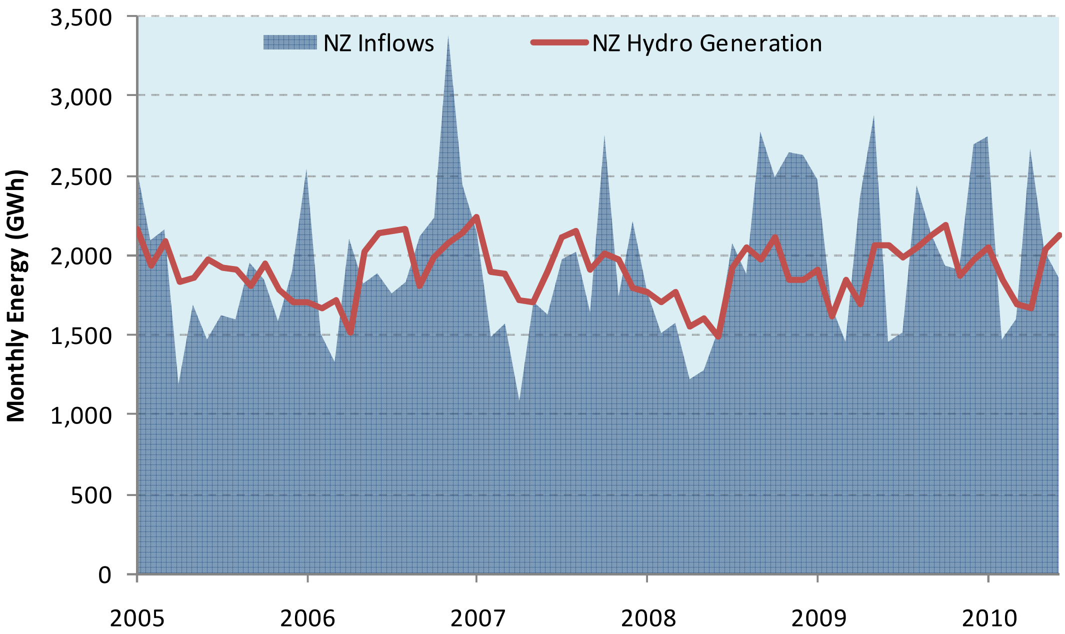
5.15 This short term flexibility will also support the further development of non-hydro renewable supply developments that are intermittent, such as wind, or inflexible, such as geothermal. In this regard, the New Zealand electricity system is well placed to accommodate further development of renewable electricity generation resources.

Medium-term coordination

5.16 The larger hydro storage lakes (in particular those forming the Waitaki Hydro scheme) fill an important role in smoothing out seasonal inflow fluctuations, better matching hydro generation to seasonal demand.

5.17 On a seasonal and year-to-year basis, the availability of hydro energy supply can vary considerably depending on inflows to individual hydro catchments. Figure 14 illustrates monthly hydro inflows and hydro generation (both in GWh per month) over the period 2005 to 2011 and the important role of hydro storage in allowing inflow variability to be managed, while matching the hydro generation to demand, and minimising hydro spill. The hydro inflow peaks are captured in the storage lakes and water can be released from the storage lakes to supplement hydro inflows when they are low.

Figure 14: Monthly hydro inflows and generation (2005-2011)



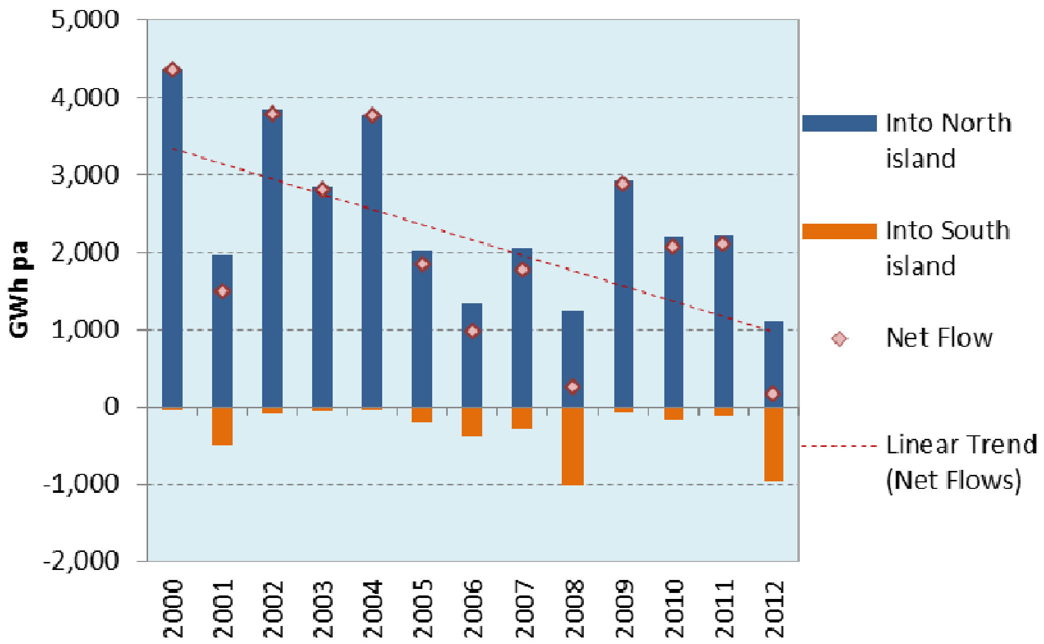
5.18 However, hydro storage lakes in New Zealand have limited energy storage capability, equivalent to approximately five weeks of winter energy demand. Many inflows to hydro catchments also bypass the main storage lakes. These features complicate the management of hydro storage, which involves continuously balancing the risk of spilling water, if lake levels rise too far, against the risk of electricity shortages, if lake levels fall too low.

5.19 Thermal electricity generation fills another critical role in this regard. When hydro supply is plentiful, thermal generation is backed off and when hydro supply is low, thermal generation is increased. This is an important function of the electricity market, which allows hydro generators to adjust offer prices so that more or less thermal generation is scheduled. Hydro storage and thermal supply thus combine to provide important seasonal and year-to-year energy supply flexibility which underpins security of electricity supply.

Interisland Energy Transfers

5.20 Most of New Zealand's hydro generation and storage is in the South Island, where electricity generation typically exceeds demand. Although electricity typically flows from the South Island to the North Island through the Cook Strait cables, increasingly, as illustrated in Figure 15, electricity can flow in the opposite direction during hydro droughts.

Figure 15: Interisland Energy Transfers (2000 to 2012)



5.21 The capability for electricity to flow north or south between the two islands is particularly important, allowing North Island thermal generating capacity to be used to compensate for variations in inflows to South Island hydro storage Lakes. It allows lake levels to be maintained within consented operating ranges, while managing the risk of hydro spill on the one-hand (if inflows are high and lake levels get too high), and electricity supply shortage risks on the other hand (if inflows are low and lake levels get too low).

5.22 The trend in interisland energy transfers has been for a lower net transfer to the North Island over time, reflecting less new generation development in the South

Island relative to the North Island, and a steadily declining surplus of generation (on average) in the South Island.

5.23 It is important to appreciate how the combination of hydro power stations, hydro storage lakes, interisland transmission capability, and thermal power stations provide short-term and medium-term security of electricity supply in New Zealand. The Waitaki Hydro scheme is particularly important in this regard.

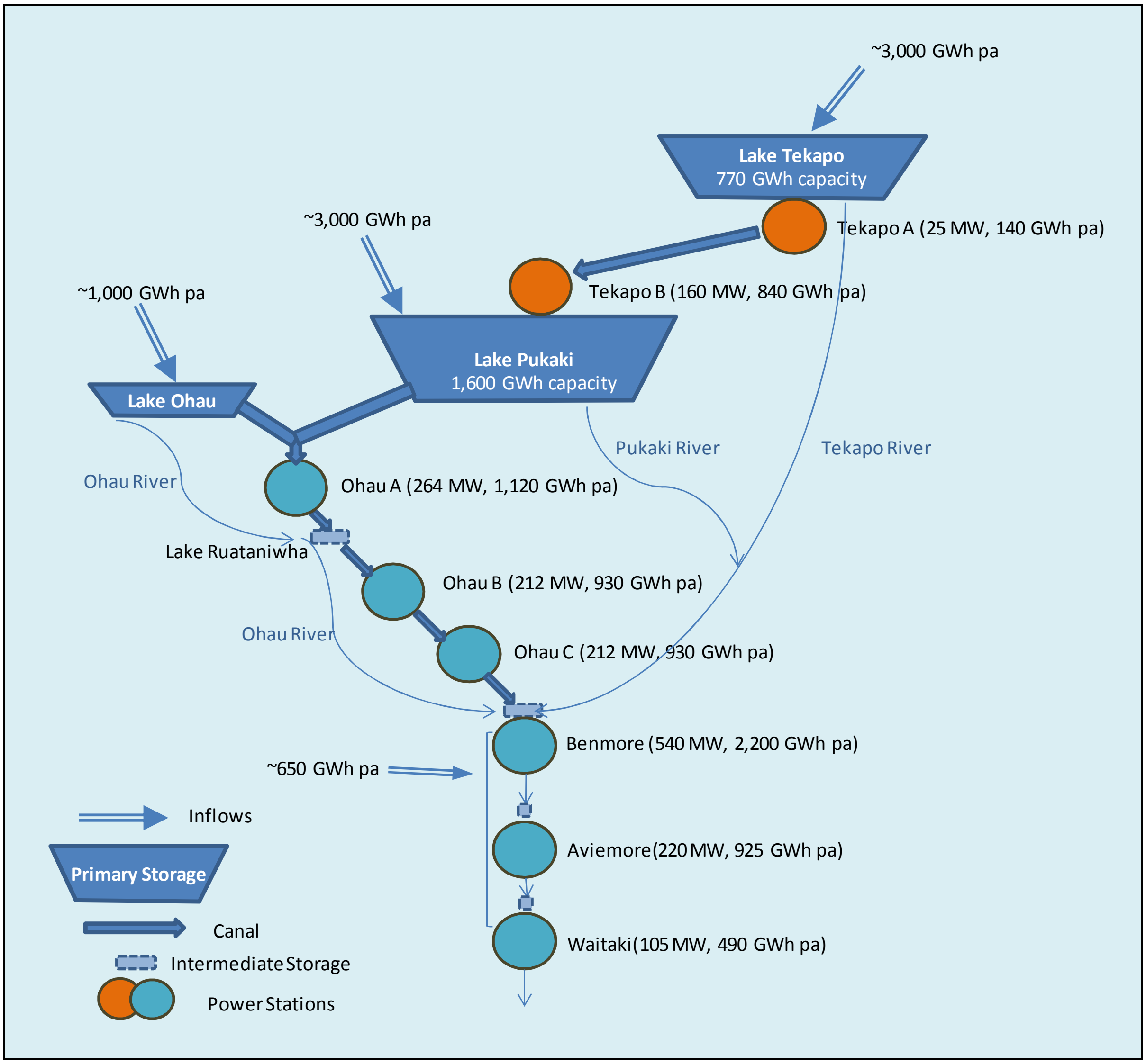
6. THE WAITAKI HYDRO SCHEME

Overview of scheme

6.1 The Waitaki Hydro scheme comprises eight power stations inter-connected by a network of rivers, canals and storage lakes. It is supplied by a number of natural inflows originating largely from the Southern Alps and the Ahuriri River.

6.2 The Waitaki Hydro scheme is the largest hydro system in NZ. The key characteristics are illustrated in Figure 16.

Figure 16: Waitaki Hydro Scheme



6.3 The Tekapo Hydro scheme (comprising the A and B power stations) is operated by Genesis Energy, while the remainder of the scheme is operated by Meridian Energy.

6.4 The HVDC 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.

6.5 The Waitaki Hydro 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.

6.6 Control structures at Lakes Tekapo and Pukaki were constructed in the 1940s because the inflows to the Waitaki River were not well correlated with high winter demand. By providing upstream storage and control, high spring and 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.

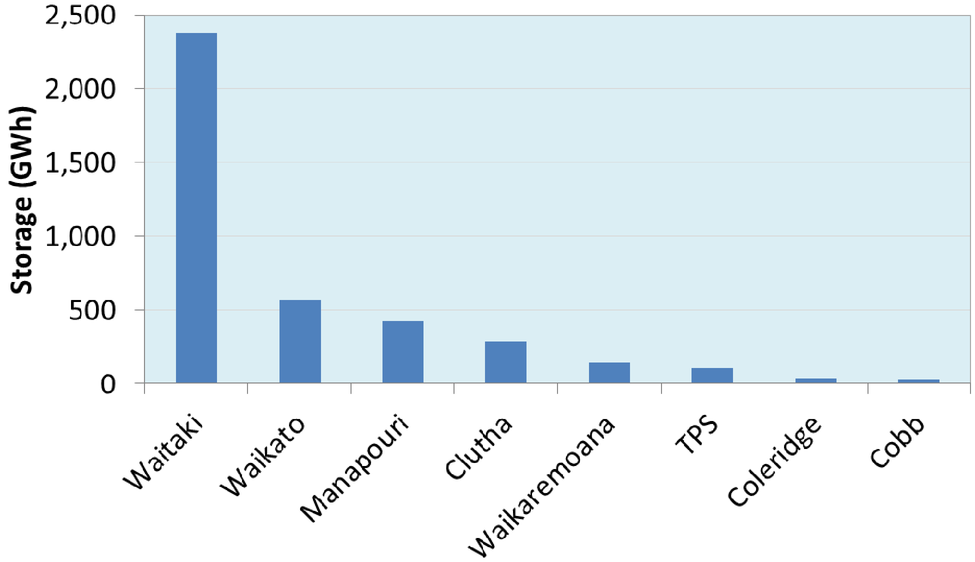
6.7 The evidence of Ms. Hickman provides a more detailed description of the Waitaki scheme and its operation.

Contribution to New Zealand Energy Supply

6.8 The Waitaki Hydro system contributes (on average) approximately 7,600 GWh per annum, representing approximately 18% of total annual supply requirements, and more than half of the South Island annual electricity demand.

6.9 Section 5 highlighted the important role that hydro generation with storage makes towards the security of electricity supply in New Zealand and, in particular, how thermal generation and lake storage are continually balanced over time. Figure 17 illustrates the relative contributions from the main hydro storage lakes in New Zealand, highlighting the key role of the Waitaki hydro scheme.

Figure 17: Contribution to Storage from Hydro Resources

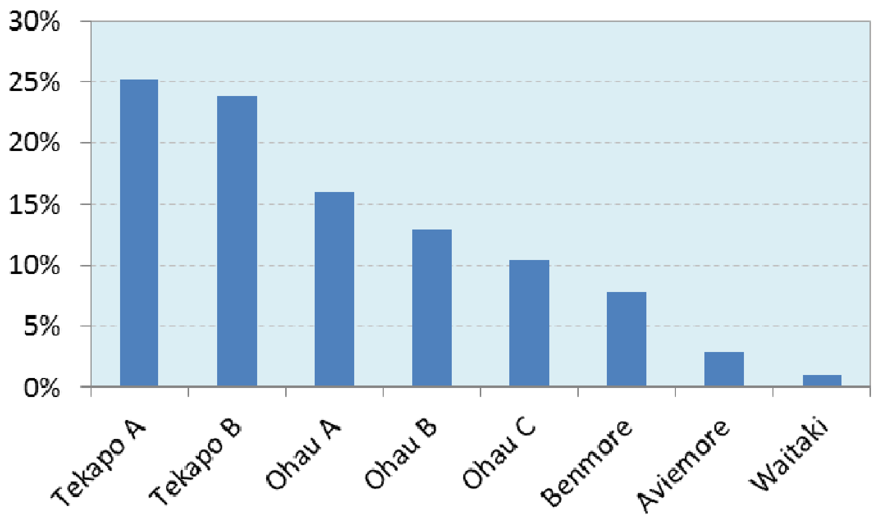


6.10 The lakes comprising the Waitaki Hydro scheme collectively provide approximately 60% of New Zealand's controllable hydro storage capacity.

6.11 It is important to note that water entering upper parts of the Waitaki Hydro scheme passes through several power stations and therefore generates proportionally more energy than water that enters lower down the catchment.

6.12 Figure 18 illustrates that water entering upstream of Tekapo A power station provides approximately 25 times more potential energy supply than water entering upstream of Waitaki power station, for example. It is also important to note that the majority of inflows enter the upper reaches of the catchment (see Figure 16) via Lakes Tekapo, Pukaki and Ohau.

Figure 18: Contribution of Inflows at Various Points



6.13 The Waitaki Hydro scheme is required to operate within the conditions of resource consents and various statutory planning documents, including the proposed Environment Canterbury Land and Water Regional Plan (LWRP). I understand that the proposed LWRP may impact upon water allocation provisions within the Waitaki catchment and this could potentially affect the continued ability of the Waitaki Hydro scheme to store water in the hydro lakes and manage lake levels. Any such affects would reduce the important contribution the Waitaki Hydro scheme makes to electricity supply that I have outlined in this section.

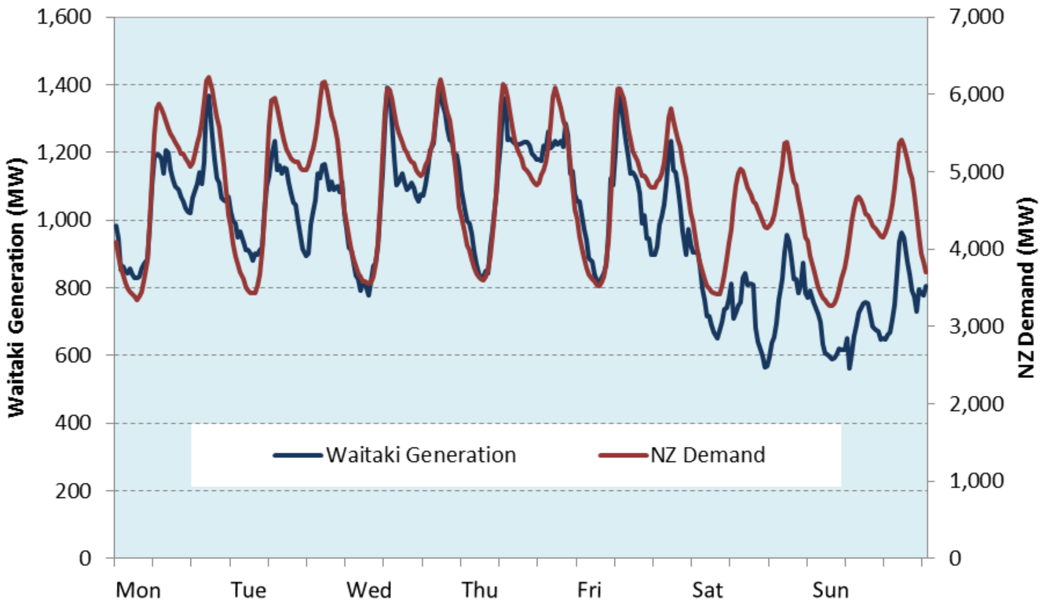
Flexible Role of Waitaki Hydro Scheme

6.14 The Waitaki Hydro scheme is a controllable and flexible source of electricity generation with a major associated storage catchment. It is readily able to respond to electricity market requirements, increasing and decreasing output to follow the daily pattern of electricity demand. This important role is typically provided by hydro schemes with storage and/or thermal power stations with particular characteristics and flexible fuel supply arrangements.

6.15 The output of the Waitaki Hydro scheme can be readily increased to generate more at times of peak demand. While the Waitaki hydro scheme provides approximately 18% of annual electricity demand, the scheme is capable of contributing up to 24% to New Zealand's peak electricity demand.

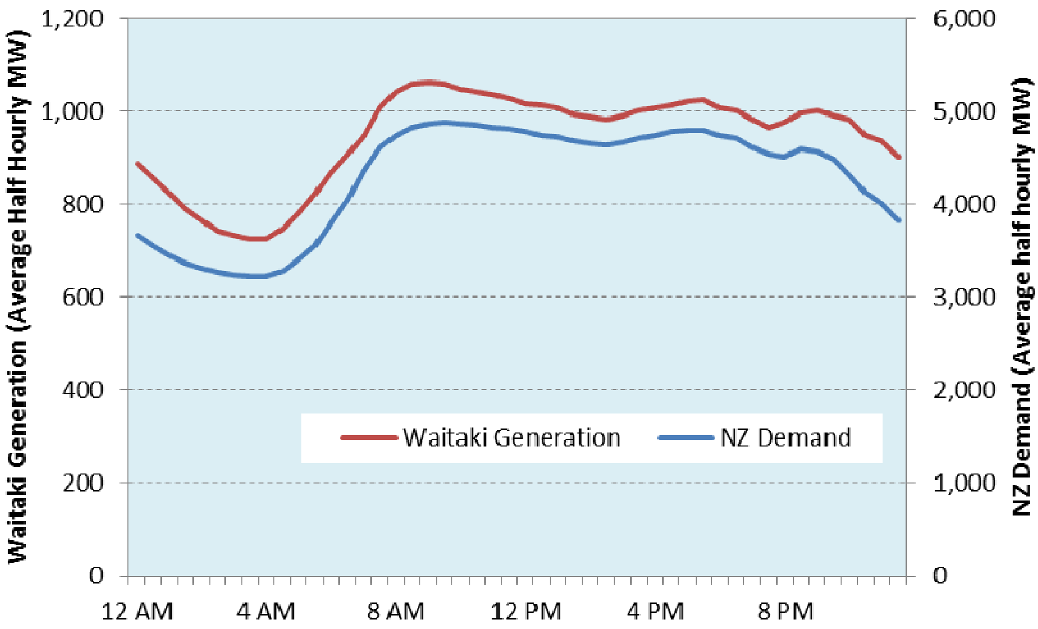
6.16 Figure 19 illustrates how generation from the Waitaki Hydro scheme tends to be scheduled to follow the daily variations in demand.

Figure 19: Waitaki Generation and New Zealand Demand (week in August 2012)



6.17 This flexibility is further emphasised by Figure 20, which shows the average half-hourly output from the Waitaki Hydro scheme (for the year-ending September 2011) plotted against the corresponding average half-hourly New Zealand demand over the same period.

Figure 20: Average Daily Waitaki Generation and New Zealand Demand

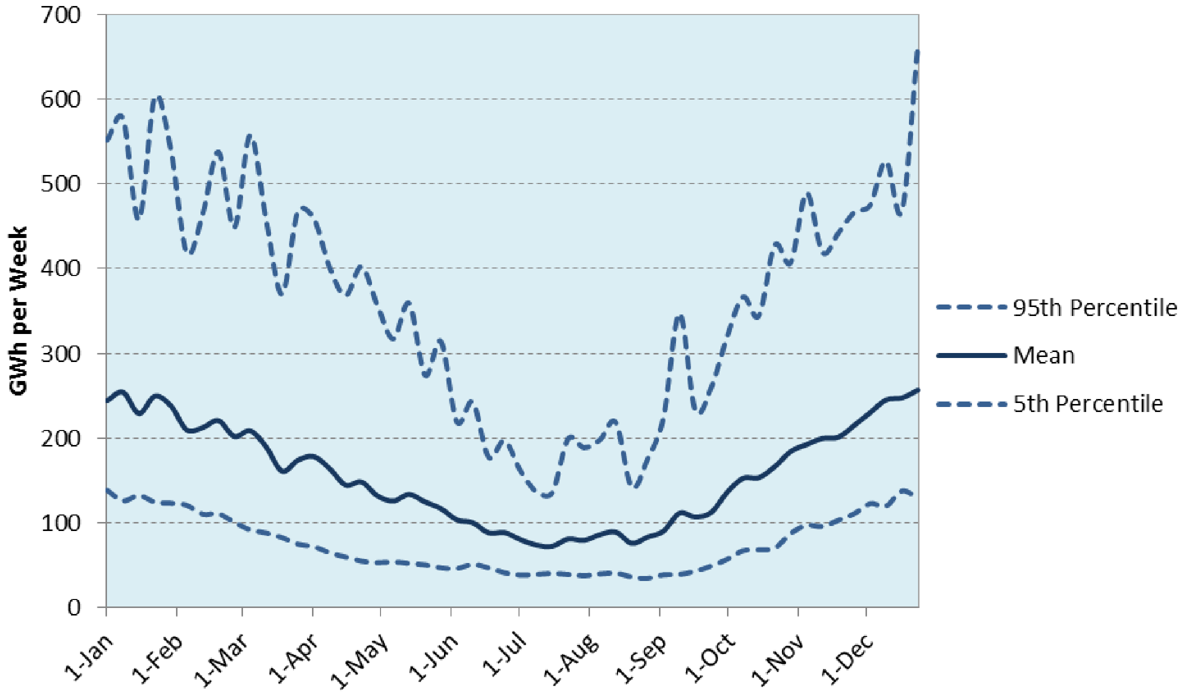


6.18 The average output of the Waitaki Hydro scheme is shown to very closely correlate with the shape of overall demand, illustrating how the scheme and its associated hydro storage is used to follow the shape of demand.

6.19 Individual generating units on the Waitaki Hydro scheme are able to start up and shut down in a matter of minutes. This contrasts with some thermal power stations which can take several hours to start up. This flexibility means that the Waitaki Hydro scheme is well-suited to meeting sudden changes in market demand or variations in other power station output.

6.20 Inflows into the Waitaki catchment can vary significantly, as illustrated in Figure 21 which charts mean weekly inflows into the catchment, together with the 5th and 95th percentiles.

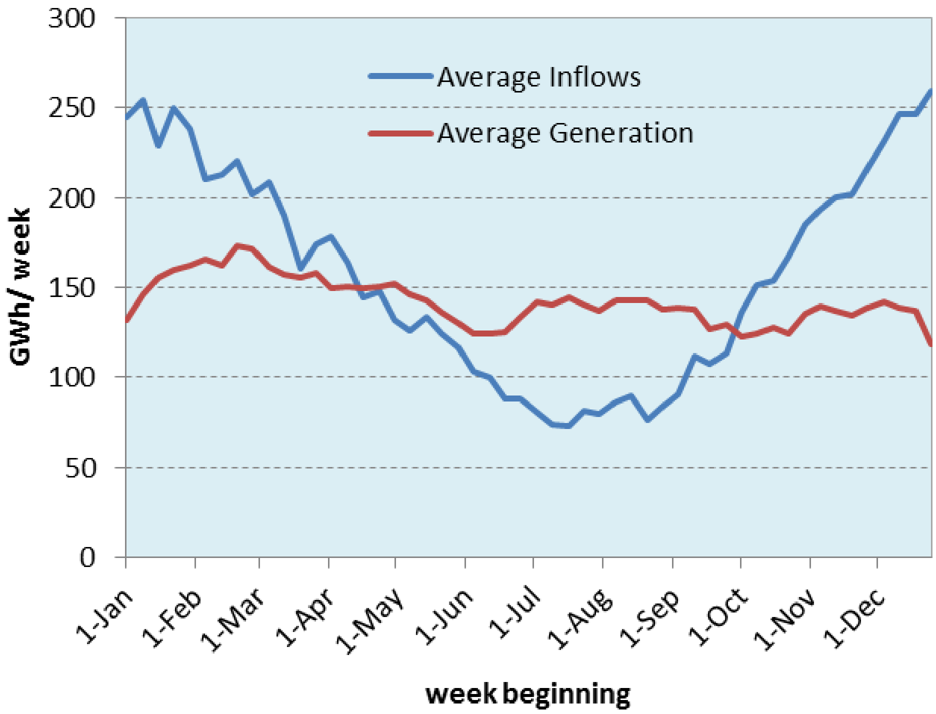
Figure 21: Weekly Inflows to Waitaki Catchment



6.21 Although mean weekly inflows vary between 70GWh and 250GWh, during high inflows they can exceed 600GWh and during dry periods they can fall to less than 40GWh. The storage capability in the lakes plays a key role in capturing the high inflows and storing the water to provide generation even during droughts.

6.22 This capability is further evident from Figure 22 which compares average weekly generation for the Waitaki Hydro scheme over the period 2000 to 2011 to weekly average inflows over the same period.

Figure 22: Waitaki Hydro Generation (2000-2011) and average inlfows



6.23 Because overall hydro storage capacity is limited, seasonal storage within the Waitaki Hydro 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.

6.24 I understand that the proposed LWRP may impact upon water allocation provisions within the Waitaki catchment and this could potentially affect the continued ability of the Waitaki Hydro scheme to provide the flexibility it currently provides by storing water in the hydro lakes and matching output to electricity demand. Any such affects would reduce the important contribution the Waitaki Hydro scheme makes to electricity security of supply that I have outlined in this section

Ancillary Services

6.25 In addition to generating electricity, the Waitaki Hydro system provides essential ancillary services including[2]:

a) **Spinning reserves:** most power stations on the Waitaki Hydro scheme (including Tekapo A and B stations operated by Genesis Energy) have 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.

b) **Frequency keeping**: some generators on the scheme (not including Tekapo A and B stations operated by Genesis Energy) are fitted with governor systems which respond automatically to system frequency deviations – an essential part of maintaining supply and demand in balance. The frequency keeping service enables these generators to return to their dispatched levels and helps to maintain supply and demand in balance between System Operator dispatch instructions.

c) **Over-frequency reserves**: some generators on the scheme (not including Tekapo A and B stations operated by Genesis Energy) have 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 electricity is being delivered 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.

d) **Voltage support**: all generators within the Waitaki Hydro scheme (including Tekapo A and B stations operated by Genesis Energy) are fitted

2 I have relied upon information provided by Genesis Energy in respect of the contributions provided by the Tekapo Hydro scheme to ancillary services.

with systems which enable them to assist the System Operator in maintaining grid voltages within acceptable levels. This service has an impact on voltage levels over large areas of the South Island grid.

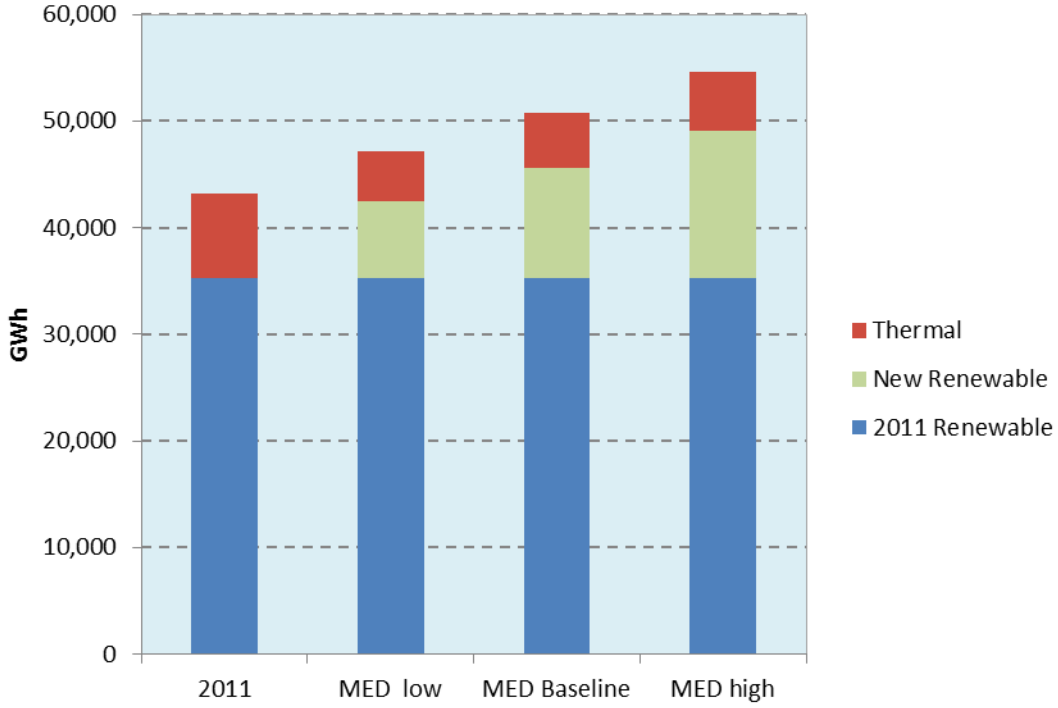
6.26 I understand that the proposed LWRP may impact upon water allocation provisions within the Waitaki catchment and this could potentially affect the continued ability of the Waitaki Hydro scheme to provide ancillary services. Any such affects would reduce the important contribution the Waitaki Hydro scheme makes to electricity supply by providing ancillary services.

Meeting Government renewable targets

6.27 The New Zealand Energy Strategy (NZES) includes the target that 90% of electricity generation be produced from renewable sources by 2025 (in an average hydrological year) providing this does not affect security of supply.

6.28 In the recent past, the level of renewable electricity generation has varied between 71% and 79% depending upon inflows to hydro catchments. Figure 23 illustrates the new renewable generation capacity (expressed in GWh per annum) that would be required by 2025 in order to meet the 90% target under a range of possible demand growth scenarios.

Figure 23: New renewable generation required by 2025 to meet 90% target



6.29 Figure 23 highlights that under most scenarios not only would all new generation need to be supplied from renewable sources, but it would be necessary to replace some existing thermal generation with renewable generation, if the 90% target is to be achieved.

6.30 As a renewable energy source, the Waitaki Hydro scheme contributes a substantial portion (on average 25%) of existing renewable energy and underpins the target of 90% renewable generation by 2025.

Contribution to government climate change objectives

6.31 The Waitaki scheme contributes to energy supply requirements with very few greenhouse gas emissions. In contrast, Table 1 shows the greenhouse gas (carbon dioxide equivalent – CO_2e) emission rates for typical thermal power stations and the annual emissions that each would produce in generating electricity supply equivalent to that from the Waitaki Hydro Scheme.

Table 1: Thermal generation emissions

Thermal CO_2 emissions	Gas ($CCGT^3$)	Gas ($OCGT^4$)	Oil ($OCGT^5$)	Coal
Tonnes CO_2e/GWh[6]	375	506	688	916
kilotonnes CO_2e @ 7600 GWh pa	2,844	3,837	5,218	6,947

6.32 The Waitaki Hydro scheme produces approximately 7,600GWh in an average year. This amount of amount of hydro generation is effectively displacing between 2,844,000 and 6,947,000 tonnes per year of CO_2e that would otherwise be produced by an equivalent amount of energy provided by a combination of gas-fired generation and coal-fired generation. To put these figures in context, they are equivalent to between 40% and 94% of all emissions from electricity generation in the year to 30 September 2012.

Future Outlook

6.33 In the near term geothermal and wind generation projects are likely to be favoured, to the extent that new electricity generation is required. These forms of electricity generation are designed to either run continuously or run when wind strengths are sufficiently high - their operation is therefore largely independent of electricity market demands or prices and they are not suited to varying their output in response to varying electricity demand.

6.34 More electricity generation in the form of geothermal or wind will place a greater emphasis on power stations that can provide flexible generation and increase

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3 Combined Cycle Gas Turbine. Modern high efficiency gas powered generators similar to the Contact Energy Otahuhu and Taranaki Combined Cycle Gas Turbine power stations and the e3p power station at Huntly owned by Genesis Energy.

4 Open Cycle Gas Turbine. Typically used as peaking plants, such as that developed at Stratford by Contact Energy.

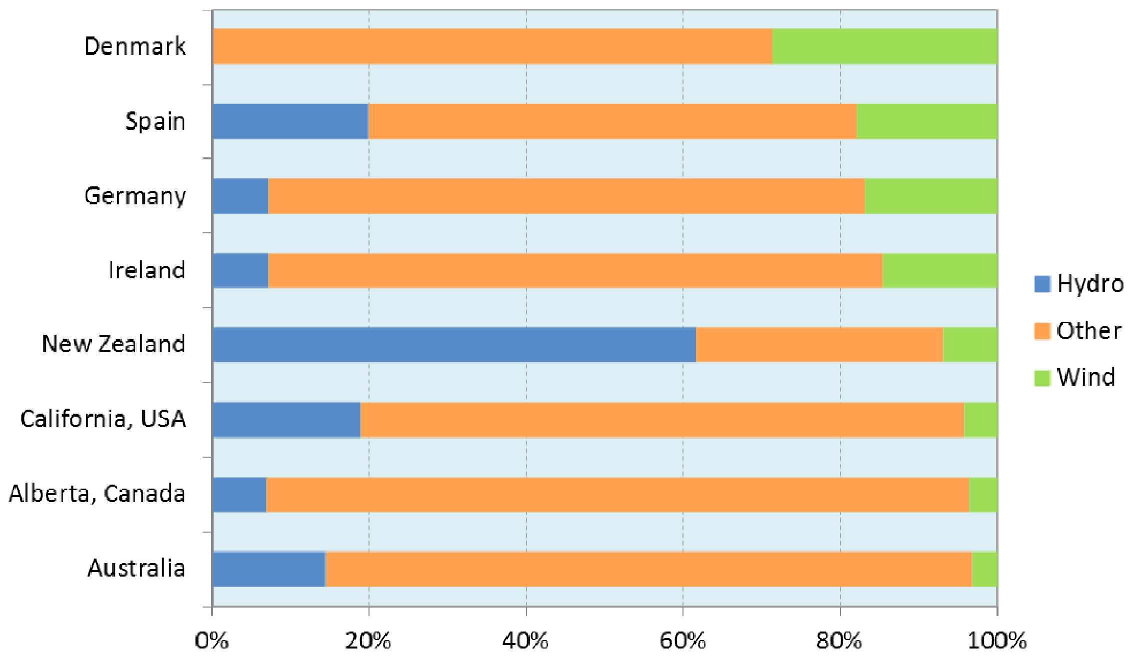
5 For example, the Whirinaki plant purchased by the government in 2004 for dry year reserve energy purposes.

6 Assuming 53.3, 68.8 and 89.4 tonnes of CO2 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.

output during high-demand periods. This confirms that the flexibility provided by the Waitaki Hydro scheme will become even more valuable to the electricity system over time in maintaining security of electricity supply.

6.35 Many countries that have developed large amounts of wind generation have considerably lower proportions of hydro generation than New Zealand, are more reliant on thermal generation, and need to rely more on fast start gas turbines to support the development of wind generation. Figure 24 illustrates the share of different generation technologies in a number of countries, with particular focus on hydro and wind generation.

Figure 24: Generation mix in other countries



6.36 Without a foundation of flexible hydro generation, of which the Waitaki Hydro 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.

6.37 I understand that the proposed LWRP may impact upon water allocation provisions within the Waitaki catchment and this could potentially affect the continued ability of the Waitaki Hydro scheme to store water in the hydro lakes and manage lake levels. Any such affects would reduce the important contribution the Waitaki Hydro scheme makes towards meeting government renewable electricity supply targets and supporting the introduction of further renewable resources.

7. CONCLUSION

7.1 Flexible and controllable electricity generation plant that is able to respond continuously to varying electricity demand is critical to maintaining a secure supply of electricity to consumers. This flexibility can generally only be provided by hydro generation with storage capability, or by thermal power stations with flexible fuel supply arrangements.

7.2 This flexibility and controllability is necessary not only to meet the daily and seasonal fluctuations in electricity demand, but also to offset the inflexibility and intermittency of other generation types designed to supply electricity either continuously (such as geothermal) or intermittently (such as wind).

7.3 Given its size, storage capacity and flexibility, the Waitaki Hydro scheme (including the Tekapo A and B stations operated by Genesis Energy) makes a substantial contribution to electricity supply and system security requirements, compensating for the inflexibility of supply from some other power stations.

7.4 The Waitaki Hydro scheme (including the Tekapo A and B stations operated by Genesis Energy) is a vital part of the electricity supply infrastructure in New Zealand. Not only does it supply 18% of our annual electrical energy requirements, but it plays a crucial role in following short-term patterns, and in ensuring security of supply during droughts.

7.5 Under most scenarios, new electricity supply will need to be developed over the next 15-20 years to meet expected demand growth and the government's target of 90% of electricity being supplied from renewable resources by 2025.

7.6 Much of this new capacity will likely come from the development of further geothermal power stations and wind farms, adding more inflexible plant into the supply mix. Under this scenario, the flexible role provided by the Waitaki Hydro scheme will become even more important to the delivery of a secure supply to electricity consumers.