Court File Reference: ENV-2018-CHC-38

BEFORE THE ENVIRONMENT COURT

I MUA I TE KOOTI TAIAO O AOTEAROA

UNDER	The Resource Management Act 1991 (RMA)
IN THE MATTER	Appeals under clause 14(1) of the First Schedule of the Act in relation to the Proposed Southland Water and Land Plan
BETWEEN	**MERIDIAN ENERGY LIMITED** **Appellants**
AND	**SOUTHLAND REGIONAL COUNCIL** **Respondent**

STATEMENT OF EVIDENCE OF DAVID THOMAS HUNT

FOR

MERIDIAN ENERGY LIMITED (TOPIC B6)

29 JULY 2022

Judicial Officer: Judge Borthwick

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TE RUNANGA O NGAI TAHU, HOKONUI RUNAKA, WAIHOPAI RUNAKA, TE RUNANGA O AWARUA AND TE RUNANGA O ORAKA APARIMA
(ENV-2018-CHC-47)

PETER CHARTRES
(ENV-2018-CHC-48)

RAYONIER NEW ZEALAND LTD
(ENV-2018-CHC-49)

ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NZ INC
(ENV-2018-CHC-50)

Appellants

AND **SOUTHLAND REGIONAL COUNCIL**

Respondent

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QUALIFICATIONS AND EXPERIENCE

1 My name is David Thomas Hunt.

2 I hold the qualifications of a BA Hons (First Class) in economics and a BA in statistics.

3 I am a director of Concept Consulting Group Ltd (Concept) which is a specialist energy and economics consultancy providing services to clients in New Zealand, Australia and the wider Asia Pacific region. I have been a director of Concept since joining the firm in 2006.

4 In my role as a director at Concept, I undertake a range of consulting assignments for Government agencies and companies in the energy and utilities sectors with a strong emphasis on economic analysis.

5 For the last 25 years, my career has been energy focussed. By way of overview:

(a) Between 1986 and 1996, I held a number of Government roles including Manager, Energy Policy at the Treasury and Economic Advisor to the Minister of Finance. I provided advice on a wide range of energy policy issues including market design, competition issues, and structural reform.

(b) In 1996, I joined Contact Energy Limited (Contact) as Strategy & Planning Manager.

(c) In 2000, I became General Manager of Corporate Development at Contact, managing strategic planning, investor relations, communications, human resources and regulatory activities for the company. I led analysis on a range of strategy and growth initiatives.

(d) In 2005, I was appointed Executive General Manager of Corporate Development at Origin Energy based in Sydney. Origin at that time was a large producer of oil, gas and LPG, had a sizeable electricity generation portfolio, and was a retailer of gas, LPG and power. During my time at Origin, I oversaw a number of strategic initiatives, including analysis regarding potential expansion of Origin's LPG retail business.

(e) Between 2005 and 2006, I was Chief Executive at Contact. That was the last management role I held before joining Concept.

(f) At a governance level, I have served as a director of Synergy, the largest electricity generator and retailer in Western Australia, and I am currently a board member of the Accident Compensation Corporation.

6 In preparing this evidence I have read the evidence prepared on behalf of Meridian Energy Limited (Meridian) for this hearing by Guy Waipara and Dr Jennifer Purdie.

7 I have also reviewed the following:

(a) the relevant provisions of the proposed Southland Water and Land Plan (the Plan) as they relate to the Manapōuri Power Scheme (MPS);

(b) Meridian Energy Limited's submission and further submission;

(c) the submissions and further submissions of other relevant parties; and

(d) the evidence of Dr Jack McConchie, Dr Kristy Hogsden; Andrew Feierabend and Jane Whyte.

CODE OF CONDUCT

8 I confirm that I have read the code of conduct for expert witnesses as contained in the Environment Court's Practice Note 2014[1]. I have complied

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[1] https://environmentcourt.govt.nz/assets/Documents/Publications/Practice-Note-2014.pdf

with the practice note when preparing my written statement of evidence and will do so when I give oral evidence before the Environment Court.

9 The data, information, facts and assumptions I have considered in forming my opinions are set out in my evidence to follow. The reasons for the opinions expressed are also set out in the evidence to follow.

10 Unless I state otherwise, this evidence is within my knowledge and sphere of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

SCOPE OF THIS EVIDENCE

11 My evidence addresses the following matters:

(a) An overview of the electricity sector and how it operates

(b) How the electricity sector is likely to change in the future

(c) The benefits to the electricity sector of the MPS

(d) Various uncertainties in the electricity sector and how they relate to the MPS.

EXECUTIVE SUMMARY

Electricity Sector Overview

12 New Zealand's electricity demand is met primarily from hydro generation (57%). The remaining demand is met by a mixture of thermal and other forms of renewable generation. The electricity system must be kept in balance at all times. As demand and intermittent generation constantly fluctuate, flexible generation such as hydro or thermal is important to maintain this balance.

13 New Zealand has ambitious decarbonisation goals. To achieve these will require electrification of many parts of the economy currently dependent on fossil fuels (such as use of light vehicles), development of new renewable generation and retirement of thermal generation. As a result, the importance of flexible hydro generation (including from the MPS) will grow in the future.

Economic Benefits of the MPS

14 The MPS is a large hydro power station that generates approximately 4,900 GWh of electricity every year. For a sense of scale, this is enough energy to serve over 670,000 average residential customers, or all Southland residential customers almost 15 times over.

15 If the MPS were unavailable, I estimate it would cost between $440 million and $830 million per year in the short run to replace this energy using existing thermal generation capacity. This would also increase New Zealand's emissions by between approximately 1.9 million and 4.7 million tonnes of carbon dioxide equivalent per year.

16 In the longer run, if the MPS were unavailable its output could be replaced with new renewable generation. Substitution with new flexible hydro production of scale would be unlikely given regulatory and policy barriers associated with such development.[2] I estimate this would cost between $5.1 billion and $6.4 billion (in present value terms).

17 The MPS also provides ancillary services, namely multiple frequency keeping, instantaneous reserve and over-frequency reserve. While the economic cost of providing these services elsewhere is difficult to calculate, it is likely to be a material cost (as the MPS provides a material proportion of New Zealand's total ancillary services).

Uncertainties

18 There are several uncertainties that could affect my estimates of the economic benefits of the MPS. These include the rate of decarbonisation in New Zealand, the future of the Tiwai smelter, and whether a large pumped storage hydro facility is developed at Lake Onslow. For the reasons set out in the body of this evidence, I believe the MPS will continue to provide significant economic benefits to New Zealand and the electricity system, irrespective of these uncertainties.

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[2] I recognise that the government is currently considering the Lake Onslow pumped hydro storage project, which I discuss in more detail from paragraph 117. I note that if it is built, Project Onslow would be a storage resource, not a generation resource, and would be a net consumer of electricity.

ELECTRICITY SECTOR OVERVIEW

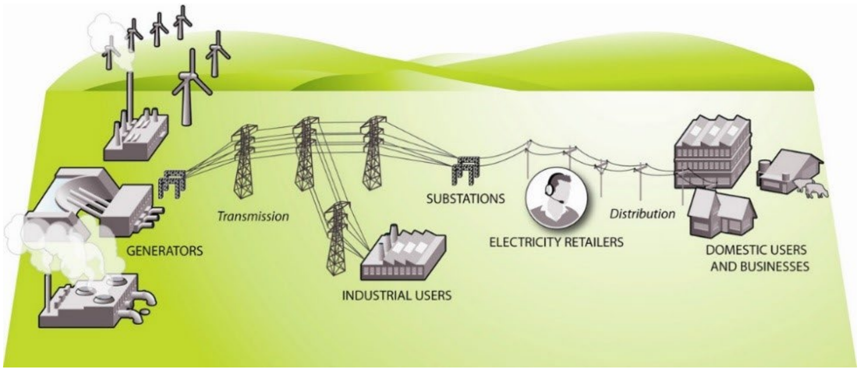
Electricity Industry Structure

19 The electricity supply chain can be divided into four main segments: generation, transmission, distribution, and retail sales. This is shown diagrammatically in Figure 1.

20 Competition is possible in the generation and retailing segments and regulation of these sectors has been focussed on facilitating competition.

21 The transmission and distribution segments are not subject to competition because it is generally uneconomic to replicate electricity networks. These businesses are regulated under Part 4 of the Commerce Act. This provides for price control of their services, except where there is strong alignment of supplier and consumer interest via community ownership of a network.

Figure 1 – Overview of electricity industry structure



Source: Ministry of Business, Innovation and Employment

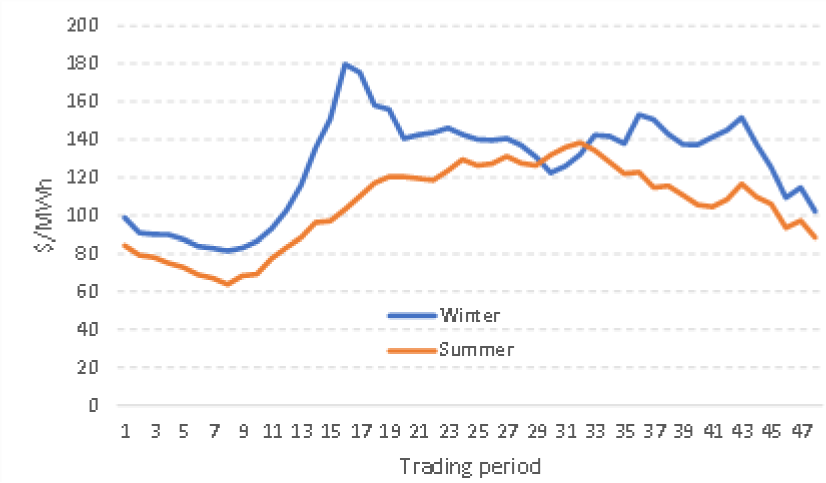
Wholesale Electricity Market

22 The platform that underpins generation sector competition is the wholesale electricity spot market. All generators connected to the grid are required to participate in this market where their electricity is sold in a half-hourly auction process. The cheapest combination of generation offers that will securely meet demand is used to determine which generation will be selected to run in each half hour.

23 Supply and demand conditions can vary substantially within a day and across the year. The cost of generating power in peak demand periods is typically much higher than other periods. This leads to relatively predictable variations in spot prices across the day, as shown by Figure 2.

24 Spot prices will also fluctuate due to unexpected events, such as the early arrival of a cold front which lifts power demand for electric heating, or tighter supply such as a prolonged calm period which reduces wind generation.

Figure 2 – Typical price profile - winter day versus summer day



Source: Electricity Authority data

25 Because spot prices are higher when the supply/demand balance is tight and vice versa, generators[3] that can control their output are able to earn a premium over those that operate at a constant rate or cannot control their output. The presence of this premium is important to maintain reliable supply, because it encourages generators to be available when there is the greatest need for additional supply. I discuss the need for flexible supply in more detail from paragraph 35.

Locational Signals

26 Another feature of the spot market is that prices are determined at many locations across the grid for each half hour. Prices at each location reflect the local balance of supply and demand, including the effect of physical transmission losses if power needs to be carried over long distances from generators to points of usage.

27 Price differences also occur if parts of the grid reach their maximum physical operating limit. When such limits arise, spot prices will typically rise downstream of a transmission constraint to indicate to generators or

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[3] Or other types of resources that can improve the supply/demand balance, such as batteries or electricity consumers who can reduce their usage – known as demand response providers. While batteries and demand response have provided limited flexibility in the New Zealand electricity system to date, it is widely considered that they will provide much more flexibility in the future. Some of the discussion in this evidence about generators also applies to batteries and demand response providers. However, for brevity and given the scope of this evidence, I have generally focussed on the role of generators in the electricity system.

retailers/purchasers located there that they should increase production or reduce consumption respectively to relieve the effects of the constraint.

Contract Market

28 Most electricity customers do not want to deal with the complexity of half hourly price variations in the spot market. Nor do most generators wish to be wholly reliant on the spot market with prices that are uncertain and constantly varying.

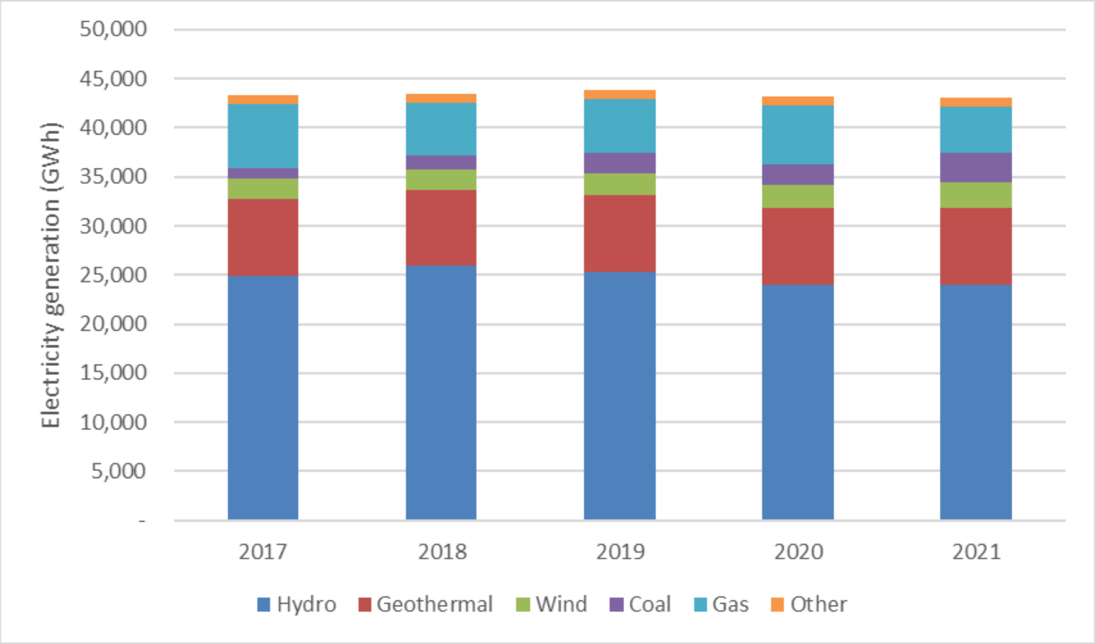
29 Instead, the great majority of electricity generation and consumption volumes are sold on contracts which smooth out short term price volatility. These can be retail supply contracts where generator-retailers organise the transmission and distribution services for the customer as well as supplying wholesale energy, or bilateral ‘hedge’ contracts which smooth spot price volatility, with the customer retaining responsibility for organising transmission and distribution services.

30 While contracts can provide generators and consumers with insulation from short-term variation in spot prices, this only lasts for the contract duration (typically 1-3 years). More generally, when contracts are being negotiated, the price will be affected by the parties’ expectations about future spot prices. This is because buyers and sellers each have the alternative of not contracting and relying instead on the spot market. Hence their expectation of future spot prices will affect their willingness to contract at different prices.

Current Make-up of Supply

31 Electricity is supplied by a range of generation types as shown in Figure 3. During the last five years hydro was responsible for around 57% of electricity generation in New Zealand. Over 90% of this hydro generation came from the five largest hydro schemes, being Waikato, Tongariro, Waitaki, Clutha and Manapōuri. The other significant generation types were geothermal (18%), gas (13%), and wind and coal (both 5%).

Figure 3 – Historical electricity generation



Source: Energy in New Zealand 2021, MBIE.

Supply and Demand Must Be Balanced at All Times

32 Electricity is unusual because supply and demand must be kept in a tight balance at all times and at all locations on the grid. If this is not achieved, it can lead to widespread blackouts. In particular, if insufficient electricity is supplied to meet demand, the electrical frequency will begin to drop below the normal level of 50 Hertz (and vice versa). Power plants are designed to operate within a fairly narrow frequency range and if the grid frequency moves outside this range for too long, the power plant will automatically disconnect from the grid (called a 'trip') to protect itself from damage.

33 Ultimately, if too many power plants disconnect due to a frequency disturbance there will be 'sympathetic tripping' by other plant and cascade failure. This can lead to widespread blackouts affecting many customers. For example, over 850,000 customers lost power in Australia in 2016 due to an event of this type. Restoring power after such events can take some time as supply and demand need to be brought back in a way that maintains balance throughout.[4] In the Australian event power was restored to some customers within a few hours while for others it took several days.

34 The system operator (i.e. Transpower) procures ancillary services to ensure that system remains in balance, that voltage levels are maintained,

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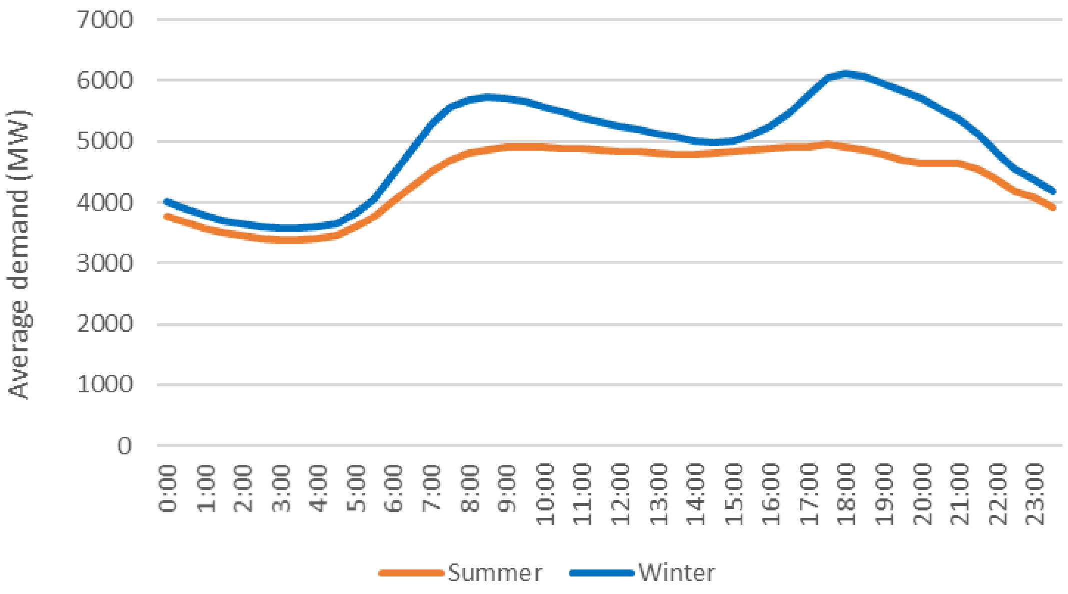
[4] See Black System South Australia 28 September 2016 | AEMO.com.au

and that the system can come back online in the event of a complete cascade failure.

Need for Flexible Supply

35 Demand for electricity is not constant through the day or across seasons. Figure 4 shows grid power demand for a typical summer and winter day. The chart shows how demand varies between a minimum level of around 3,400 MW and a peak of 6,100 MW – a variation of over 80% between trough and peak. Another point to note is the steep increase in demand on winter mornings, with a rise of around 50% between 5am and 9am.

Figure 4 – Average electricity demand for summer and winter days in 2020



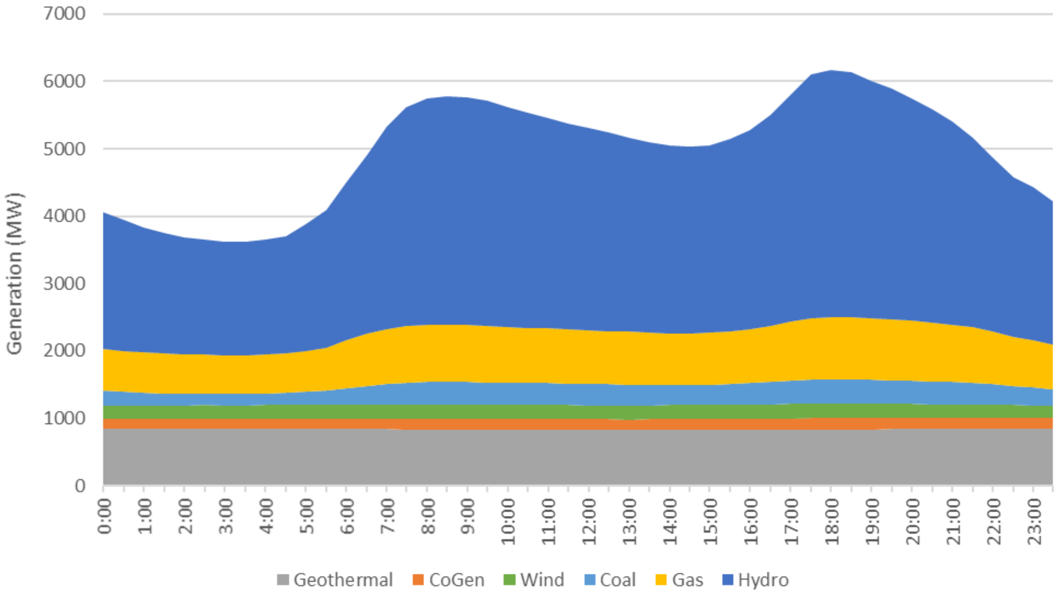
Source: Electricity Authority data.

36 These sorts of changes in demand mean that the electricity system needs flexible supply sources that can be ramped up or down quickly to ensure that the grid remains balanced.

37 Some forms of generation cannot be readily controlled – often being referred to as ‘intermittent generation’ or ‘variable renewable generation’. Examples are wind and solar generation, whose power output will vary with prevailing weather and solar conditions. Another intermittent source is ‘run-of-river’ hydro generation. These are hydro power stations that have little or no access to storage lakes, and hence generate according to natural flows in the river.

38 By contrast, hydro stations with sizeable storage reservoirs are an important source of flexible supply. These stations provide much of the short-term flexibility needed to counteract hourly, daily, and seasonal variations in demand and intermittent supply. This is illustrated by Figure 5 which shows the variation in hydro generation at the national level across a typical winter day, and how this is a major source of flexibility to meet varying levels of demand.

Figure 5 – Typical generation profile for winter day



Source: Electricity Authority data.

39 However, even hydro stations with storage are exposed to supply fluctuations. This is because they are dependent on rainfall and/or snow melt to fill their storage lakes. Accordingly, after prolonged dry periods storage lakes will be lower, limiting the amount of power that the associated hydro stations can generate. The flexibility of hydro stations is further limited by consent conditions relating to river flows and lake levels, and in the case of the MPS by the 2002 Lake Level Guidelines. These impose obligations on the operator of the MPS to keep Lake Te Anau and Lake Manapouri within certain operating ranges.[5]

40 Historically, thermal stations (running on diesel, gas and coal) have been a significant source of flexibility in the New Zealand electricity system, including during prolonged dry periods.[6]

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[5] See Operating Guidelines for Levels of Lakes Manapouri and Te Anau | Gazette.govt.nz

[6] However, as I discuss later, fossil-fuelled thermal generation will have a lesser role in the New Zealand electricity system in the future due to New Zealand's decarbonisation goals.

ELECTRICITY SECTOR DEMAND AND SUPPLY

New Zealand's Decarbonisation Goals

41 As is discussed in Dr Jen Purdie's evidence, New Zealand is a signatory to the global Paris Agreement to reduce greenhouse gas emissions. As such carbon reduction legislation is enshrined in New Zealand law, and increasing international pressure to increase decarbonisation efforts is expected to grow in coming decades.

Decarbonisation Is Expected to Substantially Lift Electricity Demand

42 Electricity demand is expected to grow very substantially as New Zealand uses more electricity to decarbonise the economy. For example, electricity is expected to largely displace petrol and diesel as an increasing number of electric vehicles take to the country's roads. Likewise, electricity is expected to replace coal and gas for industrial process heat in many applications, and for domestic heating.

43 Figure 6 shows a projection of future electricity demand published in early 2022 by the Market Development Advisory Group (MDAG), a cross-industry body appointed to provide advice to the electricity regulator.[7]

44 Clearly, the very long horizon of the projection (to 2050) means that it has some inherent uncertainty. Having said that, projections from other sources such as Transpower and the Climate Change Commission show a broadly similar picture.[8] In particular, while there are some differences in pace and scale of electrification, they all predict significant increases in demand over time as major sectors switch away from fossil fuels to electricity.

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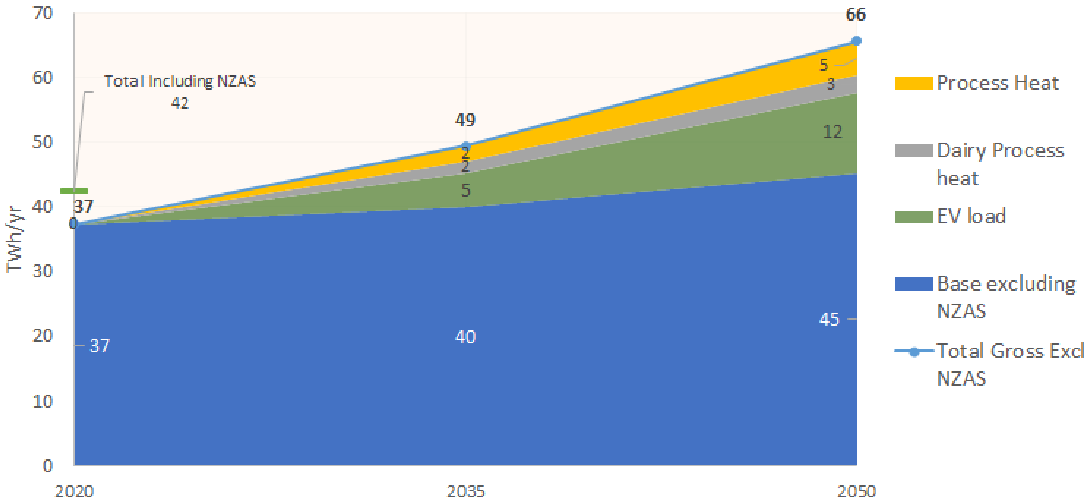
[7] This is an industry advisory group appointed by the Electricity Authority and the projection was published in an issues paper which can be found at Price discovery under 100% renewable electricity supply: issues discussion paper | ea.govt.nz.

[8] See Whakamana i te Mauri Hiko data report figures | Transpower.co.nz and Electricity market modelling datasets 2021 final advice | Climatecommission.govt.nz.

Figure 6 – Projected future electricity demand projection



Source: Electricity Authority, Market Development Advisory Group

45 Key points to note from the projection are:

(a) Demand (excluding for the Tiwai aluminium smelter) is expected to grow by around 33% by 2035, and a further 33% by 2050. This projection assumed the Tiwai smelter would close after 2024. If the smelter remains in operation (see later discussion from paragraph 92), this would lift the 'starting point' level of demand, but is not expected to affect the growth trajectory associated with decarbonisation.

(b) Most of the increase is expected to come from electric vehicles (EVs) and the increasing use of electricity for process heat in industry, especially food processing.

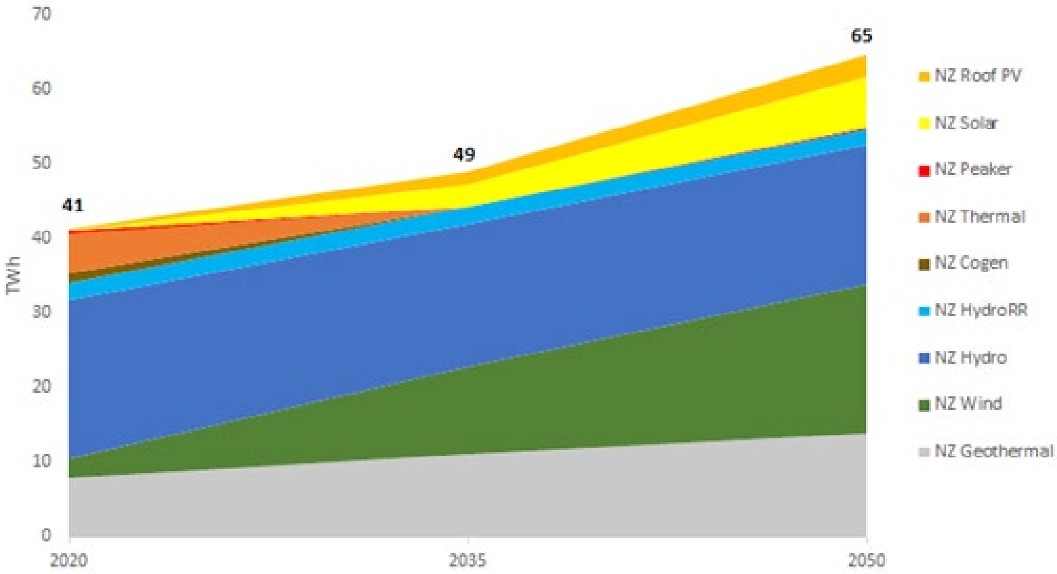
(c) Base demand is projected to be relatively stable – this is because population and economic growth are expected to be largely offset by rising efficiency of energy use (for example through greater insulation of homes).

Substantial Growth in Renewable Electricity Supply Will Be Required

46 Very large increases in renewable generation will be required to provide the electricity to achieve New Zealand's decarbonisation goals. Some of the new generation will be needed to displace existing thermal generation and directly reduce electricity sector emissions, but ultimately an even greater volume will be needed for electric vehicles and electricity for process heat to decarbonise other parts of the economy.

47 Figure 7 shows a recent projection from the report published by MDAG of the potential sources of future supply generation. As with projected demand, given the long horizon there is some inherent uncertainty about the precise mix of sources. Nonetheless, the projection is mainstream and other sources paint a similar picture for new supply.

Figure 7 – Projected future electricity supply



Source: Electricity Authority, Market Development Advisory Group

48 Key points to note from the projection are:

(a) Geothermal power is expected to grow over time – reflecting its position as a proven technology with competitive costs. However, its growth is limited by the availability of sites with access to the underlying energy source.

(b) A much larger contribution to new supply is expected to come from wind and solar generation. These have become much more competitive over time with improving technology, and further gains are expected.

(c) There is little change in the contribution from hydro generation. This reflects the fact that new hydro generation schemes are expensive to construct and face significant regulatory and policy barriers. There is also an assumption that the contribution from hydro generation will not decrease.[9]

(d) In aggregate, the proportion of electricity generated from intermittent sources (solar and wind) is expected to increase from 6% in 2020 to around 50% by 2050. As discussed below from paragraph 50, this change has significant implications for the role of flexible hydro generation.

49 Achieving New Zealand's decarbonisation goals will require the development of generation at a pace that is unprecedented. As shown in Figure 7 it will require the development of around 1,100 GWh of new renewable generation capability on average every year until 2050. This pace of development is almost 2.5 times the rate of renewable development achieved in the 30 years up to 2020.[10]

50 To provide a sense of scale, in energy production terms, it is roughly equivalent to adding a new MPS to the electricity system approximately every 4 years until 2050, or a White Hill wind farm approximately every two months.

51 These projections assume that all existing renewable stations (including major hydro schemes) will retain their current generation capabilities after their current resource consents expire – i.e. that their operating capabilities will not be reduced during reconsenting processes. If that doesn't eventuate, the required future scale-up in renewable development would be even greater than projected earlier. The required generation projections are also dependent on demand growth assumptions. If demand is higher than anticipated (e.g. if a hydrogen or other so-called 'power-to-X' economy evolves) then additional generation will be required, and vice versa.

Increased Need for Flexible Supply

52 As I noted in paragraphs 35 to 40, the electricity system needs flexible electricity supply to ensure the grid remains balanced at every instant in time. This need for flexible supply will increase in the future due to a

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[9] I recognise that the government is currently considering the Lake Onslow pumped hydro storage project, which I discuss in more detail from paragraph 117. I note that if it is built, Project Onslow would be a storage resource, not a generation resource, and would be a net consumer of electricity.

[10] This figure does not include any new generation to replace renewable generation as it wears out. Such investment will be required, noting that some existing wind farms are approaching the end of their economic life.

substantial increase in the proportion of electricity generated by intermittent sources such as wind and solar. At the same time, operation of fossil-fuelled thermal stations will need to be phased down to meet New Zealand's decarbonisation goals.

53 In short there will be a rising overall need for flexibility at the same time that thermal generation sources of flexibility are being withdrawn.

54 To fill this gap new sources of flexibility will be required. A range of possible solutions are being explored, including storage options such as batteries or pumped storage hydro, bio-fuelled plant and increased use of flexible demand response (electricity consumers who can reduce their usage at times).

55 It is too early to know which of the new flexibility options will be developed in New Zealand given their technical and cost uncertainties. However, it is clear that maintaining access to flexible hydro generation will have substantial electricity system benefits for New Zealand. This is because:

(a) There are significant costs associated with developing any new flexibility source – unlike the existing hydro generation system which has relatively low costs to maintain (because the construction costs have already been incurred);

(b) The hydro generation system produces energy on a relatively flexible basis. By contrast, some of the flexibility options are solely storage devices, and therefore need an energy source to operate; and

(c) As discussed in paragraph 38, hydro generation is currently a major source of flexibility for the electricity system. Any reduction in flexibility from this source would compound the challenge that New Zealand already faces as it transitions away from fossil-fuelled generation.

Diversity of Generation Sources Will Be Important

56 The expected increase in the proportion of electricity supplied by intermittent generation will increase the benefits of having diverse generation sources. This is because output from intermittent generation sources located largely in the same region tend to be highly correlated. For example, if a large proportion of New Zealand's generation capacity was wind farms located in the same region, it is likely that these wind farms would start and stop generating at similar times. This would tend to result

in there being excess generation in some periods and tight supply in other periods.

57 A diversity of generation types (e.g., wind, solar, hydro, and geothermal) and location will reduce the risk of both supply shortages and excess generation occurring. It will also be important for there to be non-intermittent generation supply that can provide "baseload" (constant generation over time) and flexibility.

MANAPŌURI POWER SCHEME

58 The MPS is a hydro power station located in the Fiordland National Park. It was constructed in 1971 and is now owned by Meridian.

59 The MPS can generate up to 800 MW of electricity from the water that flows from the surrounding mountains as rainfall and snowmelt into Lake Manapōuri and Lake Te Anau (which flows into Lake Manapouri via the Waiau River). The power station is at the western end of Lake Manapōuri and is located 200 metres underground. Once water has passed through the generator, it travels 10 kilometres through a tunnel and is released into Doubtful Sound.

60 Further details of the MPS and its operational environment and compliance obligations are provided in Andrew Feierabend's evidence in chief dated 19 February 2019 which was presented to the Court as part of the topic A hearing.

61 The MPS provides electricity system benefits in three key ways:

(a) It provides renewable energy to power homes and businesses across New Zealand.

(b) It is a source of controllable energy that can provide some flexible electricity generation to help keep the overall electricity system in a state of balance.

(c) It provides various ancillary services that support the New Zealand electricity system.

ELECTRICITY SUPPLIED BY MANAPŌURI POWER SCHEME

62 On average, the MPS produces around 4,900 GWh of 100% renewable electricity each year, approximately 12% of New Zealand's total electricity

generation.[11] For a sense of scale, this is enough energy to serve over 670,000 average residential customers, or all Southland residential customers almost 15 times over.[12]

63 The economic value of this energy can be estimated by considering the costs that would be incurred if the MPS was not available to operate, or was constrained in operation through changes to its operating licence. The greater those costs, the greater the benefits from continued operation of the MPS and vice versa.

64 These cost estimates consider the economic effects on New Zealand society as a whole. The commercial effects for the owner of the MPS will differ from these economic effects. The cost estimates also only incorporate electricity-related effects.

65 These costs can be separated into two categories: the costs of replacing lost or reduced MPS generation in the short-term by using other existing spare generation capacity, and the costs of developing new generation capacity to replace lost or reduced MPS generation in the long term.

66 These cost estimates consider the economic effects on New Zealand society as a whole. The commercial effects for the owner of the MPS will differ from these economic effects. The cost estimates only incorporate electricity-related effects.

FLEXIBILITY SUPPLIED BY MANAPŌURI POWER SCHEME

67 Before considering the economic cost implications if generation from the MPS was lost or reduced, it is important to briefly discuss the differing types of flexibility provided by the MPS.

68 Flexibility can be considered over a range of different time periods. Below I consider the intra-day, intra-week and intra-year flexibility of the MPS.

Intra-day Flexibility (Hourly Variation)

69 The flexibility of the MPS is apparent when comparing its average output by time of day (relative to its daily average) since 2001. This is shown by

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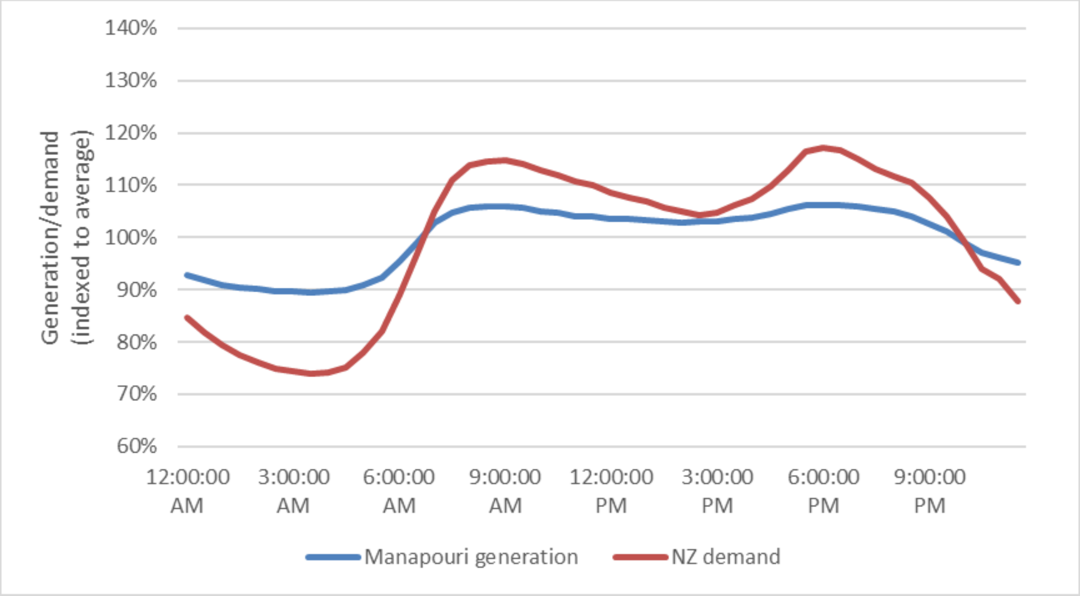
[11] Based on average generation data from 2001-2021 (inclusive) from EMI and MBIE.

[12] Based on an average usage of 7,219 kWh/year (based on MBIE data) for New Zealand ICPs and 8,423 kWh/year for Southland ICPs (based on Electricity Invercargill and The Power Company data).

the blue line in Figure 8. Also shown is the relative level of electricity demand by time of day for the entire country.

Figure 8 – Daily generation/demand correlation



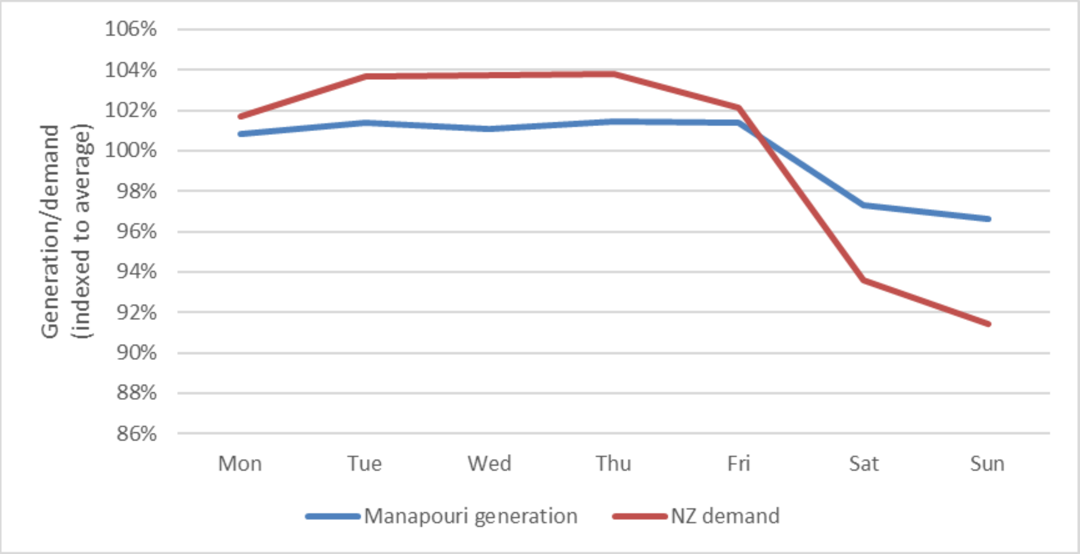
Source: Electricity Authority data.

70 The average output of the MPS follows the same broad pattern of total New Zealand demand (previously described in paragraph 29), albeit to a lesser degree. This means the MPS contributes higher electricity supply when the system needs it more (i.e. when national demand is higher each day), and vice versa.

Intra-week Flexibility (Daily Variation)

71 The MPS also has some flexibility to alter its level of generation across each week. This is illustrated by Figure 9, which shows daily MPS generation and system demand (relative to their weekly averages).

Figure 9 – Weekly generation/demand correlation



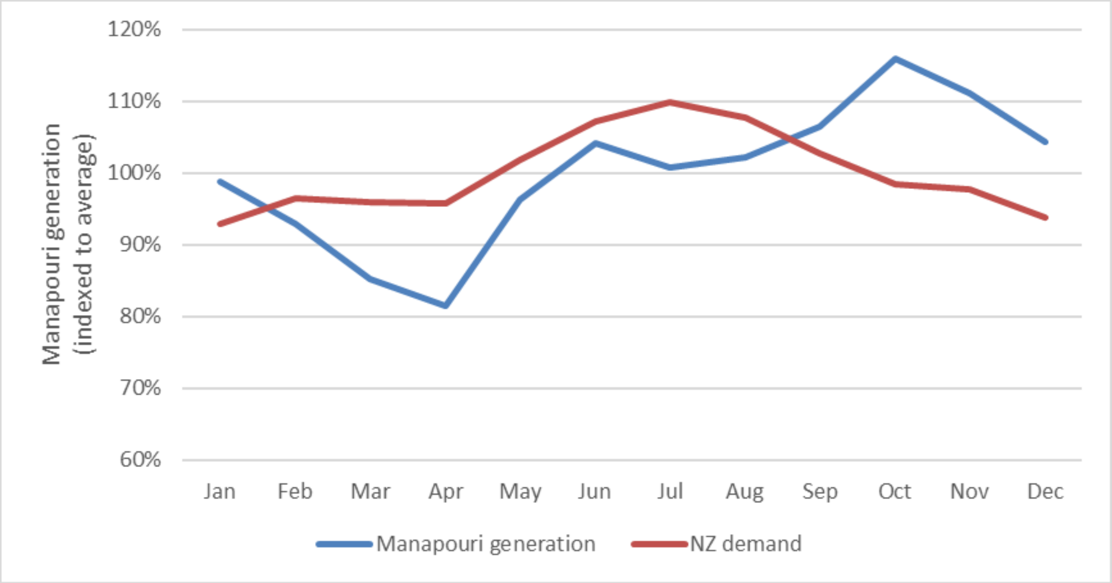
Source: Electricity Authority data.

72 The chart shows that daily New Zealand demand is fairly consistent throughout the business week, but then drops over the weekend (particularly on Sundays). Again, generation from the MPS is correlated to this trend, but to a lesser degree.

Intra-year Flexibility (Seasonal Variation)

73 The MPS has little flexibility over longer timeframes, i.e. across the year (or between years). Figure 10 shows that demand (relative to each yearly average) follows a seasonal pattern, being highest in the winter months and lowest in the summer months. The MPS does not follow this pattern. While it still follows a seasonal cycle, generation is lowest in autumn, and highest in spring.

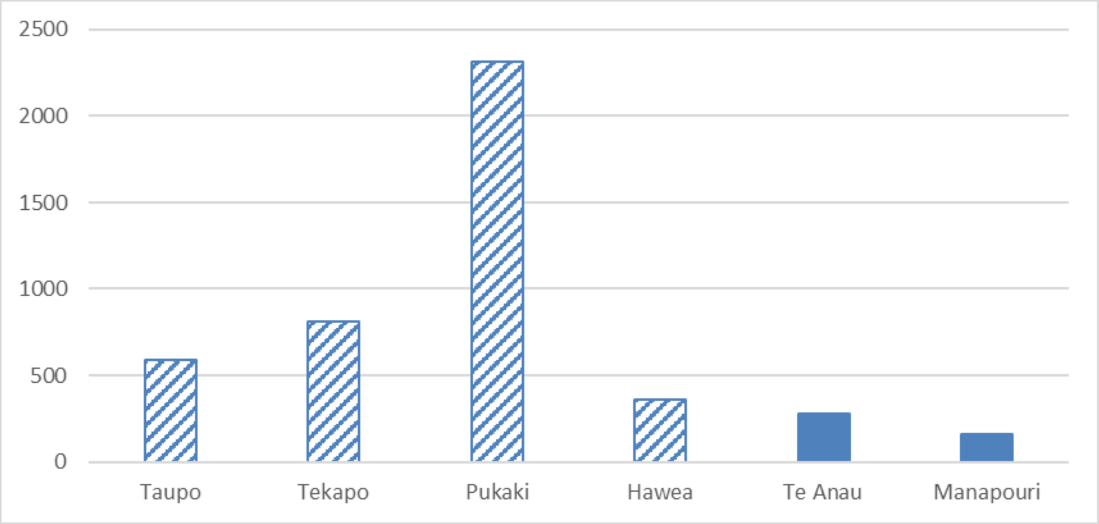
Figure 10 – Annual generation/demand correlation



Source: Electricity Authority data.

74 This lack of correlation is because hydro inflows have typically been highest in the spring months due to snowmelt and rainfall patterns. By contrast demand peaks in winter. In addition, the MPS has a combined total of 438 GWh of storage capacity which is relatively modest compared to other major storage lakes as shown by Figure 11 below.

Figure 11 – Storage capacity of New Zealand hydro lakes (GWh)



Source: Transpower

75 The charts above illustrate how the MPS provides flexibility across two important time dimensions: intra-day and intra-week. Both types of flexibility help to keep the electricity system in balance. The charts also show that longer-term flexibility currently comes from other sources.

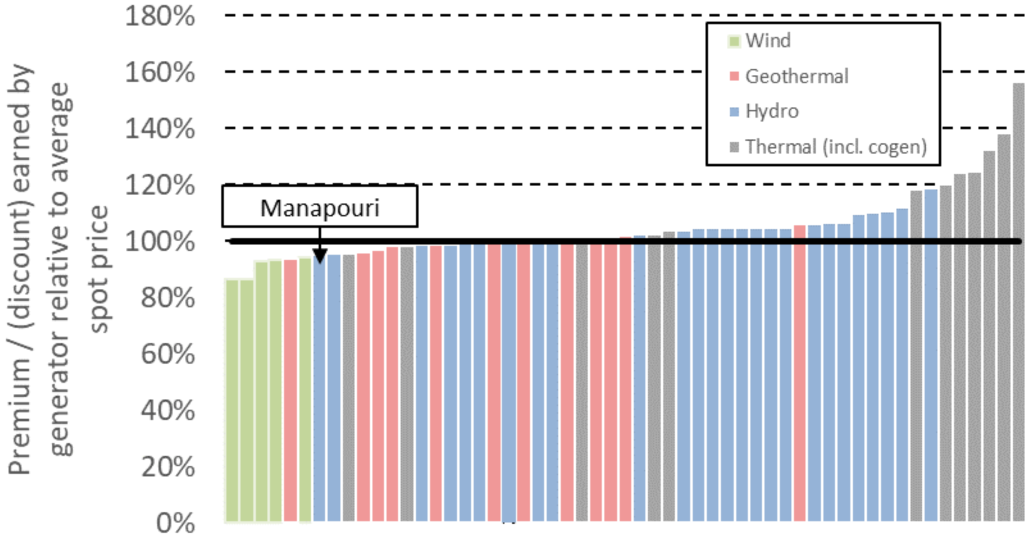
Measuring the Value of Flexibility

76 A statistic which measures the value of flexibility is the so-called ‘capture rate’.[13] This is defined as the generation weighted average spot price earned by a specific generator divided by the time weighted average price at the same location, i.e. the price a generator would receive if it has constant output (i.e. baseload generation) every half hour. This constant output generator can be thought of as providing ‘vanilla’ electricity into the system.

77 Generators that achieve a capture rate above 100% are (on average) providing supply when it is more beneficial to the system. The premium above 100% indicates their output is more valuable than the standard vanilla product and that they are net contributors to flexibility.

78 In contrast, generators with a capture rate below 100% are (on average) contributing supply at times when it has lower benefits to the system. Put another way, their output is less valuable than the standard vanilla product. Figure 12 shows historical capture rates for all major generators in New Zealand since 2015.

Figure 12 – Indicative capture rates



Source: Concept analysis

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[13] Also known as the GWAP/TWAP ratio.

79 Key observations from the chart are:

(a) Most generators achieved historical capture rates within 5% of the vanilla rate of 100%. The MPS falls into this category, with a historical capture rate of 95%.

(b) Some generators achieved capture rates that were an appreciable discount to the vanilla price. Wind generators were the main generation type in this group.

(c) Some generators achieved capture rates that were an appreciable premium to the vanilla price, reflecting their ability to provide generation when it was most valuable to the system. Flexible thermal generators were the main generation type in this group.

80 The analysis above indicates that historically the MPS has not been a major contributor to overall system flexibility. I base this observation on the fact that it has achieved an average capture rate of 95%.

81 However, looking to the future, I would expect that to change for two reasons. Firstly, as thermal plants retire, the grey bars on the right hand side of the chart will disappear. In addition, as more intermittent renewable generation (wind and solar) is built, more green bars will appear on the left hand side of the chart. This will make the New Zealand electricity system more reliant on the flexibility within the country's hydro generation fleet, and lift the value of that flexibility.

82 An indication of the scale of this effect is provided by comparing historical capture rates for the entire hydro system with projected future rates under 100% renewable generation supply. A comparison of this sort was included in analysis published by MDAG in early 2022. The analysis projected a rise in the hydro system's capture rate to 134% by 2050. This compared to a capture rate of 97% for all hydro generation for the base year of 2020.[14]

83 The second reason to expect a lift in the capture rate is because the MPS seasonal generation profile is likely (on average) to better match with New Zealand electricity demand. I base this observation on the evidence of Dr Jennifer Purdie that MPS hydro inflows in the future are likely to be higher (on average) in winter due to climate change.[15] This will increase the

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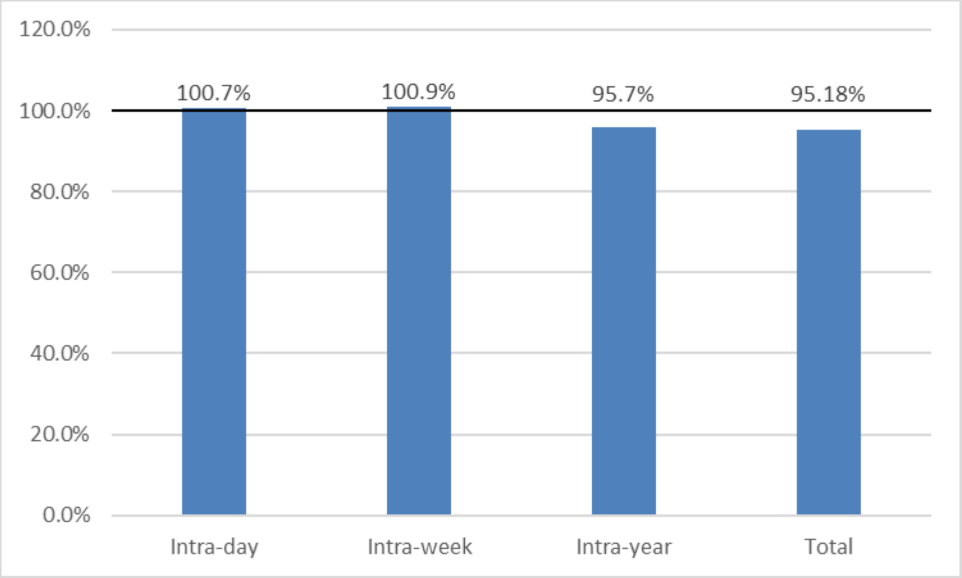
[14] Based on a benchmark simulation calibrated to average historical prices. See Simulation assumptions and results | Ea.govt.nz. My analysis of large hydro scheme generation achieves a similar result.

[15] See from paragraph 35 of Dr Jennifer Purdie's statement of evidence.

generation capacity of the MPS in winter months, allowing it to generate more electricity in months when New Zealand demand is highest. As shown by Figure 13 below (which decomposes the MPS's historical total capture rate into different flexibility dimensions), it is the relatively poor correlation between MPS's seasonal (i.e. intra-year flexibility) that has lowered the capture rate of the MPS.[16] That 'discount' would be expected to decline if the MPS generation patterns shift more toward winter.

Figure 13 – MPS Capture rate premium across multiple timeframes



84 Overall, it is difficult to know what the MPS capture rate will move to in the future as a result of these two influences. However, I would expect it to be appreciably above 95%.[17] For the purposes of the next section, I have assumed it will be 100%, although this may well be conservative (noting the points in paragraph 82 about the hydro system as a whole)..

COST IMPACTS IF MPS NOT AVAILABLE

Short-term Cost Impact

85 If the MPS was not available or its generation capability was reduced, substitute energy would initially need to be provided by alternative generation assets already in existence, as additional power stations generally take years to construct. The electricity system normally has

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[16] Calculated by finding the capture rates for each individual day, week and year from 2015-2021 (inclusive) and then calculating the average daily, weekly and yearly capture rates. This is compared to the capture rate across the whole dataset (again, 2015-2021).

[17] For completeness, I note that the recently completed transmission upgrades in the lower South Island may be a further factor that could lift the capture rates for the MPS. However, I have not considered the impact of these upgrades in detail.

some unutilised plant that can operate at relatively short notice to provide so-called reserve. This reserve is largely comprised of thermal power stations. However, this type of plant has relatively high operating costs (one of the reasons it is seldom used) and is therefore not suitable as an ongoing substitute.

86 The most likely initial effect of the MPS not being available or having reduced output would be increased operation of thermal power stations running on gas or coal.

87 Table 1 below sets out estimates of the costs of obtaining power from these types of generation units. The underlying fuel cost estimates are based on the longer-term average prices for gas and coal (prices are currently much higher) and forward projections for New Zealand carbon prices.

Table 1 – Short-term impact of MPS being unavailable

	Gas-fired substitute	Coal-fired substitute
Cost to replace lost energy ($m/year)	$440	$830
Increase in emissions (tCO2e/year)	1,898,000	4,720,000
Emissions equivalent (number of cars)	1,069,000	2,660,000

Source: Concept Consulting analysis

88 As shown in Table 1, it would be very costly to replace energy from the MPS with electricity generated from thermal power stations. Even the cheapest option (gas-fired) would incur a cost of over $440m per year.[18] Using coal-fired generation instead would almost double the cost. As a broad rule of thumb, if the electricity output of the MPS was reduced (rather than being lost entirely) the replacement costs and emissions increases would adjust proportionally – so if the MPS was reduced by 50% the substitute costs and emissions in Table 1 would be multiplied by 0.5.

89 However, it is important to note that the estimates in Table 1 assume that sufficient spare thermal plant is available to fully substitute for the MPS. That assumption is unrealistic given the large volume of energy that would be lost if the MPS could not operate – which is the equivalent to about 60% of New Zealand's thermal generation output[19] and 40% of New Zealand's thermal capacity. A more likely outcome is that thermal generation would

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[18] This is net of avoided expenditure on the MPS assets.

[19] Average MPS generation output compared to average thermal generation output (excluding co-generation) over the last 5 calendar years.

be a partial substitute, and power rationing would be required in some periods (e.g. cold winter evenings) due to insufficient spare thermal capacity. In that case, the costs would be even higher than those shown in Table 1.

90 The table also shows the expected emissions impact of replacing the renewable energy from the MPS with output from thermal power stations. If gas-fired units were available to replace lost energy (a best case for thermal energy), emissions would rise by almost 1.9 million tonnes of carbon dioxide equivalent per year. If coal-fired units were used as the source, there would be an increase of over 4.7 million tonnes per year. To put these figures into perspective, that would be roughly equivalent to the annual emissions from an additional 1.1 million and 2.7 million vehicles respectively.

Long-term Cost Impact

91 If supply from the MPS was not available on an ongoing basis, new generation sources would need to be developed as a replacement. The most likely alternatives are geothermal, solar or wind generation, or some mix of these. On a dollar per unit of energy basis, they would have lower economic costs than the thermal plant options discussed above. However, they would all involve significant upfront capital expenditure and take years to build. Table 2 shows the estimated ongoing costs to produce substitute energy if the MPS was not available. The estimates incorporate the additional expenditure that would be required on alternative new power stations, less an allowance for avoided expenditure on the MPS assets.

Table 2 – Long-term impact of MPS being unavailable

	Lower estimate	Higher estimate
Annual cost ($m/year)	$ 310	$ 390
Total cost over 35 years ($m)	$ 5,100	$ 6,400

Source: Concept Consulting analysis

92 Given the uncertainties in some variables, I have calculated lower and higher cost estimates for obtaining substitute energy. The overall cost impacts range from approximately $310 to $390 million per year. These estimates are lower than the costs associated with replacing MPS output with thermal generation but are still very substantial in annual terms.

93 They are even more significant when viewed over the likely lifetime of substitute energy sources such as solar or wind farms. In present value terms, the costs would range from approximately $5.1 to $6.4 billion.

ANCILLARY SERVICES SUPPLIED BY MANAPŌURI POWER SCHEME

94 As has been explained above in paragraph 32 the New Zealand electricity system needs to be kept in balance at all times. Ancillary services are additional services procured by Transpower (in its capacity as the System Operator) to ensure that the New Zealand electricity system runs smoothly and reliably.

95 The MPS provides the following ancillary services:

(a) Multiple frequency keeping – to offset small but continuous changes in demand or supply

(b) Instantaneous reserve – to provide quick-response back-up generation if there is a sudden and significant drop in supply

(c) Over-frequency reserves – to offset sudden and significant drops in demand.

Multiple Frequency Keeping

96 New Zealand's electricity system is designed to operate at a frequency of 50 Hertz. There are millions of electricity consumers across the country that are constantly varying their demand as appliances and machines are turned on and off. While the System Operator coordinates large-scale generation to match the day's general demand profile, these smaller fluctuations in demand can cause the system frequency to stray outside of a prescribed band. The MPS (and other hydro or thermal generators) can provide frequency keeping services by quickly increasing or decreasing its output if the frequency goes outside this band. Some types of generation are not well suited to performing this frequency keeping service. Notably, it is harder for wind and solar generators to provide this service.

97 The MPS provides approximately 10% (by value) of New Zealand's frequency keeping services.[20]

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[20] Based on ancillary revenue received by the MPS for year ended 31 May 2022 and Transpower's total procurement expenditure for year ended 30 April 2022.

Instantaneous Reserve

98 The supply of electricity needs to be constant. In the event that generation is suddenly lost (i.e. due to a generation plant tripping or a transmission fault), substitute generation will need to be ready to come online at very short notice. The system operator procures instantaneous reserve from generators or from large customers with demand response capability (interruptible load).[21]

99 The MPS provides approximately 4% of New Zealand's instantaneous reserve.

Over-frequency Reserves

100 Just as the sudden loss of generation can cause a shortage of electricity in a particular area, the sudden loss of load can cause an oversupply of electricity and a sudden rise in system frequency, which can be damaging to plant connected to the grid. In such events, the MPS (and other hydro or thermal generators) can quickly and automatically disconnect from the grid to reduce the energy being injected into the system.

101 The MPS provides approximately 28% of New Zealand's over-frequency reserve.

102 If the MPS were not available, these ancillary services would need to be provided by other resources. This may require other generating stations to be upgraded to allow them to provide these services (or to provide them to a greater extent). The total economic cost is difficult to quantify based on the available information. However, a starting point would be ancillary services revenues earned by the MPS, on the assumption that the next best alternative providers have a higher cost. In the year to April 2022, the revenues earned by the MPS were approximately $3 million. I note that ancillary service costs are currently much higher than in past years, reflecting a combination of factors that are unlikely to be sustained over the longer term. I would therefore regard the $3 million per year as a likely upper estimate of the cost of replacing any lost ancillary services at MPS.

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[21] A 2022 code amendment now allows energy storage systems (i.e. batteries) to also provide generation reserve, but I am not aware of any such systems that operate in the reserves market at present.

UNCERTAINTIES TO TAKE INTO ACCOUNT

103 When making predictions about the future it is important to consider any factors which could significantly affect the outlook. In this subsection I briefly discuss the key areas of uncertainty and their implications for the electricity system outlook.

100% Renewables Policy

104 The Government has announced a target to achieve 100% renewable electricity supply by 2030.[22] This target is not enshrined in law and is due for review in 2025. There is potential for either the target date or the target itself to change.

105 A change in renewables target would change the rate of generation investment needed to replace thermal generation. However, even if the target is softened (by extending the target date and/or reducing the target itself), I still expect investment in renewable generation to be required at an unprecedented rate.

106 The key reason for this view is that the target of net zero carbon by 2050 is enshrined in statute. Achieving that target will require decarbonisation of the transport and industrial process heat sectors, shifting from fossil fuels to renewable electricity and other zero carbon energy sources. Even assuming that current renewable assets such as the MPS are able to continue to provide output, flexibility and ancillary services at historical levels, meeting such a target will not be possible without major expansion of renewable generation.

Rate of Demand Growth Due to Electrification

107 The rate of electricity demand growth due to electrification will be affected by a range of uncertainties, such as the extent of electric vehicle rebates, battery technology improvements, and wider government policy. If the rate of electrification is slower than projected, that would reduce the required rate of renewable development, and vice versa.

108 However, my broad sense is that there is growing international and domestic concern about climate change and the need to reduce greenhouse gas emissions. Therefore, I expect that renewable growth

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[22] See Speech from the throne | Beehive.govt.nz

projections presented in Figure 7 are more likely to be understated than overstated.

109 More generally, the Russian invasion of the Ukraine and other rising international tensions have lifted fossil-fuel prices. If this pressure is sustained, it is likely to accelerate the shift to renewable electricity as an energy source simply because it is cheaper than the fossil-fuel alternatives.

Tiwai Smelter

110 The Tiwai Point aluminium smelter (Tiwai) is New Zealand's biggest consumer of electricity. It consumes roughly the same amount of electricity as the MPS generates (around 4,960 GWh of demand compared to 5,140 GWh of generation in 2021).

111 Although the MPS was constructed primarily to supply electricity to Tiwai, there is no dedicated physical connection between the two facilities. Instead, the MPS feeds into the national grid, and Tiwai draws its power from the grid. The contract between Meridian Energy and the owners of Tiwai, New Zealand Aluminium Smelters Limited (NZAS), is a financial instrument that hedges the price of electricity that NZAS purchases from the wholesale electricity market (as described in paragraph 23).

112 There is uncertainty around whether Tiwai will continue to operate and, if not, when it will cease operation. The smelter's electricity purchase contract with Meridian is currently due to expire at the end of 2024. It is possible that the smelter could exit at the end of 2024[23]. Were this to be the case, approximately 5,000 GWh of annual electricity demand would be lost to the New Zealand system.

113 Such a drop in demand would mean the equivalent amount of generation would no longer be needed somewhere on the grid. Although the MPS was originally constructed to power the Tiwai smelter, I expect it would be beneficial for New Zealand to continue to operate the MPS if the smelter were to close. The reasons for this view are:

(a) The MPS is a renewable generator with low short-run marginal costs. It would be more efficient to reduce operation from thermal stations

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[23] NZAS recently released a statement noting that it has begun exploring potential pathways with
electricity generators for the Tiwai smelter's future beyond 2024. See NZAS statement on power discussions | NZAS.co.nz).

connected to the grid (which are expensive to run and have high emissions) than reduce output from the MPS. Previously, a significant proportion of the electricity generated by the MPS could not be exported north due to transmission constraints if the smelter were to close. However, the Clutha Upper Waitaki Lines Project was recently completed. This relieves the constraint, allowing much more generation output to flow northward if needed.

(b) I understand that Meridian and Contact Energy have each been exploring initiatives to stimulate additional demand in the lower South Island (e.g. hydrogen production or data centres). If such demand sources were developed, they could mitigate a drop in demand associated with a Tiwai smelter closure.

(c) As discussed in paragraphs 42 to 45, even if the Tiwai smelter closes, substantial growth in electricity demand is expected over time as households and businesses switch to electricity to decarbonise their energy consumption. This will require unprecedented levels of generation development. Essentially, any generation surplus created by the Tiwai smelter exiting will likely be used up within around 5 years.

(d) The MPS does not just provide renewable energy, but also flexibility and ancillary services to the grid as discussed from paragraph 94.

New Zealand Battery Project

114 As New Zealand increases its proportion of intermittent generation, the ability to store energy for later use will become more important. Through the New Zealand Battery Project, the Ministry of Business, Innovation and Employment (MBIE) is investigating how energy can be stored when it is plentiful (e.g. lakes are full, wind is blowing and sun is shining) and called upon when it is needed (e.g. when it is dry, calm and cloudy/dark). MBIE is investigating a range of solutions, most notably the Lake Onslow pumped hydro project in Otago.[24]

115 If constructed, the Project Onslow solution may be able to store up to 7 TWh of energy. In principle, this could be used to provide energy in dry years, as intermittency back up, and possibly as fast-response reserve.

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[24] Other options include flexible geothermal, hydrogen, and biofuels. See NZ Battery E-news - July 2022 | Createsend.com.

116 MBIE is still in Phase 1 of the New Zealand Battery Project. Indicative business cases for Project Onslow and other options, followed by decisions as to which options to investigate in more detail, are expected by the end of 2022. A more detailed business case and final investment decisions are still to occur in Phase 2. The scale, complexity and cost of this project[25] mean that a final decision on whether to proceed is still very uncertain. If it does go ahead, it is also difficult to know when it will be completed. There is no timetable for the implementation of the project as that would depend on the results of Phase 2 work.

117 Australia's experience with developing pumped hydro schemes re-emphasises the uncertainty involved with projects of this type. The Snowy 2.0 pumped hydro scheme was originally intended to be completed in four years at a cost of $2 billion, but current projections estimate the project will take almost ten years and cost over $10 billion.[26]

118 Putting these uncertainties to one side, I would expect the MPS to continue to provide significant benefits to the New Zealand electricity system even if Project Onslow was to be commissioned. This is because Project Onslow would act as energy storage, not generation. Electricity must come from another source to pump water up to the lake which can later be used for generation. Pumped hydro storage is generally about 75% efficient,[27] meaning that a quarter of stored energy would be lost. Therefore despite having generation capacity, this makes Project Onslow a net user of energy. As mentioned in paragraph 49, as New Zealand decarbonises it will require more flexibility sources, but also an unprecedented amount of new generation. The MPS actually generates electricity, as its reservoirs are filled naturally by rain and snowmelt, not by first using electricity to pump water.

CONCLUSIONS

119 The MPS has significant benefits to the New Zealand electricity sector particularly in the context of decarbonisation.

(a) The generation output of the MPS is particularly significant, as indicated by the substantial economic costs of replacing this output in

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[25] MBIE estimates it will cost about $4 billion.

[26] See Happy birthday to Snowy 2.0 in Australia | IEEFA.org

[27] See Pumped Hydro-Energy Storage System - an overview | ScienceDirect.com

both the short-run ($440-$830 million per year) and the long-run ($6.3-$7.7 billion in present value terms).

(b) The MPS provides a material proportion of the ancillary services that the system operator procures. While the economic costs of providing these services from alternative sources is difficult to calculate, I expect they would be material.

120 There are several uncertainties that face the New Zealand electricity system. However, I do not expect any of these to materially reduce the economic benefit estimates or other conclusions outlined above.

David Thomas Hunt
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29 July 2022