Meeting Date: 4 August 2021

UNDERSTANDING DEMAND FOR ELECTRICITY

SECURITY AND RELIABILITY COUNCIL

This paper gives information about electricity demand forecasting. The main body of the paper is a report from the system operator (with high-level summary) covering its approach, including appendices and extra links for further information.

Note: This paper has been prepared for the purpose of the Security and Reliability Council. Content should not be interpreted as representing the views or policy of the Electricity Authority.

1. Understanding consumer demand for electricity

1.1 The Security and Reliability Council's (SRC) functions under the Electricity Industry Act 2010 (Act) include providing advice to the Electricity Authority (Authority) on:

a) the performance of the electricity system and the system operator, and

b) reliability of supply issues.

1.2 The purpose of this paper is to help the SRC understand the range of electricity demand forecasting over various timeframes and provide assurance about the industry arrangements for demand forecasting.

1.3 This paper is part of a suite of papers the SRC will be discussing, as part of its theme of *Impacts of disruption on the longer-term outlook for security and reliability*.

1.4 This paper does not seek to retrospectively analyse which forecasters have been most accurate, or to examine the incentives on different types of demand forecasters.

2. Questions for the SRC to consider

2.1 The SRC is asked to consider and provide advice on the following questions:

Q1. Does the SRC require further information about demand forecasting?

Q2. What advice, if any, does the SRC wish to provide to the Authority?

Q3. What guidance or feedback does the SRC have for the system operator on its approach to demand forecasting?

Q4. What feedback does the SRC have for the secretariat as to the format and approach to this paper for future meetings?

Appendix A Understanding demand for electricity

UNDERSTANDING DEMAND FOR ELECTRICITY

INTRODUCTION

Load forecasts perform an important role in the market which both the System Operator and market participants use for decision making and information sharing. Forecasting demand is becoming more complex and less certain as the uptake of new technology and electrification increases, in part responding to the need for action on climate change. While no forecast can be 100% accurate, having a reliable forecast helps the System Operator and market participants better understand and prepare for potential future conditions.

This paper seeks to educate the SRC on the range of demand forecasts used by the System Operator over various timelines and provide assurance about the industry arrangements for demand forecasting as the forecasting environment becomes more complex.

1

DEMAND FOR ELECTRICITY

Historical demand trends

Electricity demand in GWh (energy) has been relatively flat over the past decade compared to strong growth seen in earlier decades where approximately 2% year on year increases were observed. In recent years the following factors have put downward pressure on energy demand offsetting factors that would otherwise drive demand growth:

- Some reduction in industrial demand, for example, at Norske Skog Tasman Mill, Pacific Steel, and Tiwai.
- Improvements in household energy efficiency, through uptake of more efficient appliances.
- Increase in embedded generation.

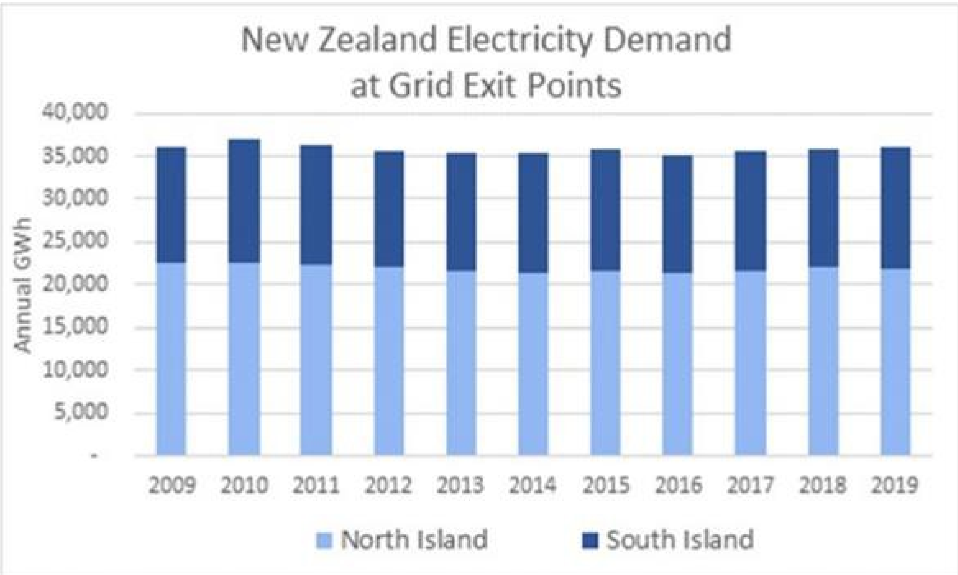

Figure 1: New Zealand Grid Exit Point electricity demand (GWh)

Electricity peak demand in MW is more variable due to the influence short cold snaps has on heating load. With the exception of 2011, peak demand has followed a similar trend to energy, with flat growth in the last decade following approximately 1.5% year on year growth. Factors contributing to this are:

- More efficient homes.
- More efficient appliances used during peak demand periods such as heat pumps, and lighting.

- More embedded generation.
- Load control by Electricity Distribution Businesses (EDBs) in response to Transpower's Regional Coincident Peak Demand (RCPD) transmission charge.

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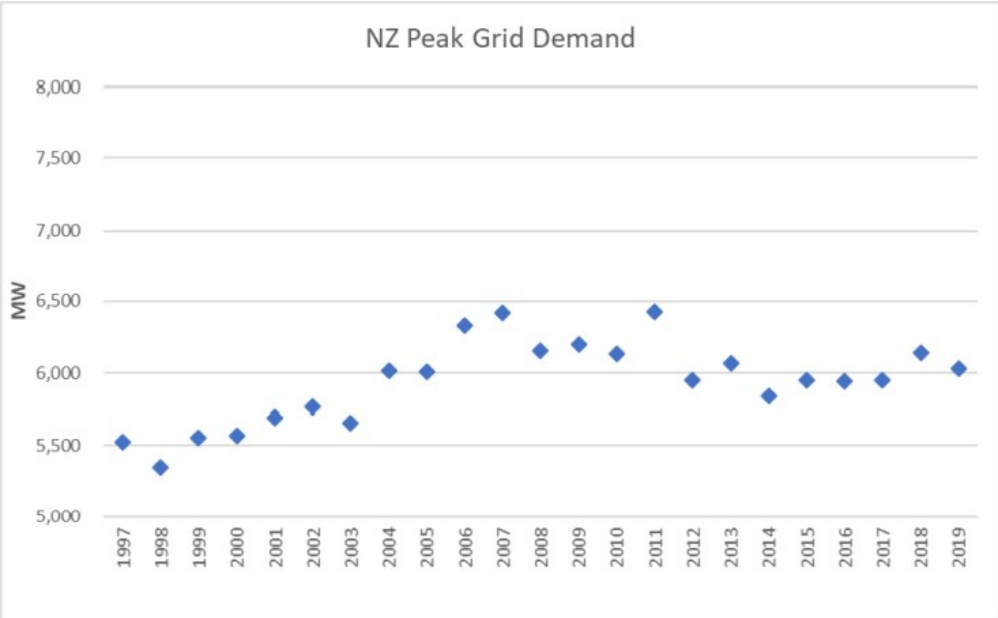

Figure 2: New Zealand peak grid demand

Effect of climate change and new technology

The climate is changing. To mitigate climate change and meet its Paris accord commitments, the New Zealand government is adopting policies that increase electrification and renewable generation. Examples of some of these technologies are electric vehicles (EVs), solar PV, wind farms, household batteries, energy management systems, and electrification of coal boilers and process heat.

Examples of current government policy that will affect demand are:

- Government clean car discount. This will incentivise increased EV uptake. When and how EVs are charged has the potential to increase peak demand, and growth in EVs will increase total demand.
- Banning new coal fired boilers and providing $70 million funding to support transition. Increased electrification of these process heat applications will increase demand for electricity.
- Banning offshore exploration permits. This is supporting growth of renewable energy such as wind and solar. Wind and solar are intermittent generation which is often embedded. Embedded intermittent generation increases the complexity of forecasting demand[1].

Future government policy is uncertain. However overseas observations provide insight into how uptake of new technology impacts demand, such as solar PV. Our demand forecasts do not try and predict government policy, but instead look at various uptake levels of different technologies and the impact they may have on demand. We do know that:

- Policies which increase the uptake of new technology will change the daily demand shape, increasing the complexity of medium-term forecasting (1 - 7 days). This will require more flexible forecasting arrangements to meet fast-changing needs. It will also require more complex algorithms and specialised knowledge to understand these multi-faceted factors. In addition, it will require more scenario analysis to inform of a wider range of outcomes. Examples of the

[1] This is because they are "behind-the-meter" and their output is only currently visible through the net impact they have on the demand measured at the grid exit point (GXP).

types of technologies that require this consideration are solar PV, EV charging, batteries, and household management systems.

- Policies that increase electrification will not only increase demand for electricity but may also be partly offset by efficiency gains. This creates increased uncertainty around pace of demand growth. This requires demand forecasts with a range of scenarios with descriptions of the assumptions underpinning them.

Different demand forecasts used by the System Operator

As System Operator we use three different demand forecasts - a medium term load forecast, forecasting 30 minutes to 14 days ahead; a 200-day monthly peak demand forecast; and a long-term peak and energy demand forecast. We also use a short-term forecast which is a 5-minute forecast used for dispatch, this is outside of the scope of this paper.

Medium-term load forecast

This is a tool provided by General Electric (GE) and is embedded in the market system. Its key inputs are temperature, time of use, and load history. It supplies demand into the forecast schedules, which are used by both the System Operator and market to co-ordinate resources in an efficient and reliable way.

Monitoring

The System Operator controllers monitor the medium-load forecast accuracy daily, using specified processes to manually adjust if required. Each time the forecast is adjusted, the controllers record the action in the operator log.

We also monitor the medium-load forecast accuracy monthly to identify continuous process improvement initiatives. Recent examples of where we have made improvements are:

- Process for managing school holidays
- Incorporating increased frequency of temperature updates from the MetService.

An example of our monthly forecast accuracy reports is in Appendix 1.

Current initiatives underway

We are currently in the process of developing an interface that will allow the System Operator to import an externally created load forecast into the market system. This will allow the System Operator to buy a load forecast as a service rather than it being an embedded application. Importing the forecast as a service removes the significant costs associated with changing applications. This provides the System Operator flexibility to choose different providers with different specialist expertise to cater for changing needs. We will also be retaining our existing tool as a backup.

Other providers

The System Operator is aware of at least two forecast providers that are currently providing medium-term forecasts in New Zealand. We are currently developing a request for proposal from the market. As such it is not appropriate to comment further on those providers. However historical analysis on external providers has indicated that there is opportunity for an improved medium-term load forecast through using a specialised service.

200-day monthly peak demand forecast

A 200-day peak demand forecast is created by the System Operator using historical peak demand. This is used in the New Zealand Generation Balance (NZGB). NZGB is a high-level indicator to both us and market participants of spare generation capacity (or generation balance) over the next 200 days. Participants use this to assist in planning outages.

The monthly NZGB reports provides results using three demand forecast scenarios:

- Base scenario: based on similar period from last year plus a growth/buffer factor
- Winter scenario: based on last 3 years winter months (Jun-Aug) plus a growth/buffer factor
- Users can also choose to use a short-term demand forecast that looks at the highest peak load in the last three weeks.

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Other sensitivities are applied to the supply side, such as low wind, or gas.

Monitoring

We monitor for events that may exceed the demand assumptions in NZGB and adjust accordingly. For example we changed the forecast to use the higher of 2019 or 2020 historical peak demand to account for effects of lockdown seen in 2020.

Current initiatives underway

Looking forward we have surveyed Electricity Distribution Businesses (EDBs) to understand the impact removing RCPD transmission charge will have on demand. As a result we are currently in the process of adjusting the growth/buffer.

Other providers

The System Operator is not aware of other forecasters providing a peak demand forecast of this nature. However, given the formula is relatively simple for the System Operator to generate we have not performed a market scan.

Long-term peak and energy demand forecast

This is a 50-year forecast provided to the System Operator by Transpower as the Grid Owner. The System Operator uses the first 10 years of this forecast in creating:

- Security of Supply Annual Assessment (SoSAA). This provides a ten-year view of supply and demand balance for both peak and energy needs. It is used by the market participants to inform investment decisions, and signal over or under supply ahead years in advance.
- System Security Forecast (SSF). This assesses the ability of the System Operator to meet our principal performance obligations and provides information to market participants on power system constraints over the next three years. As transmission constraints can introduce large locational price differences in the nodal spot market, market participants use the SSF to better understand the impacts of transmission constraints to inform their own decisions on potential risk management strategies.
- Electricity Risk Curves (ERCs). These show the risk of running out of hydro storage over a period of up to 24 months. This is used by the market to manage resources to avoid shortage, by key stakeholders as an indicator of our exposure to low inflow events, and they set the point at which the customer compensation campaign and the official conservation campaign begin.

The Grid Owner uses an ensemble approach to forecasting, combining four different forecasting models. The benefits of using an ensemble approach is that the forecast load is not tied to one view of how load can change over time.

The demand forecast approach used by the Grid Owner has recently changed to a two-stage process outlined in the Transmission Planning Report[2]. Stage 1 considers how underlying, business-as-usual growth will evolve. Stage 2 considers how the uptake of electric vehicles, solar PV, battery storage and industrial electrification will impact demand. The forecast also considers specific information from EDBs and major users of electricity about their expectations of future demand and developments in their areas. This is a complex process, involving information from a wide variety of sources.

We review this forecast and based on the specific input requirements of the analysis being undertaken, apply post-processing adjustments accounting for embedded generation, losses and demand response. This high-level process is shown in Figure 3.

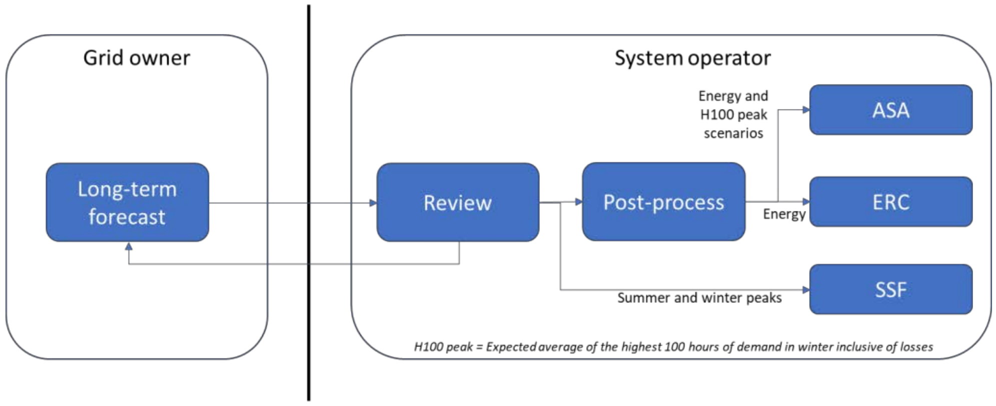

Figure 3: High-level process for the System Operator long-term load forecasts

We currently use the Grid Owner forecast as we are able to leverage the Grid Owner expertise in developing a long-term forecast of peak and energy demand. Other advantages are:

- **Efficiency:** We do not have to duplicate the data collection, data processing and long-term forecast model development and maintenance. Doing so would require additional specialised System Operator resources.
- **Predictability:** There is greater consistency between the data and models used within the operational and planning functions reducing the likelihood of mixed signals being sent to the industry.
- **Robustness:** We apply an independent, operational lens when reviewing the load forecasts provided to us. Potential issues are fed back to the Grid Owner. This helps the Grid Owner improve the robustness of the long-term forecast. The System Operator has a demand forecasting committee

By using the Grid Owner forecasts this means we benefit from the assurance that other parties are using and/or reviewing the forecast. These parties include:

- Periodic independent reviews to help ensure the Grid Owner is following good forecasting practice.
- Reviews by Transpower's transmission planning and strategy teams as part of their workflow processes when using the forecasts[3].
- Reviews by parties involved in the grid investment consultation process
- Reviews by external consultants as part of Transpower's regulatory control period (RCP[4]) independent verification process

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[2] Transpower's *Transmission Planning Report 2020*: https://www.transpower.co.nz/sites/default/files/publications/resources/TPR%202020.pdf

[3] The Grid Owner forecasts are also used to support grid investments and Transpower's strategy, Te Mauri Hiko.

[4] The RCP is a 5-year period over which Transpower's expenditure and proposed performance measures are set by the Commerce Commission.

- Reviews by distribution companies, particularly regarding local developments and their expectations for growth at each grid exit point (GXP)

Monitoring

We monitor the environment for step changes in demand such as when large users start or terminate their business. Adjustments or scenarios can be made to the demand forecast used in the Electricity Risk Curves through the monthly update cycle. For example, when the future of Tiwai was uncertain in 2020 we ran and published scenarios with and without Tiwai load.

The long-term forecast we receive from the Grid Owner is reviewed annually and where issues have been observed we raise these directly with the Grid Owner for resolution. We also have input into the long-term load forecasting function through our representation on Transpower's demand and generation modelling governance group.

Current initiatives underway

We have recognised that the demand forecast in the Electricity Risk Curves should be updated more frequently than annually. A more frequency update cannot be provided by the Grid Owner. From Q4 2021, Energy Link who perform the risk modelling used in the Electricity Risk Curves will be providing the demand forecast instead of the Grid Owner. This will enable quarterly updates. It will also enable general movement (non-step changes) in demand to be included outside of an annual update.

We are working with the grid owner on improving the transparency and publication of the assumptions behind their long-term forecast.

Other providers

The Ministry of Business, Innovation and Employment (MBIE) also provide a demand forecast as part of its Electricity Demand and Generation Scenarios (EDGS) publication. This forecast is at a higher level providing an indication of the expected annual energy in 2050 and does not provide the required detail.

Appendix 2 describes how both the Grid Owner and MBIE forecasts use scenarios to model different assumptions.

A comparison of MBIE forecast and scenarios relative to the Grid Owners are shown in Figure 4.

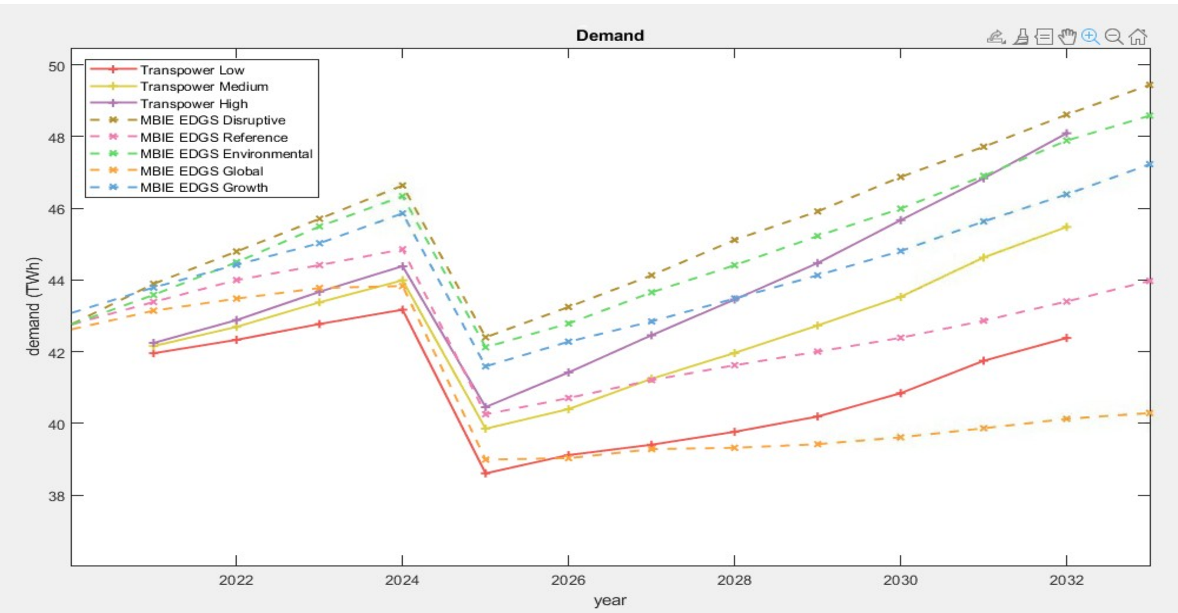

Figure 4: A comparison of MBIE forecast and scenarios relative to the Grid Owner forecasts

Transpower's demand forecasts show an increased growth rate in demand compared to the MBIE forecasts due to a faster uptake of electric vehicles and electrification of process heat aligned with Whakamana i Te Mauri Hiko – Empowering our Energy Future. For comparison, in 2032, MBIE EDGS Reference has a forecast for demand of 0.9 TWh and 0.6 TWh for electric vehicles and process heat respectively, whereas the Transpower's medium-term load forecast has 2.5 TWh and 3.1 TWh'.

Other forecasting initiatives

While load forecasting and associated price are a source of uncertainty in the market schedules, increased penetration of intermittent generation is also likely to exacerbate this situation. To help understand this effect, we have trialled a wind forecast tool, comparing the wind forecasts against the quantities submitted by market participants for their wind generation. The comparisons undertaken indicate the wind forecast tool could assist in providing better estimates of wind generation capability compared to the total quantity offered by market participants, particularly further ahead of real time, as shown in Figure 5.

The System Operator is planning to undertake further investigative work in the 2021/22 financial year on intermittent generation forecasting and how this can help drive improved accuracy into its security planning and market schedules. This will assist with managing power system security and improve market price signals. There is also a future wind forecast service enhancement project in our roadmap. Currently this is not expected until 2026/27 and is subject to Electricity Authority approval. This project will also be informed by the further investigation work discussed above.

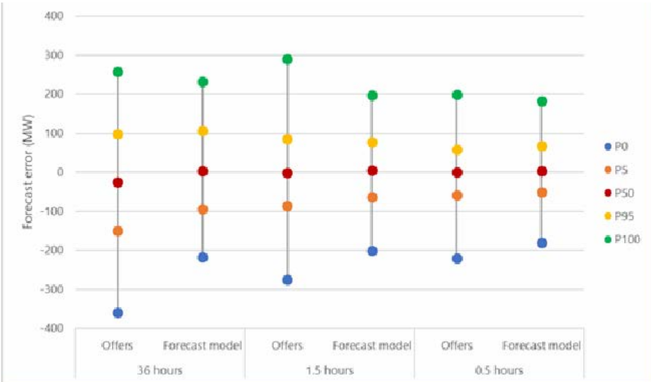

Figure 5: Comparison of percentile errors at different forecast horizons between wind generation offers and trial forecast model

CONCLUSION

Climate change is happening, this is being reflected in government policy which is incentivising electrification and the uptake of new technologies. Government policy will accelerate change, not prevent it. We can no longer use history as an indicator for future trends.

Electrification and new technology will increase demand for electricity and create a much more complex daily load profile. Both of these outcomes increase uncertainty. The challenges for the System Operator are ensuring we are:

- flexible to change as our needs change
- able to utilise specialist forecasting services
- show uncertainty through a range of scenarios
- transparent in our assumptions, when we can.

We are addressing many of these challenges through ongoing pieces of work. And where we are currently unable to meet these needs, we have initiatives underway. Such as:

- The System Operator is changing the way we produce medium term load forecasts, increasing our flexibility allowing us to use specialist services as our needs evolve. We are also working with the grid owner to increase transparency of the assumptions used in their scenarios.

- We continue to monitor for changes in the environment and adjust as needed, changes the growth rate in the NZGB in response to RCPD is a prime example of this.

The initiatives we are pursuing are aimed at ensuring the System Operator is well-placed to continue to provide high quality, robust forecasts and scenarios to support both the System Operator functions and the market in an uncertain environment.

Appendix 1: EXAMPLE OF MONTHLY LOAD FORECAST ACCURACY REPORT

This is available on our website *here*

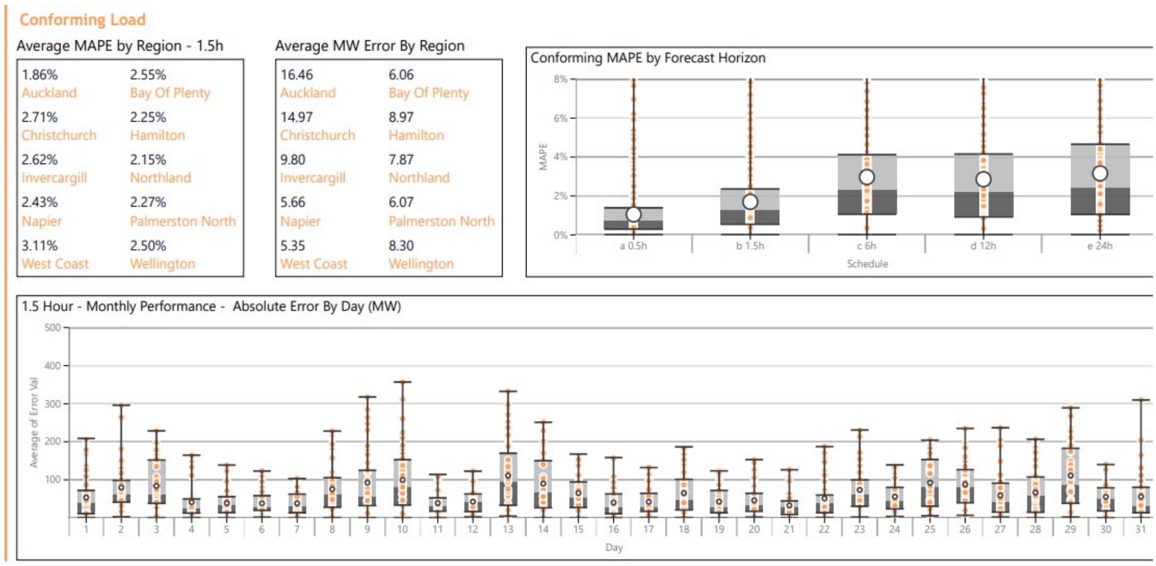

Figure 6: Example of monthly load forecast accuracy report

Appendix 2: ALTERNATIVE LONG-TERM FORECAST SCENARIOS

Transpower uses scenarios to show a range of potential futures with different levels and uptake profiles for new technologies. These are set out in Whakamana i Te Mauri Hiko - Empowering our Energy Future (WiTMH) and summarised in Figure 7 below. More details can be found in the WiTMH modelling appendix, available on Transpower's website[5]

10 For the purposes of planning, Transpower complements its business-as-usual modelling with the assumptions in the most likely scenario to form the expected base case forecast – the one selected is the Accelerated Electrification scenario. This "expected forecast" is used in the Annual Security of Supply Assessment as the medium forecast. The high and low forecasts are created by altering the different base growth rates – the low forecast looks at the recent trend of small growth, the high forecast uses a longer period over which the growth rate is higher. The assumptions used to determine the uptake of new technologies for the low and high forecasts also vary slightly to the Accelerated Electrification assumptions, but are consistent with other scenarios in WiTMH.

In comparison, in the long-term forecast for Transpower's Planning Report, the first seven years of the expected forecast are replaced with a P90 forecast of the base growth (where there is only a 10% chance of exceedance) to provide a "prudent forecast".

WiTMH SCENARIOS

The base case: **'Accelerated Electrification'** Accelerated Electrification presents a realistic yet aspirational scenario for the New Zealand economy and electricity industry. It anticipates a large-scale transformation that will require integrated, coordinated planning and action from across the economy and government.

'Electric Tiwai' Exit The scenario assumes the same context as the Accelerated Electrification base case with the only difference being Tiwai's staggered exit between 2021 - 2025 and the requirement to expand transmission capacity to move more electricity north to sources of demand.

Higher electricity demand: **'Mobilise to Decarbonise'** The assumptions behind the scenario is that the world is currently sitting on its hands, on a track to a climate disaster. The scenario assumes that at some point the world gets serious and moves into rapid action. When this occurs, we will mobilise and the response to climate change will be much stronger and urgent. It is not the rate of development of technologies that will change under this scenario, but rather the strength of the decarbonisation effort.

Slower case: **'Measured Action'** The 'Measured Action' scenario tests a variant of the base case in which slower electrification of transport is realised. It assumes the same context as the base case with the only difference being electric vehicle adoption occurring more slowly.

Lower case: **'Business as Usual'** This scenario envisions a future in which other policy mechanisms to manage the effects of carbon, such as forestry abatement, are prioritised over emissions reduction via electrification.

Figure 7: WiTMH scenarios

The Ministry of Business, Innovation and Employment (MBIE) also uses scenario planning in its forecasts shown in Figure 8. These electricity demand and generation scenarios (EDGS) were published in July 2019. EDGS explores future levels of electricity demand and how it could be met out to 2050 under five scenarios. The EDGs scenarios encompass the equivalent of both Transpower's

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[5] WiTMH modelling: https://transpowernz.sharepoint.com/sites/volt/W4NZ/TMH/Documents/Whakamana%20i%20Te%20Mauri%20Hiko%20Appendix.pdf

base-case and new technology scenarios. More details are contained in the document "Electricity demand and generation scenarios: Scenario and results summary"[6]

MBIE EDGS SCENARIOS

Current trends continue (Reference Case). The central theme of this scenario is that long-term historic trends continue, with minimal disruption. This scenario could be characterised as the "business as usual" situation, against which the other scenarios are compared.

Accelerated economic growth. Higher immigration drives increased population growth, while policy and investment focuses on priorities other than the energy sector.

Global economic changes. New Zealand's economy is battered by international trends, leaving little room for growth or innovation.

Sustainable transition. Strong environmental leadership driven by regulation and incentives, rather than technology.

Disruptive technologies are developed. New and improved technologies enable rapid and disruptive transformation in the energy sector.

Figure 8: MBIE EDGS scenarios

[6] EDGS scenarios: *https://www.mbie.govt.nz/dmsdocument/5977-electricity-demand-and-generation-scenarios*