Meeting Date: 22 February 2024

FUTURE POWER SYSTEM OPERATION

SECURITY AND RELIABILITY COUNCIL

This paper introduces papers and presentations on the theme of Future Power System Operation. The secretariat has been asked to provide the SRC with material to support its understanding of this important topic and its advice to the Authority.

Future Power System Operation

1. Introduction

1.1. The SRC has asked the secretariat to provide information on the issues relevant to future power system operation, to support its advice to the Authority on issues impacting power system security and reliability.

1.2. Drivers for this work include the changing composition of generation assets, repurposing and retirement of thermal assets, increasing demand-side participation and the increasing need for real-time information and coordinated control of grid and non-grid solutions.

1.3. The projected levels of increased demand, increased intermittent generation in the system, transitional thermal peaking and addressing capacity constraints all require investment underpinned by suitable market signals and a receptive regulatory framework.

1.4. Members have expressed the need for coordination and planning to ensure a cohesive or joined up regulatory approach that remains technology agnostic and supports such investment is in place. In this work, members have noted the importance of challenging previous assumptions and understanding incentives to properly inform policy and decision-making.

1.5. To support this theme the secretariat has arranged for presentations from the Authority on its current and future-proposed workstreams. This information will be presented by the Policy Operations team and Future Security and Resilience team (covering short, medium and long term).

1.6. As the SRC has also asked for a detailed update on winter initiatives (agenda item #10) much of that material covers the short-term Authority work relevant to item #7 (future power system operation). To avoid duplication, on the day the Authority presentation for the future power system operation theme focuses on the medium to long term, with shorter term covered in item #10.

1.7. These presentations will be complemented by presentations from the system operator and grid owner and include, where relevant, lessons from overseas.

1.8. This information will support the SRC to advise the Authority on where there may be gaps, where additional resources may be needed and potential opportunities for collaboration and efficiencies and to reduce risk.

1.9. Members are encouraged to consider additional areas of focus or methodology, ask questions, and provide feedback.

1.10. The presentations and papers are included as Appendices 8a, 8b, and 8c to this paper.

2. Questions for the SRC to consider

The SRC is asked to consider the following general questions.

Q1. What further information, if any, does the SRC wish to have provided to it?

Q2. What gaps, overlaps or inefficiencies need to be addressed and by whom?

Q3. What additional information-sharing across the sector is desirable to support current and future workstreams?

Q4. What advice, if any, does the SRC wish to provide to the Authority?

Appendix A: The Authority's work on future power system operation

Appendix B: System operator support for industry evolution

Appendix C: Grid owner perspectives on future power system operation

The future of system operation

22 February 2024

Executive summary

This paper is prepared for the Security and Reliability Council to discuss at its February 2024 meeting. This paper covers the Authority's reflection on how the power system will change in the medium to long term from a security and resilience point of view, relevant developments in Australia, and the benefits and risks of Artificial Intelligence for the power system.

A changing power system and the impact on security and resilience

New Zealand's power system is in the process of an unprecedented transformation as the country transitions to a more electrified economy with lower emissions. This transition will have a significant effect on the operation of the power system and challenge the general assumptions held in the sector.

In 2022 the Authority started the Future Security and Resilience (FSR) work programme to ensure New Zealand's power system remains secure and resilient during the transition. The Future System Operation (FSO) workstream is part of the FSR work programme and looks at the potential challenges and opportunities associated with future power system operation.

On 15 February 2024 the Authority released a consultation paper, *The future operation of New Zealand's power system* (the FSO consultation paper) to progress this work stream. This paper is the starting point for an ongoing discussion with stakeholders on what may be needed for the future operation of the power system.

The FSO consultation paper acknowledges the role of consumers and their interactions with the power system are expected to change significantly in the future as consumers purchase more distributed energy resources (DER) such as rooftop solar, electric vehicles and batteries. The purpose of the FSO paper is for the Authority to test its understanding of the challenges and opportunities with stakeholders which will then inform whether any measures are needed to address these.

Lessons from Australia relevant to New Zealand

Many developed countries are transitioning to a low emissions economy and the Authority is mindful that we can learn from others. As part of the FSO work, we commissioned EY to do an international literature review, including Australia. The EY report noted that the characteristics of each country's energy system determined the challenges and opportunities they face.

Looking to Australia, we must be mindful of the differences between our power systems such as New Zealand having a much bigger proportion of renewable electricity and Australia having a much more complex power system structure. Despite these differences, there are opportunities to learn from Australia. For example, Australia has world-leading rates of distributed (rooftop) solar adoption and as a result, they have an advanced response for managing high penetration of DER and dealing with emerging operations challenges associated with high levels of instantaneous non-synchronous renewable penetration.

The benefits and risks of Artificial Intelligence to future power system operation

Artificial Intelligence (AI) techniques can be very helpful throughout the power system. For example, it can reduce computational time, keep consumer costs down and can contribute to the reliable operation of the power system. While AI has benefits, some risks and trade-offs will need to be considered when using this technology. For example, environmental impacts, data privacy issues and ethical issues relating to how prioritising decisions are made by AI.

Contents

1. Purpose

1.1. This paper is prepared for the Security and Reliability Council to discuss at its February 2024 meeting. It sets out the challenges of the medium and long term operation of the power system from a security and resilience point of view, with a specific focus on:

(a) the Authority's reflection on how the power system will change in the future, including current assumptions, and the impact on security and reliability

(b) relevant developments in Australia, particularly around network planning

(c) benefits and risks of Artificial Intelligence for power system operation.

2. A changing power system and the impact on security and resilience

2.1. New Zealand's power system is in the process of an unprecedented transformation as the country transitions to a more electrified economy with lower emissions. This transformation will include more renewable electricity generation, increased use of distributed energy resources, more participants in the electricity system (including consumers), as well as new ways to participate.

2.2. These changes will have a significant effect on power system operation and challenge the general assumptions held in the sector, including:

(a) large and centralised synchronised generation

(b) one-way transmission / distribution flow

(c) relatively stable and predictable demand growth

(d) fossil fuel energy storage to balance supply and demand

(e) infrastructure built for peak demand.

2.3. While it is clear that these assumptions will change in the future, it is not clear how the power system will be impacted. In 2022 the Authority started a multi-year work programme – Future Security and Resilience (FSR) - to ensure New Zealand's power system remains secure and resilient during the transition. The FSR work programme is just one of a range of the Authority's projects supporting New Zealand's transition to a low-emissions energy system.

2.4. What is certain is that coordinating the operation of New Zealand's power system will need to evolve to accommodate and facilitate the changes occurring in the electricity sector. Coordinating the operation of New Zealand's power system will become more complex as more variable and intermittent generation and load resources connect to the power system and the flow of electricity across the power system becomes increasingly bi-directional.

2.5. The Future System Operation workstream (FSO) is part of the FSR work programme and looks at the potential challenges and opportunities associated with future power system operation. On 15 February 2024 the Authority released a consultation paper, *The future operation of New Zealand's power system* (the FSO consultation paper) to progress this workstream. This paper is the starting point for an ongoing discussion with stakeholders on what may be needed for the future operation of the power system.

2.6. The FSO consultation paper starts from the premise that coordination of the power system involves all components of the New Zealand electricity system that underpin the New Zealand electricity market, including generation, transmission, distribution, and load (demand) assets.

2.7. System operation is the real-time coordination of the electricity system, and the system operator role is performed by Transpower. The system operator is responsible for the scheduling, pricing and dispatch of electricity in real time, avoiding fluctuations in the frequency and voltage of electricity supply, or the disruption of electricity supply. Transpower also has the role of grid owner which involves planning, building and maintaining the transmission network.

2.8. As mentioned above, there are also important roles for other participants, for example distributors must plan, build, maintain and operate their distribution networks, and ensure there is adequate co-ordination with the system operator.

How can the future operation of the power system give consumers what they want?

2.9. The power system is expected to evolve to give consumers new ways of interacting in the power system. Consumers will be able to produce electricity as well as consume it.

2.10. The efficient development of the power system and its operation is essential to the long-term benefit of consumers. The power system must enable consumers to participate actively in the power system, as they purchase distributed energy resources (DER) including rooftop solar, electric vehicles (EVs), EV chargers and batteries.

2.11. Things consumers should be able to do to exploit the potential value of their investment in DER are:

(a) defer their consumption of electricity if it is too expensive or as demand response

(b) advance their consumption of electricity if it is cheap by storing it for later

(c) produce electricity for some part of their own consumption (thereby becoming a ‘prosumer’), including when there is a power outage

(d) consume electricity from their own storage (whether they have produced it themselves or charged their batteries from the network)

(e) sell electricity produced or stored by themselves, whether it is excess to their needs or when it is required by other participants in the power system.

2.12. These potential changes to the participation of consumers in the power system should enable consumers not only to exploit their investment in DER but also to become more independent of the network and more resilient to disruptions.

2.13. However, consumers will only benefit fully from their investment in DER if there is better co-ordination of the power system, which requires much more granular and real-time information on the existence and status of DER so they are visible to distributors, flexibility traders and the system operator.

Changes in the sector that might impact security and reliability

2.14. The transition to a low-emissions economy brings significant changes to the operation of the power system. These changes are related to several factors, including the electrification of heat processes, the uptake of rooftop solar, EVs and their chargers, and a greater reliance on weather-sensitive wind and solar generation.

2.15. The FSO consultation paper notes the drivers of changes to the power system, and the opportunities and challenges that these changes create. The purpose of the FSO consultation paper is for the Authority to test its understanding of these issues with stakeholders to decide whether any measures are needed, and if so, determine what they should be and when they will be needed.

2.16. The key drivers expected to affect power system operations are the changes in generation technology, consumer technology, operational technology, information technology, extreme weather events and the electrification of key sectors of the economy.

2.17. The following questions are posed to stakeholders in the FSO consultation paper:

(a) Is there sufficient coordination of system operation?

(b) Are existing system operation obligations/requirements compatible with DER and variable and intermittent generation?

(c) Is there sufficient coordination of network planning?

(d) Are there significant conflicts of interest for participants involved in more than one of the roles that include network ownership, operation and planning?

2.18. The proliferation of energy resources, driven by the uptake of DER is causing increasingly bi-directional flows of electricity, and these two aspects are driving a huge increase in the complexity of system operation. In turn, that leads to an enormous increase in the need for timely and granular information on the location and status of DER.

2.19. In addition, the weather is now just as important for the supply of electricity as it always has been for demand. The demand for electricity has always been driven partly by the need for heating in winter and for cooling in summer. Now, the transition to renewable energy resources means more wind and solar generators, which both depend on the weather to generate electricity.

2.20. Therefore, it is more critical than ever to have accurate and up-to-date weather forecasting to co-ordinate the power system. This and the need for greater DER visibility are both leading to massive increases in the need for real-time and granular information.

2.21. The processing of all this complex and dynamic information cannot be accomplished by humans, but requires increasingly sophisticated information processing algorithms, such as machine learning software, in other words artificial intelligence (AI) systems.

2.22. The changes in power system operation that are being driven by the transition and by technology is explored in the Authority’s FSO consultation paper. Similar thinking is happening in other countries, including Australia, to which we turn next.

3. Lessons from Australia relevant to New Zealand

3.1. New Zealand is not the only country transitioning to a low emissions economy. Many developed countries have the same goal and are experiencing similar challenges. The Authority is very mindful of the experiences in other countries and what we can learn from others.

3.2. As part of the FSO work, the Authority commissioned EY to do an international literature review in 2023 on the key challenges and opportunities in six jurisdictions[1] and their responses now and in the future. This report has been included in the FSO consultation paper.

3.3. The EY report found that the most relevant and pressing challenges and opportunities for each of the jurisdictions varied depending on the characteristics of their energy system.

3.4. The SRC has asked the Authority's view on what lessons we can learn from Australia that are relevant to New Zealand. In particular, from the Australian Energy Market Operator (AEMO), the Australian Energy Regulator (AER), Australian Energy Market Commission (AEMC), and the Energy Security Board. In assessing what these are, we also need to be mindful of the differences between our two power systems.

Differences between Australia and New Zealand power systems

3.5. New Zealand has a much greater proportion of electricity generated from renewable sources - about 80 to 85 percent compared to 30 percent in Australia.

3.6. The power system in New Zealand and Australia is structured very differently. In New Zealand, Transpower perform both functions of system operator and grid owner.

3.7. Australia has a much more complex structure. The Australian power system is operated by the AEMO, similar to New Zealand's system operator. Transmission network service providers (TNSPs) build, maintain, plan and operate the network transmission networks in the NEM.[2] The NEM refers to both the wholesale electricity market and the physical power system.

Lessons from Australia relevant to New Zealand

High DER penetration

3.8. Australia has world-leading rates of distributed (rooftop) solar adoption, most likely due to government subsidies. Rooftop solar accounts for 8 percent of Australia's electricity generation. As a result, Australia has an advanced response for managing high penetration of DER and dealing with emerging operational challenges associated with high levels of instantaneous non-synchronous renewable penetration. For example, with high solar penetration, Australia has found that supply is much higher than demand in the middle of the day, resulting in curtailment and 'spill' of generation. This requires Australia to develop mechanisms to 'time-shift' loads to the

[1] Australia, Great Britain, Ireland, Nordics, California Independent System operator (CAISO) and Pennsylvania New Jersey Maryland Interconnection (PJM), the independent system operator for 13 US states

[2] The NEM operates in New South Wales, the Australian Capital Territory, Queensland, South Australia, Victoria and Tasmania. Western Australia and Northern Territory is separate from the interconnected NEM.

time of day where the generation is required. New Zealand can benefit from the same mechanisms to help us shift generation to calm and cloudy evenings where solar and wind generation would be insufficient to meet demand.

Managing variability and uncertainty in power system conditions

3.9. Similar to New Zealand, the NEM is currently undergoing a transition as capacity-limited thermal generation retires and more weather-dependent variable renewable energy enters the system. This changing profile gives rise to an increase in variability and uncertainty in the power system.

3.10. In 2020, the AEMC consulted on the introduction of an Operating Reserve Market to help respond to large continuing changes in energy requirements. They made a draft determination in December 2023 not to progress this option because it would not offer any material performance improvements relative to the current arrangements while introducing significant additional costs for consumers.

3.11. This view was supported by modelling that showed a fleet that evolves to firm renewables with very flexible storage technologies would likely be well-placed to manage variability and uncertainty through the transition.

3.12. The AEMC is instead focusing on incremental changes to improve information transparency and forecasting, with relation to security and reliability. This includes publishing information on energy availability such as state of charge (the energy availability of batteries), daily energy constraints (energy constraints on other scheduled plant types) and maximum storage capacity.

3.13. These improvements will provide the opportunity to observe the future fleet's response to changes in market signals before introducing any complex changes.

3.14. The Authority is currently seeking feedback on similar issues through its consultation paper on *Potential solutions to peak electricity capacity issues*.[3] Consultation closes on 1 March 2024.

Roadmap for the Australian transition

3.15. Similar to New Zealand, Australia (AEMO) has developed a roadmap for the transition of the NEM power system - Draft 2024 Integrated System Plan (ISP) – which is published every two years. The plan outlines the lowest-cost pathway of essential generation, storage and transmission infrastructure to meet consumers' energy needs for secure, reliable and affordable energy to achieve net zero emissions targets.

3.16. The ISP is focused on ensuring the NEM has the capacity to triple its supply energy by 2050 to replace retiring coal capacity and to meet increased electricity demand. This must be managed carefully as other countries are going through the same transition and will be drawing on the same pool of resources for renewable energy generation equipment and the human resources needed to build and install it. For example, there is significant investments under the US Inflation Reduction Act, and the Japanese Green Development Strategy, among others.

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[3] https://www.ea.govt.nz/documents/4385/Consultation_paper_-potential_solutions_for_peak_electricity_capacity_issues.pdf

3.17. The Draft ISP sets out scenarios for reaching net zero by 2050 and settles on ‘step change’ as most likely to be the ‘Optimal Development path’. This involves some $121 billion of transmission augmentation, and utility scale generation and storage capex, out to 2050. However, it excludes consumer energy resources, distribution network upgrades and an explicit cost of carbon.

3.18. Assuming these investments can be delivered, they must also be paid for by consumers, which leads to potential affordability concerns. The AER notes that short-term affordability is only protected if investments are repaid over long-term schedules that do not penalise current consumers. The ISP assumes that these payment schedules are adopted by investors and reflected in wholesale energy markets.

3.19. This logic only works if the increase in electricity infrastructure (and therefore electricity supply) is matched by the increase in demand for electricity by consumers. The AEMO realises this as a problem of timing, requiring its judgement about balancing the risks to consumers of investments being made too early (and causing higher prices to the extent some are not needed in the end) versus being left too late (and causing security and reliability problems).

3.20. An important lesson for New Zealand is that to bolster its own ‘judgement’ on reliability and security matters, the AEMO surveyed and met in person with residential consumers across the NEM about their risk preferences and found that consumers generally prefer somewhat early investments to be made.

Renewable energy zones to connect renewables

3.21. To ramp up renewable electricity generation, some Australian States have introduced renewable energy zones (REZs) to encourage investment. AEMO states that renewable energy zones (REZs) are selected for the quality of their renewable resource, and their proximity to consumers and existing transmission. They list certain benefits of REZs, including more coordinated and effective community consultation, and sharing the costs of transmission, connection and support infrastructure (such as weather observation stations) across multiple projects.

3.22. In its draft 2024 ISP, the AEMO seeks to optimise resource diversity, with the right level of expected economic spill (when generation reduces output due to market price) and transmission curtailment (when generation is constrained down or off due to congestion), to maximise the rollout of renewable generation (excluding DER) while minimising the transmission network expansion.

3.23. Renewable energy developers, network companies and governments are responsible for developing REZs, including early and active engagement with communities, land title holders and affected persons as part of the detailed design of REZs.

Transpower and renewable energy zones

3.24. New Zealand has also explored REZs. Transpower[4] sees REZs as when multiple parties agree to co-locate and share the costs of a single connection to the grid, as well as possible network upgrades required to enable the new load. REZs can bring

[4] See https://www.transpower.co.nz/projects/renewable-energy-zones

new renewable generation onto the grid, and/or help large industrial energy users connect into the grid and electrify their operations.

3.25. Transpower recognises the REZ model provides efficiencies of time and planning as well as cost. Northland was selected as a possible location to test the concept of a REZ in New Zealand. Working together with Top Energy and Northpower, the test provided an example for stakeholders to consider, and to indicate the potential for REZs in New Zealand.

3.26. The Transpower REZ consultation in 2022 generated wide interest and engagement on the proposal. Most submitters were in favour of developing REZs and agreed with the proposed criteria for selecting suitable regions. However, there were several concerns expressed, such as the need to clearly define the problem REZs are seeking to address. There were also concerns that the benefits or drawbacks of the concept were not clear, and nor was the nature and extent of the market failure being addressed.

3.27. Respondents pointed out that for clusters of variable renewable energy generators in a REZ, it is difficult to manage intermittency and security of supply. This would require balancing assets such as storage, dispatchable generation and demand-side management – note the difference to the Australian objective of optimising the mix of wind and solar to minimise the impact of intermittency.

Storage and gas to firm renewables

3.28. The next part of the ISP describes the AEMO's estimates of what types of storage and gas resources are needed to firm the increased levels of renewables in Australia. The requirements are broken down according to 'depth' or duration of the storage or generation resource.

3.29. For example, consumer-owned storage (CER or DER storage) is behind-the-meter household, business or industrial batteries, including EVs that may be able to send electricity back into the grid. Coordinated CER storage is managed as part of a virtual power plant, while passive CER storage is not. While the combined installed capacity of these batteries is large, they can only dispatch electricity for about two hours at full discharge rates, so deeper[5], utility-scale resources are also needed.

The Australian Energy Regulator is amending distribution tariffs

3.30. The Australian Energy Regulator (AER) is preparing new regulatory frameworks for tariffs. Distribution tariffs can be an important tool in power system operation to drive participant responses and to relieve congestion.

3.31. Responding to the significant growth in rooftop solar and the need to constrain injection into the grid, the AER is introducing two-way, multi-part distribution tariffs, including export tariffs for DER (eg rooftop solar, and batteries).[6]

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[5] Deep storage refers to strategic reserves that can dispatch electricity for more than 12 hours, to shift energy over weeks or months or cover long periods of low sunlight and wind, backed up by gas-powered generation.

[6] See https://www.aer.gov.au/industry/registers/resources/guidelines/export-tariff-guidelines

4. The benefits and risks of Artificial Intelligence to future power system operation

4.1. There are diverse Artificial Intelligence (AI) techniques that can be applied in power system operation, control and planning. AI applications reduce computational time, keep consumer costs down and can contribute to the reliable operation of the power system. AI techniques can process data faster and automate and increase the performance of power systems.

4.2. AI includes technologies such as expert systems, pattern recognition (machine learning), genetic algorithms and neural networks.

4.3. However, there are some caveats about the expectations of what AI will deliver for the operation of power systems, including:

(a) AI algorithms produce outputs that impose obligations or behaviours on power system participants and there is a natural tendency for humans to expect to be told what to do by a person rather than a machine

(b) AI algorithms have not reached a point yet where they are able to optimise system operations in large scale commercial settings. However, there are pilots and research projects underway to deploy AI to use real-time data and visibility.

(c) In particular, in active distribution systems[7] the deep penetration of DER introduces new challenges and complexities, such as variations in voltages, power quality issues, the uncertainties of DER generation, and increased bi-directional power flow.[8]

4.4. AI can contribute in many areas, for example it can be used to resolve system frequency changes, maintain the voltage profile to minimise transmission losses, reduce the fault rate and minimise reactive current in distributed systems, to increase the power factor and improve the voltage profile.[9]

4.5. Note that AI can also provide financial and safety benefits to consumers, especially in smart homes. Sustainable smart home networks can improve energy efficiency, use local renewable energy, decarbonise heating and cooling systems, and promote responsible electric vehicle charging.

4.6. AI in power system operation attempts to exploit the convergence in aspects of machine learning, optimisation, forecasting and operations research. Some of the pros and cons, benefits and costs, and the potential trade-offs and risks are discussed below, mainly with reference to Australian case studies.

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[7] Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of computation and physical components

[8] See: Chung, S.; Zhang, Y. *Artificial Intelligence Applications in Electric Distribution Systems: Post-Pandemic Progress and Prospect*. Appl. Sci. 2023, 13, 6937. https://doi.org/10.3390/app13126937

[9] See *Applications of artificial intelligence in power system operation, control and planning: a review,* Utkarsh Pandey, Anshumaan Pathak, Adesh Kumar, Surajit Mondal. In Clean Energy, Volume 7, Issue 6, December 2023, Pages 1199–1218, https://doi.org/10.1093/ce/zkad061

Benefits

4.7. Machine learning uses algorithms to analyse huge data sets to identify trends and patterns. The algorithm is tasked with making predictions about a target variable, based on the ‘rules’ programmed into the algorithm and the data it receives. The algorithm seeks to identify patterns in the data, use those findings to modify its ‘rules’, and optimise them to undertake further analysis.

4.8. Machine learning technologies are increasingly being used in climate science to improve climate modelling and with more renewable energy sources coming online, utilities need better ways of predicting how much energy is needed, in real time.

4.9. Utilities and generators are also using algorithms to analyse industry-wide early equipment failure rates, to predict the probability of failure. Preventing just one equipment failure can avoid cascading blackouts, such as the blackouts in South Australia in 2016.[10]

4.10. In Australia, AI trading platforms are helping renewable energy asset owners confront the challenges of operating them profitably in an increasingly complex National Electricity Market (NEM). Energy and ancillary services are requiring assets to trade at five-minute intervals while integrating ever-higher amounts of variable renewable energy penetration. Renewables and battery asset operators are having to deal with exposure to negative prices, physical grid constraints, frequency control ancillary services (FCAS) costs, and managing trading strategies. Trading renewables and energy storage has become so complex it requires AI-based software to manage decision making.

4.11. For example, Fluence Energy[11] manages 1.5 GW of new wind, solar and battery energy storage contracts in Australia with its AI-powered Trading Platform. It analyses thousands of variables to forecast prices and anticipate grid conditions likely to cause negative prices. The platform generates optimal bids, which can increase revenue for wind and solar asset owners by up to 10% in a year.

4.12. Microgrids benefit from AI management[12]. There are now several microgrids in Australia. Microgrids are smart private networks for commercial, industrial or residential precincts. Microgrids generally comprise of renewable energy generation (usually solar), an energy storage system and a network distributing electricity. Microgrid communities draw upon a mix of their own energy resources and the regular grid, and the source they favour at any one time depends on multiple factors. This is managed dynamically and will increasingly involve AI.

[10] Energy Source & Distribution, 26 July 2022. *What role will AI play in Australia’s energy transition?* See https://esdnews.com.au/what-role-will-ai-play-in-australias-energy-transition/

[11] PV Magazine Australia, 21 May 21021. AI-powered trading platforms on the rise in fast-moving markets. See https://www.pv-magazine-australia.com/2021/05/21/ai-powered-trading-platforms-on-the-rise-in-fast-moving-markets/

[12] Electrical Comms Data, 22 February 2019. See https://www.ecdonline.com.au/content/electrical-distribution/article/ai-in-australia-s-electricity-sector-49048136

Trade-offs and risks

4.13. Some of the risks and trade-offs of AI have been identified as follows[13] :

(a) **Environmental impact** – training an algorithm can use vast amounts of computing power and therefore consume large amounts of energy with very significant emissions. For example, natural language processing (a machine learning technique that helps machines interpret and generate text) is especially power-hungry. The environmental impact of AI can be minimised if the energy used is carbon-neutral.

(b) **Data stewardship** – machine learning processes rely on vast amounts of data collection, and data sharing is critical to implementing machine learning technologies in the energy sector. This raises privacy concerns and the potential for accidental or malicious surveillance, profiling, behaviour tracking, or even identity theft. Utilities are acquiring additional (and potentially onerous) responsibilities as guardians of this data and must deal with legal questions of customer consent, and with issues around the appropriate use, transfer, ownership, storage and disposal of customer data.

(c) **Ethical issues** – AI might not correctly prioritise electricity distribution between different users, especially in periods of scarcity. Those who use AI systems must be able to understand and explain why the algorithm made a particular decision and be accountable for the consequences of these decisions. This means remaining open to criticism, disclosing unknowns, and allowing for fixing up issues with poor training data. There is a need to ensure decision making is lawful, transparent, explainable, used responsibly, and subject to human oversight, review and intervention.

[13] Energy Source & Distribution, 26 July 2022. What role will AI play in Australia's energy transition? See https://esdnews.com.au/what-role-will-ai-play-in-australias-energy-transition/

TRANSPOWER

System Operator’s support of industry evolution to address future challenges

22 February 2024

Aim of the presentation

This presentation responds to the Security and Reliability Council (**SRC**) questions about how Transpower, in our role as system operator, is supporting industry evolution and working with the industry to address future challenges.

We have structured the presentation to answer each of the questions set out in the SRC Secretariat's paper of 16 August 2023:

a) How the system operator is planning to meet sector and consumer needs through the transition,

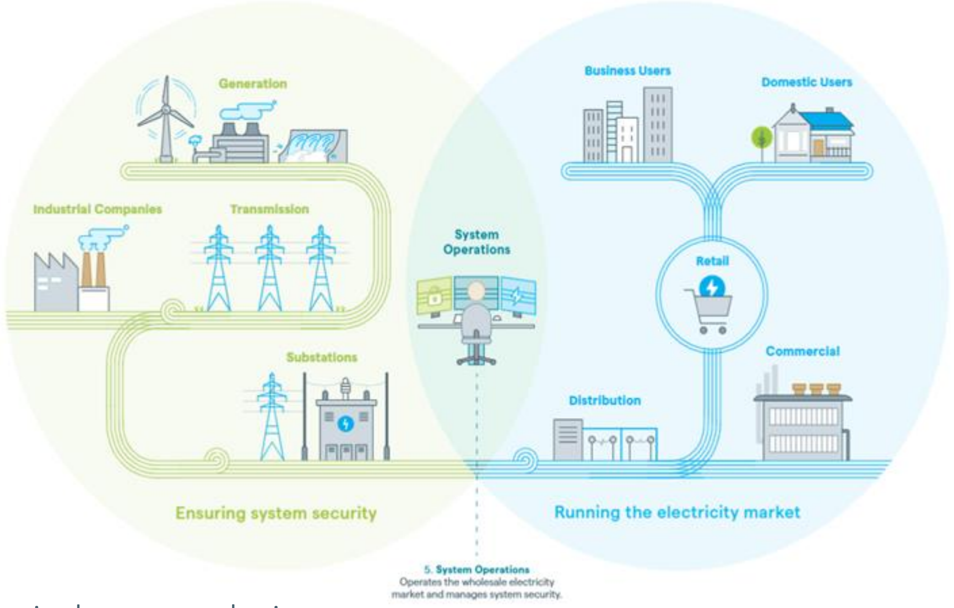
b) How the system operator's processes are evolving to meet the needs of a more decentralised power system, with greater direct consumer input,

c) How the system operator is engaging across the sector to ensure it has the information it needs to manage the system in real time, and plan forward,

d) How the system operator is using and sharing information to support industry's understanding of security and reliability risks,

What can we do to meet future challenges as system operator?

- The nature of our role means we have a broad industry perspective and are ideally positioned to support the industry transition to a low emission energy system.
- We learn from others and are always looking at fresh ideas, based on our experience and that of others in New Zealand and overseas, and have the opportunity to work with the Electricity Authority (**Authority**) to trial, and potentially implement these initiatives.
- We work as part of a wider team, relying on the continued engagement we enjoy with the Authority, industry participants, and consumers to prioritise our efforts.



- We will be seeking cooperation from other industry players to directly bring about industry evolution.
  For example, in terms of peak demand and energy demand, we continue to provide information and highlight the key needs for more flexible capacity and dry-year storage, and expand this service to meet the industry's evolving needs, however we will need support to directly change the market design and deliver market incentives and enhancements to stimulate investment in new resources or the coordination of demand response.
- We are and will continue collaborating across the industry with existing, new and potential market participants, providing knowledge and support to those exploring new ways of working, including pilots and trials, and will seek industry partnership to bring about the changes required.
- We support both regulator and industry-led initiatives that will facilitate change and investment and will continue to collaborate with the Authority and the industry throughout the transition.

Supporting industry evolution through planning and engagement

How the System Operator is planning to meet sector and consumer needs through the transition

- We update our strategy regularly to respond changes in the sector
- We monitor how consumer's needs for reliability and cost-effectiveness are changing over time
- We collaborate with the Authority to future-proof the power system
- We are working with the Authority to deliver the Future Security and Resilience (FSR) programme
- We aim to deliver a cost-effective service through capability uplifts that respond to changing power system needs

How the System Operator's processes are evolving to meet the needs of a more decentralised power system, with greater direct consumer input

- We are enabling demand-side participation within wholesale market settings
- We support new participants with technical expertise, trials and pilots, and adapting our tools and processes
- We are managing increasing uncertainty through better forecasting and providing more comprehensive risk analysis

How the System Operator is engaging across the sector to ensure it has the information it needs to manage the system in real-time, and plan forward

- We improve interactions with participants through industry exercises and collaboration
- We constantly seek information from across the industry and are improving our operational communications channels

How the System Operator is using and sharing information to support industry's understanding of security and reliability risks

- We are providing enhanced real-time and forward-looking information
- Our security of supply information facilitates forward-planning
- We have developed a range of channels to provide updates and insights

How the System Operator is planning to meet sector and consumer needs through the transition

We update our strategy regularly to respond changes in the sector

The system operator service is delivered by Transpower to the Authority under the System Operator Service Provider Agreement (**SOSPA**).

Under the SOSPA, we prepare an System Operator Strategic Plan (**SO Strategic Plan**), which is updated annually and looks out for at least the next five years. The SO Strategic Plan describes the risks and opportunities that we have identified across the long-term horizon and our near-term focus areas for adapting how we operate to deliver the service. This enables our long-term thinking and current priorities to reflect changes in the industry and our broader operating context.

In developing the 2023 SO Strategic Plan, we engaged with participants from across the industry (including new entrants) to ask about:

- Key trends or themes that will change the power system.
- Potential risks and opportunities.
- What changes might be needed in our role and our tools to manage the risks and leverage the opportunities.
- What we should be focussing on in the next five to ten years.

The feedback we received provided a valuable insight into stakeholder expectations for the future delivery of the System Operator service and helped us to shape our strategic focus areas to meet future industry and consumer needs, including enabling whole system development, integrating new technologies, and providing enhanced market information in operational timeframes

In 2024 our Strategic Objectives have been updated to reflect changes to the Authority’s (and Transpower’s) respective strategic objectives and wider frameworks.

We monitor how consumer's needs for reliability and cost-effectiveness are changing over time

We know that consumers need secure, reliable access to electricity that does not cost more than it should. Our strategic objectives describe how we intend to achieve this.

The transition to a low-emissions economy brings opportunities. It will enable consumer energy resources (e.g. domestic solar and battery storage), which means consumers will be better able to manage their own power reliability. However, the transition could impact reliability and we need to ensure the exit of base-load thermal generation is managed in a coordinated fashion to mitigate any potential impact on power system reliability in the medium-term.

We want to support the uptake of consumer energy resources, which means improving access to opportunities to increase their value (e.g. supporting SolarZero's involvement in the instantaneous reserve market). We are looking at a future where consumer and distributed energy resources will become more important to how the power system operates. We are doing this by improving load forecasting, developing and ensuring conformance to technical standards, and embracing opportunities for those resources to engage more in the wholesale market.

Our strategic objectives are designed to facilitate the transition to the future state without compromising reliability or confidence in the power system.

SO strategic objectives

Building trust and confidence
Acting with integrity and professionalism in all our activities, so the system operator is seen as a trusted adviser to the industry.

Facilitating innovation
providing information and support to market participants as they evolve their own operations.

Enabling a low emissions energy future
Developing our expertise and operations to create opportunities for a lower carbon power system.

Facilitating an efficient electricity market
Scheduling and dispatching the power system while promoting new and diverse participation on a level playing field basis.

Ensuring a reliable electricity system
Performing our core roles competently and with expertise to maintain frequency, voltage, and balance supply and demand in real time[5]. We are also a source of information to the market and policymakers to support their role in ensuring an efficient supply.

Providing efficient service delivery over time
Working to improve the value and efficiency of how we execute our roles.

We collaborate with the Authority to future-proof the power system

We collaborated with the Authority to refresh our annual performance metrics for 2023-24. The performance metrics capture how we will support the Authority to evolve and develop the electricity market and power system. The refreshed metrics include a focus on ensuring the industry is equipped for the future by testing our risk register with participants, hosting an annual pan-industry event exercise, publishing thought leadership publications and engaging with stakeholders in our project delivery.

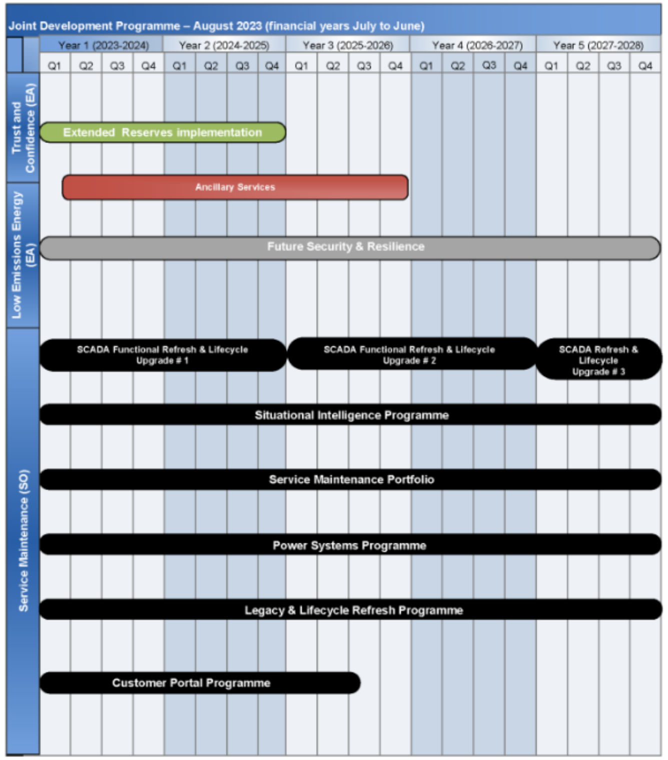
Quarterly future-thinking sessions

Together with the Authority, we have instigated increased engagement in operational and market development. Our more structured approach includes quarterly sessions involving:

- sharing plans of upcoming workstreams and thought leadership publications and consultations,
- assessing developing issues in the electricity sector and market from reach organisation's respective viewpoints,
- initial scoping and concept development for market development initiatives.

Joint Development Programme (JDP)

We put the agreed projects on the JDP, which is agreed with the Authority at least annually. The JDP covers the period of the next five years. Its purpose is to enable both parties to plan delivery of market development initiatives and system operator service maintenance projects in a coordinated fashion.



We are working with the Authority to deliver the Future Security and Resilience (FSR) programme

Since 2021 we have been supporting the Authority to examine the security and resilience of the power system as it transitions to a low-emissions future.

- Our Phase One report set the scene and identified the opportunities and challenges expected to affect the security and resilience of the power system through the transition.
- Our Phase Two report set out a road map of activities to address the opportunities and issues identified in Phase One.
- We are now assisting the Authority with Phase Three, which is a multi-year work programme to deliver on the Phase Two roadmap.

Our recent Phase Three activities include:

- Supporting the Authority to accurately describe the status quo for its upcoming Future of System Operations discussion paper.
- Assisting the Authority to identify the Common Quality provisions within the Code that need to change to enable new generation technologies.
- Supporting the Authority to develop and publish the FSR indicators to monitor how and when the opportunities and challenges may materialise.
- Providing technical support (as a member) to the industry's Common Quality Technical Group.

We will continue to evolve our processes and tools to align with each activity on the FSR roadmap.

Opportunities and challenges	Timeframe	Priority
Enabling DER services for efficient power system operations	3-7 years	Medium
Visibility and observability of DER	3-7 years	Medium
Coordination of increased connections	0-3 years	High
Balancing renewable generation	3-7 years	Low
Managing reducing system inertia	7-10 years +	Low
Operating with low system strength	3-7 years	Medium
Accommodating future changes within technical requirements	0-3 years	High
Leveraging new technology to enhance ancillary services	Enduring	Medium
Maintaining cyber security	Enduring	High
Growing skills and capabilities of the workforce	Enduring	High

Rise of Distributed Energy Resources · Changing generation portfolio · Foundational opportunities and challenges

We aim to deliver a cost-effective service through capability uplifts that respond to changing power system needs

We have implemented a robust business planning framework which builds on the strategic planning process. The framework:

- identifies the urgent and most impactful risks and opportunities for the system operator service from considering our changing operational environment
- elaborates the likely impacts to delivering on each aspect of the system operator role
- describes the business outcomes we want to see in response to those impacts
- Identifies the gaps in our current business capabilities that need to be filled to achieve the business outcomes
- scopes and prioritises investment initiatives within appropriate resourcing envelopes.

How the System Operator’s processes are evolving to meet the needs of a more decentralised power system, with greater direct consumer input

We are enabling demand-side participation within wholesale market settings

Real Time Pricing (RTP)

In April 2023 we worked alongside the Authority to successfully deliver the final phase of the RTP Project, which is the single biggest change ever made to the wholesale market. This change unlocked the potential for more renewable energy, and provided a way of moving towards a low-emissions energy sector.

The Authority characterised RTP as follows:

> Real-time pricing delivers accurate and reliable spot prices published at the end of each half hour trading period, removing any guess work and encouraging more participants to take part in the market with certainty around costs and benefits.

As part of this project, we worked closely with the Authority to design the RTP demand-side initiatives, which included moving Dispatchable Demand (DD) to real-time and the creation of Dispatch Notified Load (DNL). The inclusion of DD and DNL in the dispatch process is the first inclusion of demand-side participation in real-time dispatch.

We supported the first DNL participation in winter 2023 and are assisting several other participants explore participation.

We support new participants with technical expertise, trials and pilots, and adapting our tools and processes

Participation in the market is increasing. New participants using new technologies (at scale) as well as new modes of operating which are challenging our existing tools and processes. We are responding to the industry's changing needs by looking for ways for interested parties to participate in the market within the constraints of the Code and our operational requirements.

Example:

SolarZero trial

In 2022 and 2023, we worked closely with SolarZero to enable its participation with batteries in the instantaneous reserve (IR) market and as DNL for winter peak management. Recognising the importance of distributed batteries to the future power system we worked with SolarZero and the Authority to enable participation in both markets on a trial basis.

This involved:

- adapting our instantaneous reserve technical requirements to allow participation from an aggregation of small-scale assets
- using aggregated battery invertor metering as proof of performance
- ensuring the Code supported SolarZero's offering into the market without administrative bottlenecks.

These adaptations enabled SolarZero to offer its full IR capability and to signal its 'emergency controllable load (DNL)' to market.

The lessons learned from the SolarZero trial will be inform the evolution of the Ancillary Services Procurement Plan, the FSR work programme, and our future planning activities.

We are managing increasing uncertainty through better forecasting and providing more comprehensive risk analysis

The transition to a low-emissions power system will mean more variable grid-scale intermittent generation, less ‘firm’ flexible generation, more time limited supply-side resources (e.g. batteries) and more distributed resources. This combination of diverse assets and resources will create an uncertain operating environment where forecasting is increasingly challenging and important.

We continue to explore AEMO’s experience of forecasting significant volumes of grid-scale and residential solar, as well as wind generation, to accelerate our own forecasting improvements. The primary insight from AEMO is that there will always be forecasting errors, the key is to quantify the uncertainty and find ways to deal with it.

Since 2022, we have made significant changes to complement and improve our forecasting capability such as:

- engaging YES Energy (formerly Tesla) to provide our demand forecast. As a specialist load forecast provider, YES Energy is best placed to make the adjustments required to the load forecast to reflect the changing power system and maintain load forecast accuracy levels.
- engaging Meteologica to provide a central wind generation forecast to give our real-time staff a ‘second opinion’ on wind generation offers. This change allows our real-time team to better understand and quantify risks to the power system of potential capacity shortfalls, which has led to improved communication of those risks to industry.
- initiating daily MetService briefings to provide our real-time team with a confidence level in the base weather forecast, along with the possible alternative weather scenarios. This means we have greater situational awareness around the forward-looking schedules, particularly wind offers.

We are currently trailing using a probabilistic demand forecast from YES energy in the New Zealand Generation Balance (NZGB) tool. NZGB is the model that indicates tightness between available capacity and demand over the next 200 days and helps to co-ordinate industry outages. This change will provide more informed risk analysis. We are targeting release by the end of March.

How the System Operator is engaging across the sector to ensure it has the information it needs to manage the system in real-time, and plan forward

We improve interactions with participants through industry exercises and collaboration

Starting in 2022 we implemented annual pan-industry exercises with the Authority. The first two exercises have stepped-through the process of managing a winter capacity shortfall requiring load control. The exercises help us to develop an industry-wide understanding of roles, responsibilities and what must be done and when.

The exercises have numerous benefits:

- We have found the exercises to be a valuable tool to identify improvements that can be made to our operational processes and practices, as we plan for more challenging and complex winters ahead.
- We have received similar feedback from other participants who appreciate the opportunity to test their own processes that these exercises provide.
- They provide an opportunity to share industry knowledge and get to know our industry colleagues.
- We can learn from others.

The 2023 industry exercise guided participants through the enhanced information initiatives implemented prior to winter (residuals, sensitivities and wind forecast information), as well as the steps involved to submit controllable load information via difference bids. The primary objective for us this year was to ensure the operational changes implemented ahead of winter around the use of controllable load were well understood by distributors.

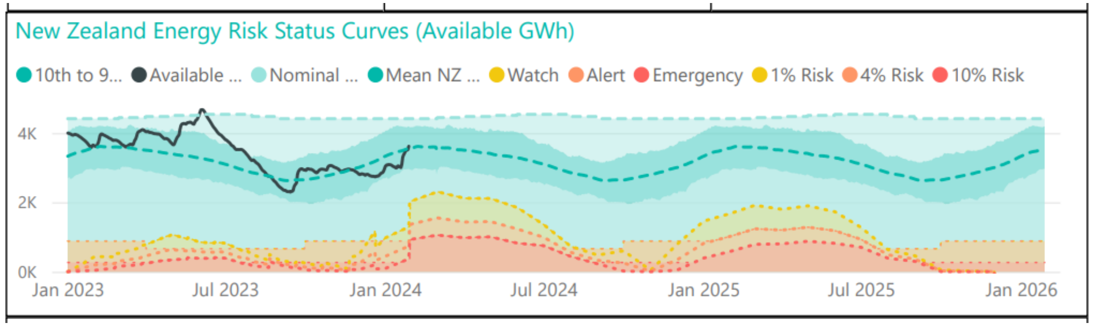
These exercises are a valuable way to share the work we are doing to future-proof our delivery and ensure that the improvements can flow into other parts of the industry. They also provide an opportunity for us to learn about changes being made by other industry participants and share ideas.

We constantly seek information from across the industry and are improving our operational communications channels

No single entity holds all the knowledge and has all the answers. There is a wealth of information and ideas in New Zealand and to be gained from looking at overseas experience. We engage and collaborate across the industry in New Zealand and overseas to tap into this knowledge to enable us improve aspects of our operations and inform our future planning. Here are some examples.

Informing our security of supply

We regularly engage with market participants to inform our security of supply assessments, particularly around hydrology, thermal fuel availability, asset maintenance and outages, and resource capabilities. The information we obtain enables us to forecast short, medium and long-term security of supply assessments.



Industry groups

We also benefit directly from our membership of, and support to, numerous industry working groups and international organisations, including:

- Flex Forum (*)
- Electricity Networks Aotearoa's Future Networks Forum
- The Association of Power Exchanges (APEx)
- The Authority's Market Development Advisory Group (MDAG)
- Electricity Engineer's Association
- System operators overseas, such as National Grid ESO (the UK system operator) and AEMO

(*) We have been working closely with electricity distribution companies this year, in particular with the Flex Forum which is exploring how to best design and procure flexibility services from market participants and consumers. As part of this forum, we discussed with National Grid ESO (the UK system operator) and Octopus Energy, the innovative UK Demand Flexibility Service which was tested recently. In June, we were elected to the steering committee of Flex Forum as it prepares for its next phase of work.

Our continuous pan-industry engagement enables us to stay across emerging technologies and business models, which will become more prevalent through the energy transition, as well as the 'big picture' operational issues system operators around the world are experiencing.

How the System Operator is using and sharing information to support industry's understanding of security and reliability risks

We are providing enhanced real-time and forward-looking information

We have had an increased focus on engagement and communications over the last two years to ensure participants have clear, actionable and timely information to help them play their roles in the efficient operation of the power system. We have also improved communication with stakeholders – including in government and more widely through the media – to ensure they understand our work and are aware of any risks to electricity supply.

Getting the messaging right is increasingly important, as more, and new, participants consume these messages; and because those same participants will be part of the solution to the message being communicated (e.g. around a potential capacity shortfall).

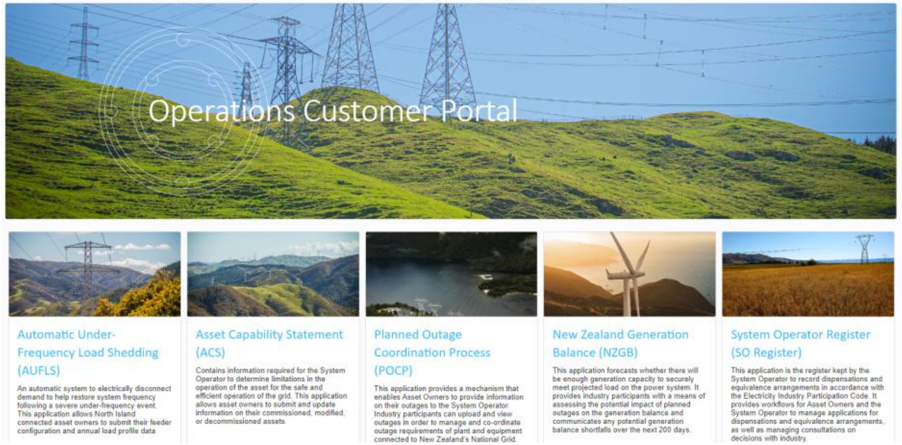
Industry forums

We launched the fortnightly System Operator Industry Forum in March last year as a regular channel to discuss market conditions, security of supply, operational issues and upcoming projects with industry. These forums are well attended from across the industry. When situations warrant a more in-depth discussion, we hold extended sessions to discuss specific issues, such as in May this year where we stepped through the 2023 winter initiatives.

Operational notices and communications

We have refreshed and improved our operational notices (CAN/WRN/GEN). These notices are a critical part of how we work with industry to manage the power system and prepare for and handle major events. We have also worked with Corporate Communications to develop key messages for major events and to develop a major power system event contact list to improve communications with our industry partners outside of control rooms.

We have also been steadily developing our Operations Customer Portal since 2020 to provide a single contact access point for the tools and systems that participants use.



Supporting new ideas and ways to present information

We are always keen to trial new ideas where we see an opportunity to provide value to the industry. Recent pilot trials we implemented were calculating and publishing sensitivity schedules and procuring an independent wind generation forecast. These pilots provided a head start for the Authority's winter 2023 initiatives, with both options implemented.

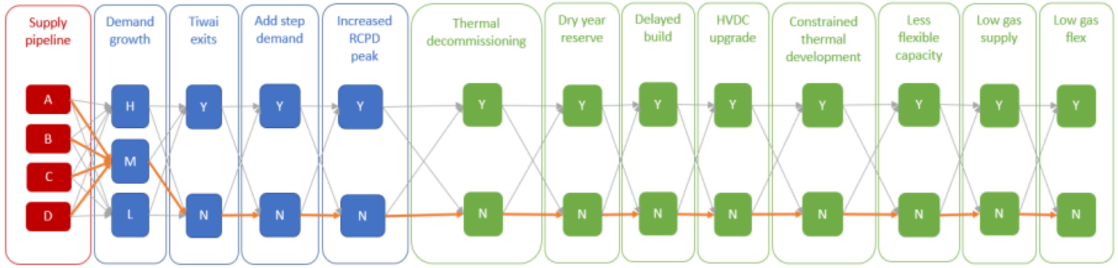
In April 2023 we hosted a webinar where we shared the results of the analysis performed on winter peak demand for 2024 and 2025 with industry. We are constantly exploring new and innovative ways to convey and present information to try to ensure maximum exposure.

Our security of supply information facilitates forward-planning

We support the recent Market Development Advisory Group (MDAG) recommendations in this area and are keen to work with the industry to help get the settings right

Security of Supply Assessment

We have significantly increased the number of scenarios included in our annual Security of Supply Assessment (SOSA) to better reflect the range of plausible futures which could transpire. Eight supply side sensitivities and four demand side sensitivities were explored in the 2023 SOSA, along with the base case, providing enhanced information for industry to consume and act upon.



Stages	Supply pipeline stages
Stage 1	Existing + committed (consented and active)
Stage 2	Consented and on hold/awaiting market conditions to change
Stage 3	Consented and on hold/awaiting market conditions to change - revision or reconsent required
Stage 4	Not consented, but consent likely sought within two years

Security of Supply Forecasting and Information Policy

We have recently progressed an update to the Security of Supply Forecasting and Information Policy (SOSFIP), which governs how we create and calculate the SOSA and the Electricity Risk Curves (ERCs). The changes reduced uncertainty and subjectivity around our analysis. The updated SOSFIP also seeks to encourage proactive information disclosure to us (in our role as System Operator), as the supply side information in the SOSA is comprised almost entirely of information provided by participants. Taking steps to best ensure the quality of the supply side information provided to us increases the utility of the analysis performed and the results shared with industry.

Consultation on Evolving Security of Supply Assessment

We published our Evolving security of supply assessment in New Zealand consultation paper in July 2023 to highlight opportunities to enhance and evolve how security of supply is considered. We need to ensure the approach to security of supply evolves to reflect changes in the electricity market and power system. In preparing the paper, we assessed resource adequacy measurements from several international jurisdictions. The overall goal is to improve information to industry and stakeholders so they can better understand potential system risks and facilitate an orderly transition towards a lower-carbon future.

We have developed a range of channels to provide updates and insights

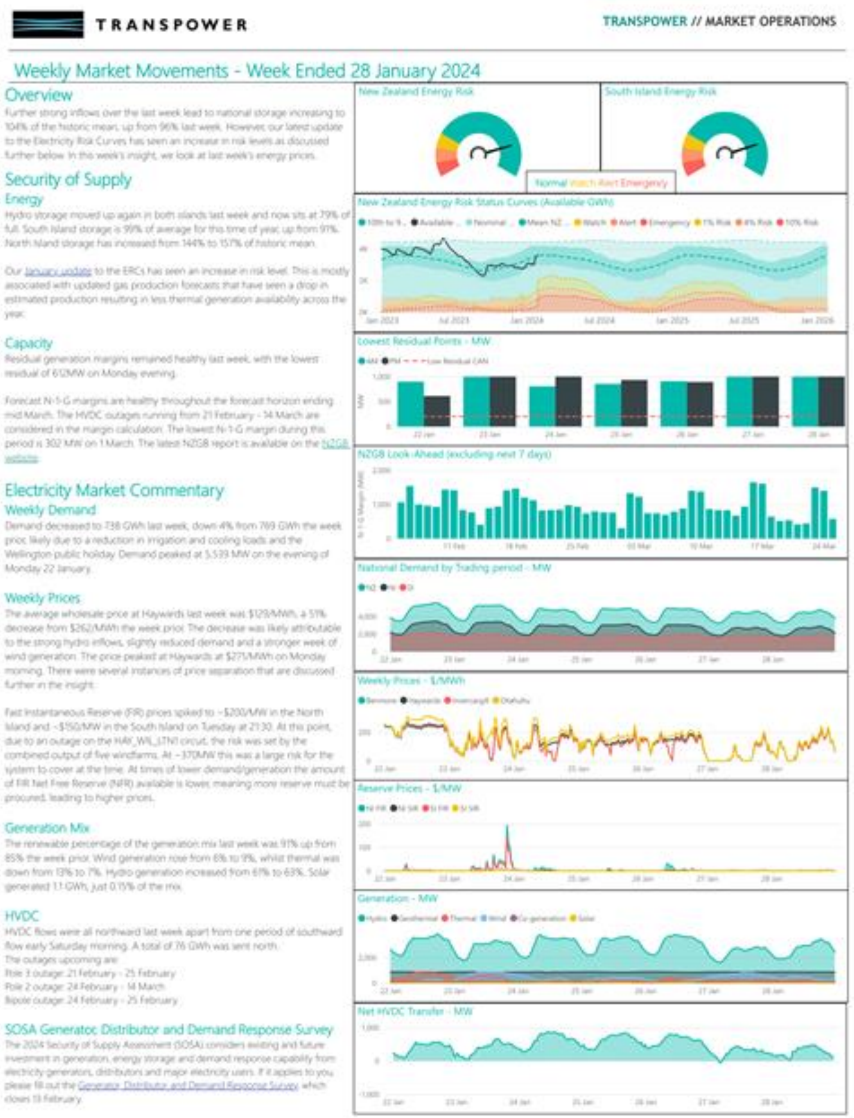
We have improved our non-real-time communications channels to better serve the industry. These channels can be used to provide regular brief updates as well as longer market insights and future looking thought pieces.

Future looking thought pieces

One way we share our forward-looking thoughts on system operations with industry is by publishing papers. Recent examples include consideration of the impacts that increased invertor-based resources will have on the performance of the power system and our views on enabling distributed flexibility to support whole of system reliability and efficiency.

Weekly insight

We also produce a weekly data and graphic rich report that is available for download or subscription. This report includes commentary on the current security of supply situation, the market, and a topical insight. These enable us to show recent trends and highlight issues that are of importance to the industry. The most recent insights have been focussed on trends in energy demand, and actual wind generation vs assumed wind generation.



We are guided by industry

Listening and responding to the industry

We are constantly adapting our role to meet the needs of a fast-paced industry evolution. We know the best way to do this is in collaboration with the industry. We value the feedback that is provided in our annual participant survey and we follow up on the comments made to increase our value and meet the industry's needs. Below are some of the comments from the 2022-23 survey, which show our work is valued but that there is always something more that can be done.

Positive feedback	Where room for improvement has been highlighted and what we've done in response.
"Level of engagement between SO and the industry is very good. Keep it up folks" "From my observations Transpower as the SO strives to meet the market needs in an ever-increasing challenging environment, I believe they are constantly looking at methods to improve their service and meet the needs of the industry" "I think Transpower do a good job of keeping up with an ever-changing environment" "Fortnightly industry briefings a huge improvement. Simulation exercise is also a big step in the right direction" "Information from various parts of the SO are great. We have many relationships across the teams" "The SO makes us abreast of what is happening and going to happen"	• Transpower has done a good job at conveying recent information. Passing real time information between Transpower & distribution operators could be improved. *Around the same time as the May survey, we hosted an industry exercise that specifically targeted distributors and the real-time communications and instructions between the System Operator and distributors (particularly around controllable load). The exercise also guided distributors through the enhanced real-time information implemented as part of the Authority's winter initiatives (residuals, sensitivities, and wind generation forecast). After the exercise, we prepared and shared a controllable load user guide with distributors to clarify some points and help them prepare their own internal training* • Transpower is too reactive and does not appear to have a clear view on intermittent renewables and how security of supply will be met in a low carbon economy. *This comment was made in the May survey. Since then, we have produced two papers that state our views. The first details work carried out to better understand the operation of different types of inverters and the second highlights opportunities we see to enhance and evolve our service in the security of supply space. Both papers can be found on our website.* *Preparing for an increase in inverter-based resources (June 2023)* *Evolving security of supply assessment in New Zealand (July 2023)*

Thank you

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Future power system – grid owner perspective

Date: 8th February 2024

To: Electricity Authority, Security & Reliability Committee

Copy:

From: Chantelle Bramley, General Manager Strategy and Customer, Acting General Manager Grid Development, Transpower

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This paper addresses a request from the Electricity Authority's Security and Reliability Committee (SRC) for Transpower, in its role as Grid Owner, to discuss how it is supporting future security and reliability. This paper forms the basis of a presentation to the SRC to further discuss issues of interest.

1. Overview

Transpower has undertaken a series of analyses into the future electrification needs of Aotearoa if it is to meet its net zero carbon targets. The first publication – Te Mauri Hiko was published in 2018 and was later updated in 2020 with the *Whakamana i Te Mauri Hiko* scenario analysis. This work has guided Transpower's long-term system and investment planning to support future security and reliability out to 2050. Our base case scenario, 'Accelerated Electrification' estimates energy demand grows by 68%, driven by underlying demand growth from vehicle electrification and process heat. In addition to electrification of transport and process heat sectors, there are emerging developments including data centres, biomass, utility scale solar, aviation fuels and green hydrogen which could materially shift the future of energy in New Zealand.

This analysis also highlights the potential impact on consumers from rising electricity costs. Transpower is focused on supporting the delivery of an optimised transition for Aotearoa – one that meets our emissions targets at pace while delivering value for money for consumers. This view underpins all our work across our roles as grid owner and system operator.

With the WiTMH analysis in mind, this paper then discusses Transpower's response to these challenges in terms of their influence on grid investment. Namely:

- Our **Regulatory Control Period (RCP4)** proposal to the Commerce Commission that sets out our investment case to ensure our existing assets can maintain a secure and reliable grid that keeps the lights on.
- Our **Net Zero Grid Pathways (NZGP)** work programme that considers broader grid augmentation, through Major Capex Proposals (MCPs) and other programmes of work. We will also touch on the next phase of this work that will look beyond the existing grid backbone and explore the extent to which new transmission lines are required from 2035 onwards. In addition, we are considering the future role of the HVDC and subsea interconnectors.
- **Regional development planning** through integrated investment planning with local electricity distribution businesses (EDBs) and resilience and sustainability work as a critical infrastructure provider.
- **Connection work** by working closely with our customers to co-ordinate our approach to meet the increased number of new generation and load connections to the grid. Our Connection Management Framework provides a more transparent and efficient process from application to grid connection and supports New Zealand as an attractive place to invest.
- **New frameworks** are required to deliver electrification at pace. For example, Renewable Energy Zones (REZ) programmes represent the first steps in a coordinated transmission response to the challenges ahead through moderate, incremental investments.

Finally, the paper sets out a number of barriers that Transpower considers may work against a more optimised transition approach including regulatory settings, consenting and property legislation.

2. Our role in the future electrification context

Whakamana I Te Mauri Hiko (WiTMH) examines the potential energy scenarios out to 2050 that may impact Aotearoa New Zealand's energy future. It sets our strategic context encompassing a range of different social and economic contexts both domestically and globally. Our base case, *Accelerated Electrification* scenario was identified as most likely for New Zealand. This scenario anticipates a large-scale transformation that will require integrated, coordinated planning and action from across the economy and government.

We publish biannual monitoring reports that track 14 indicators of progress against the *Accelerated Electrification* scenario outlined in WiTMH.[1] These indicators include core drivers of electricity supply and demand, such as population and economic growth, emissions reduction and climate policy, industrial energy use, vehicle electrification, renewable generation development and trends in distributed energy resources (DER). Through our regular monitoring we note:

- New Zealand has generally been tracking with our Accelerated Electrification scenario.
- Emissions reduction continues to be a concern for New Zealand and the rest of the world, with uncertainty stifling progress.
- We continue to point towards growth in electrification from electric vehicle uptake and process heat demand.
- Renewable utility scale generation interest continues well on track to meet 2050 forecasted energy demand from electrification.
- However, generation margins are tight with the 2024 and 2025 winter a key concern.
- Electricity demand growth is slow due to industrial load reductions, but there are strong signs of potential new growth on the way.
- Several new technologies and fuels are challenging our original assumptions, including the uptake of grid scale solar, and the potential for new electricity demand from data centres and green hydrogen.

NZ has generally been tracking with our *Accelerated Electrification* forecast

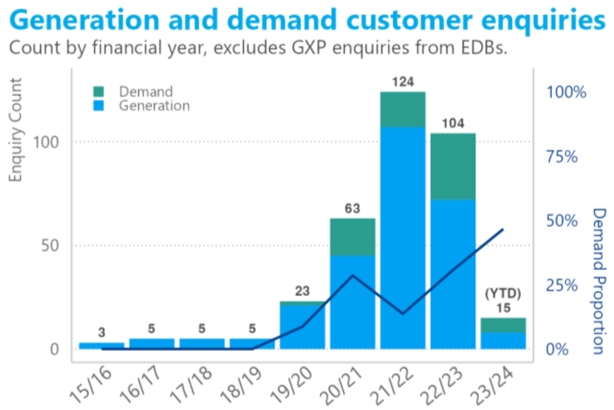
In our view, the indicators suggest that NZ is broadly aligned with the trajectory of our *Accelerated Electrification* scenario. We continue to see slower than expected overall electricity demand growth notably with lagging industrial consumption, but signals remain strong that growth is imminent. For example, we have seen a marked uptick in projections for demand growth across most electricity distribution businesses (EDBs) as outlined in their asset management plans (AMPs) and in their responses to our annual Transmission Planning Report (TPR) survey. This growth is being driven by strong electric vehicle uptake and process heat decarbonisation. In addition, peak demand has grown by around 1.5% - 2% per annum since 2020. In the year 2023 New Zealand had five daily peak demands in the top ten on record for the country, and the second highest peak on record on 2 August. Some of the recent increase in peak demand can be attributed to the removal of the regional coincident peak demand (RCPD) charge, but System Operator analysis suggests that this is only partly explanatory, and that real underlying growth is evident.[2]

To support this expected growth, we are observing an increase in renewable utility scale generation. Transpower's connection pipeline has over 30 GW of renewable generation at various stages of development: 8.2 GW of grid-connected generation is progressing through the investigation stage with a further 480MW under construction. Transpower is now regularly receiving > 100 connection enquiries per year, compared with ≤ 5 prior to 2019. Many of these enquiries have been driven by new renewable generation, e.g. utility scale solar and onshore wind (see below graph). The proportion of these requests on the demand side has been steadily growing, with 32 enquiries in the year to 30 June 2023. While all this renewable energy might not be developed, grid-scale solar in particular has emerged as a central technology that will need to be considered carefully to maintain secure system operations, and which has already been noted as an area for further analysis in the Future Security and Reliability (FSR) project. Alongside renewable energy investment, an urgent

[1] Transpower's latest report can be viewed here
[2] Transpower's Winter 2023 Review (Published by the System Operator)

need for investment in flexible resources including fast start generation, storage, or demand response has been widely signalled.

Figure 1: Connection enquiries to Transpower's grid



Green hydrogen and data centres as further areas of potential demand growth

There are emerging areas of demand, including data centres, aviation fuels and hydrogen which could materially shift the future of energy in New Zealand.

MBIE recently released its Interim Hydrogen Roadmap, which describes several use cases where hydrogen is the most likely technology for decarbonisation. It suggests hydrogen could present a very large growth in demand that WiTMH had not accounted for: 34 TWh of electricity by 2050 in MBIE's Base Case scenario *in addition to* process heat and transport electrification, leading to a 151% increase on 2020 demand. This is roughly 50% higher than our current projection and would require building additional capacity at roughly twice the rate previously estimated.

A flurry of recent announcements for new hyperscale data centres in Auckland and Southland has raised the possibility of NZ as a hub for data centres. Around 600 MW has already been announced, or approximately 5,000 GWh of energy annually, assuming a typical 95% uptime.[3] This could just be the start. International experience has shown that wherever big companies start building data centres, others soon follow. Accordingly, data centres are another area that we are closely monitoring, particularly through close working relationships with EDBs such as Vector, since data centres typically connect at the distribution level.

3. Transpower's work programme to support electrification

In order to meet our customers' and consumers expectations of the services we provide, now and in the future, we consider the following functions of the grid:

- providing a reliable and resilient electricity supply to consumers, and
- enabling an efficient energy market, which will result in energy delivered to consumers at least cost.

We also consider the need to provide a transmission system that balances the cost of investment against the benefits gained from the expenditure. These functions are considered in light of the regulatory environment in which we operate.

[3] An important factor to take into account is the Power Usage Effectiveness (PUE) score of each project, which refers to the total power consumption used over the computational energy required. The global average PUE score is 1.5, meaning for every 1 kW of computation, 1.5 kW in total is required by the centre, while 1.2 is achievable by highly efficient hyperscale centres. The 600MW and 5,000 GWh estimates use the average PUE scores for each company (or 1.2 where unavailable).

A) RCP4 Proposal – maintaining a reliable and secure grid for New Zealand

Transpower is regulated by both the Electricity Authority and the Commerce Commission. The Commission is the economic regulator and assesses that we undertake prudent and efficient investment in the grid. Every five years Transpower puts forward a proposed revenue requirement to cover expenditure for maintenance, development and investment in the transmission grid. The Commission then determines, based on analysis of our proposed expenditure, the revenue allowance over the regulatory control period (RCP).

The Commission determines a set of input methodologies (IMs) that set out the rules and processes for how they regulate businesses under Part 4 of the Commerce Act 1986. Transpower is additionally subject to a specific capital expenditure (capex) IM. The two major functions of the capex IM determined by the Commission are:

1. to provide for the scrutiny of Transpower's proposed and actual investment, and
2. to incentivise Transpower to deliver those investments efficiently.

Per the capex IM, an independent verifier's obligations include evaluating whether our individual price-quality path (IPP) proposal and key assumptions are consistent with an expenditure outcome which represents the efficient costs of a prudent electricity transmission services supplier.

In December 2023, Transpower as the Grid Owner, submitted our RCP4 proposal to the Commission, covering the years 2025–2030. Transpower's current RCP, RCP3, runs to 31 March 2025. Our proposed expenditure through RCP4 will enable Transpower to replace, refurbish, and maintain assets critical to keeping the lights on for New Zealanders while allowing us to invest in the areas necessary to support future energy needs.

As shown in Figure 2 below, most of the expenditure in our RCP4 proposal is to allow us to continue to provide a reliable and safe electricity transmission service. This ensures we maintain the level of reliable services our customers expect. These investments will also support Aotearoa New Zealand's businesses and people to shift to electricity as their main source of energy, helping reduce emissions and mitigate the impact of climate change.

The investment in our national electricity transmission network outlined in this proposal is essential to enable us to support continued electrification. By investing now, we will avoid more costly and pressured expenditure in the future. We are committed to keeping our costs as low as possible. Transmission charges remain a very small component of a typical end consumer's bill – around 8 per cent of the average residential electricity bill. We are forecasting a slight increase, to 10 per cent at the start of RCP4. As the use of electricity increases, transmission costs as a proportion of consumers' bills will come down again.

Figure 2: Proposed RCP4 base expenditure by outcome (excluding uncertainty mechanisms)[4]

Outcome	Total expenditure (2022/23 $m)	Per cent
Reliable and safe	4,009.4	95.2
Resilient	87.2	2.1
Enhancing the network (enhancement and development)	111.7	2.7
Sustainability	2.4	0.1
Total	**4,210.7**	**100**

* per cents totals are rounded

We have proposed expenditure within RCP4 under uncertainty mechanisms. These amounts are not included in our 'base' expenditure but, if accepted by the Commerce Commission, can be added to our allowance during RCP4. We have proposed $488.2 million of uncertainty mechanism expenditure for RCP4.

Customer engagement

We provide transmission lines services to its customers – EDBs, generators, and large industrials. The benefits of this flow to a wide range of consumers across Aotearoa New Zealand. Alongside our direct customers, our key stakeholders include iwi and hapū, landowners, and consumers. These relationships are vital in creating a mutually productive future for Transpower and our customers.

In 2018, Transpower set up a Consumer Advisory Panel. The panel provides an independent voice for consumers and a connection between Transpower and the wider community. The panel meets at least three times a year and is made up of representatives from business and consumer advocacy groups. The purpose of the consumer advisory panel is to:

- Help Transpower gain an understanding of consumers' interests and concerns and integrate these into business planning;
- Provide views on relevant issues, as well as Transpower's strategic approaches and priorities, and grid investment plans; and
- Strengthen Transpower's connection and trust with consumers.

A key feature of our approach to RCP4 was improving our approach to customer engagement. We utilised a range of engagement tools with different stakeholder groups to explain the proposed investment approach. Engagement with our consumer advisory panel[5], customers, end-consumers, and wider stakeholders during 2022 and 2023 has shown that our customers are satisfied with the level of service we are currently providing. Based on feedback received during that engagement, we are aiming to deliver similar levels of service to those of the last 5–10 years. It was also clear that we are expected to enable electrification of a more resilient grid.

Services we provide

[4] Page 10, RCP4 Submission November 2023
[5] Consumer Advisory Panel | Transpower

The services we provide by operation of our network and the electricity system span eight broad categories, summarised in Figure 3 below. The first three drive cost and quality of transmission services for end-consumers. For RCP4, we are proposing to introduce new customer service measures, which relate to the 'grid access' service we provide.

Figure 3: Our services framework[6]

Service	Brief Description
Grid reliability	Keep interruptions to a very low level and restore supply quickly when there is an interruption.
Grid availability	Keep a high level of availability to minimise the impacts of system constraints for generators and consumers, so the lowest cost generation can be offered into the market.
Event communications	Communicate with our customers when supply is interrupted so we can achieve the best outcomes for end-consumers.
Grid access	Work with customers to connect their assets to the grid, and plan and deliver changes to their connections.
Site access	Safely host customer equipment on our sites.
Information provision	Provide planning and other information to assist connected parties to make informed decisions.
Asset relocation	Assist in the identification, selection and execution of options to relocate transmission infrastructure.
System operation	Operate a competitive electricity market and deliver a secure power supply.

There is a need to ensure efficiency of delivery of our services and work programme to increase capacity to deliver, and at the same time find new ways to manage constraints by prioritising our work. Accordingly, we are working hard to ensure that we have prioritisation across the different work streams and, where possible, that we consider ways in which we can work more efficiently and continue to maintain our expected service levels.

RCP4 includes work for resilience and sustainability

In our RCP4 proposal, we have developed proactive resilience programmes for our vulnerable and critical assets. This recognises that despite changes in the external environment, Transpower, as a critical infrastructure provider, is increasingly expected to deliver a resilient network and transmission service. Greater reliance on electricity due to decarbonisation, for transportation and heating, will further increase the expectation by stakeholders. At the same time, climate change is exacerbating many natural hazards. Cyclone Gabrielle highlighted the public's expectation of resilience post-disaster. Our consumer advisory panel indicated that Transpower needs to take a longer-term view of resilience, including climate change risk. Further, a recent survey by the Consumer Advocacy Council found that, after affordability, the key issue for consumers and small businesses was the resiliency of the electricity system to extreme events. The resilience programme aligns with and complements our replacement, enhancement, and growth investments, as those investments also improve our resilience through new build design or a modern equivalent standard.

Our RCP4 proposal includes expenditure to support the grid in being environmentally sustainable and reduce our carbon footprint in the future. This includes our overarching aspirations and targets in relation to the impacts of climate change, environmental stewardship, operating a sustainable business and working effectively with our communities. We aim will reduce our carbon footprint over RCP4 to ensure we can achieve a 60 per cent reduction in emissions by 2030 in our aim to reach a net zero target by 2050.

[6] Service Measures Report 2023

B) Enhancing the existing grid backbone through Net Zero Grid Pathways (NZGP)

While our RCP proposals cover a large proportion of the investments we make, most of the associated expenditure to support demand growth falls outside of our RCP4 proposal. The RCP4 proposal only covers our 'base' expenditure; it does not include other areas of expenditure are agreed directly with customers or have a different Commission process for approval.[7]

Projects that relate to enhancing the network and are over $20 million[8] are required to go through a Major Capital Expenditure Proposal (MCP) process. MCPs have their own consultation and approval process separate from our RCP proposals.[9] In these proposals we are required to include evidence of the need for the specific investments by referencing relevant demand and generation scenarios. Transpower can submit a proposal to the Commission to seek approval for the recovery of major capital investment at any time. These investments enhance or develop the transmission network, rather than simply replace existing assets.

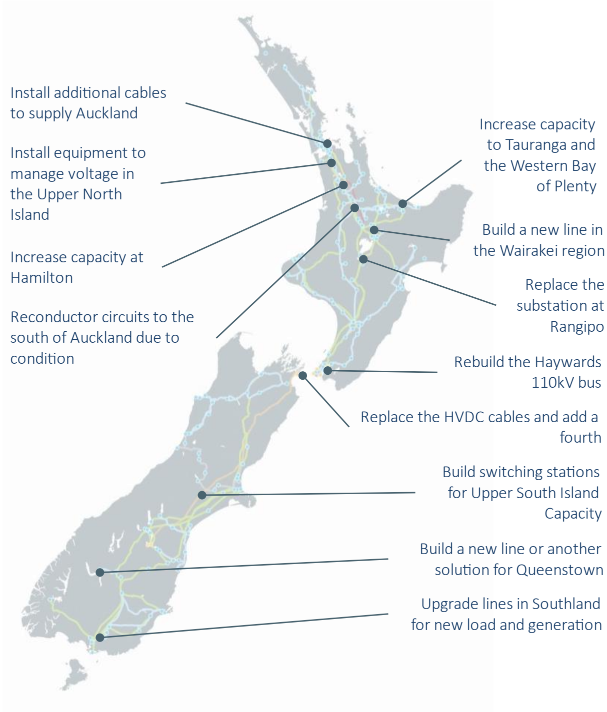
Transpower has a specific program of work – our Net Zero Grid Pathways (NZGP) project[10] - which aims to ensure New Zealand's high voltage electricity infrastructure remains fit for purpose in line with the expectation of a highly electrified economy. It does this by looking at system-wide requirements and dependencies that will enable new generation to connect to the grid, accommodate both new and growing customer load bases, move power to where it's needed, and continue to provide a secure and reliable power system. NZGP is our strategic investment work programme, and is complementary to Transpower's annual maintenance, refurbishment, enhancement and development work that extends the life of our existing grid assets. All the investments identified in this program of work will be funded through Major Capital Expenditure projects. The framework for assessing these MCPs is laid out in the Commerce Commission's Capex Input Methodologies (IM) document.[11] The supporting analysis and decision-making framework (i.e. Investment Test) requires a cost-benefit analysis, where the expected net electricity market is determined. To progress the approval of an MCP, Transpower demonstrates to the Commission that there are clear net electricity market benefits to consumers. Each proposal (and option(s)) differs, but broadly this analysis include:

- Benefits of displacing high cost fuels, e.g. coal or gas, with low cost
- Benefits of reducing losses on the transmission system
- Benefits via the reduction of involuntary demand curtailment, e.g., the cost of potential lost load
- Cost of demand-side management
- Capital costs of modelled projects, e.g., future assets that are likely to exist whose nature and timing is affected by an investment option, for instance new generation
- Relevant operation and maintenance costs, e.g., costs of existing assets, options and modelled projects

Some electricity market benefits are unquantified when the cost is likely to be disproportionately large, or when its expected value cannot be calculated. Examples of such benefits include competition effects and resilience.

[7] Note that System operator service costs are covered under a separate contract with the Electricity Authority.
[8] In December 2023, the Commission completed its review of IMs set under Part 4 of the Commerce Act 1986. The base capex threshold included in the capex IM for Transpower has been increased from $20 million to $30 million in this most recent IM review, but will only be given effect to once a new IPP begins for Transpower on 1 April 2025.
[9] These projects can be found on our website: Projects | Transpower
[10] The Net Zero Grid Pathways (NZGP) first stage of proposals have been through stakeholder consultation and were submitted to the Commerce Commission (Commission) in December 2023.
[11] Commerce Commission - Transpower input methodologies (comcom.govt.nz)

Figure 4: Projects in investigation or on the radar for 2024



Looking ahead, a key challenge we face is the fact that transmission requires very long lead times to build, especially in comparison to renewable generation; this is for several reasons:

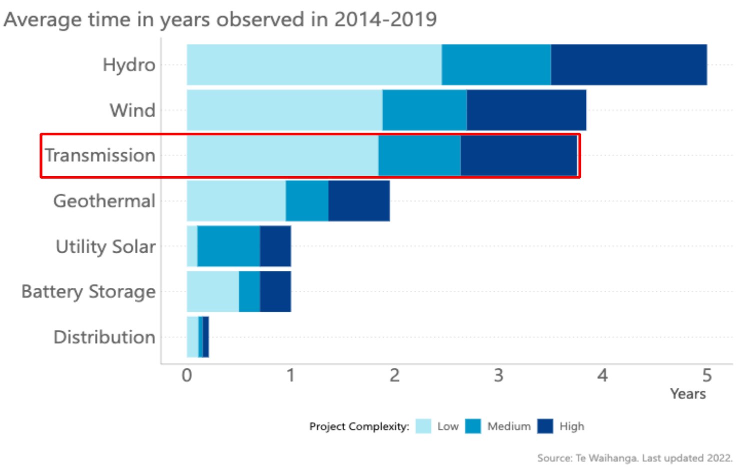
1. Transmission infrastructure takes a long time to build for several reasons. Firstly, regulatory approvals and permitting processes can be time-consuming, involving many diverse stakeholders and environmental impact assessments.

2. Additionally, securing right-of-way for power lines can face challenges when the social licence has not been well-secured, with the potential for opposition from local communities significantly slowing project deliverability.

3. Transmission assets are also in high demand internationally, often contributing to significant wait times for their arrival onshore. Delays arise as manufacturers and suppliers face challenges in meeting the soaring demand, resulting in extended wait times for the delivery of essential transmission components.

This issue is especially acute given the relative difference in project delivery times for renewable generation compared with transmission. Figure 5 below illustrates the difference in project delivery times for renewable generation compared with transmission, this difference with the average time in years to gain resource consent, observed in New Zealand between 2014-2019. Note that this illustrates only the time it takes to gain resource consent; this says nothing of the time required to secure land and community support, nor of the time to build the line.

Figure 5: Length of consent time for energy asset types



However, delays in building transmission infrastructure can hinder the unlocking of renewable generation potential. Without a well-developed and interconnected transmission grid, the full benefits of renewable energy sources, such as wind or solar, may not be realised. Timely transmission development is crucial to ensuring that renewable energy can be efficiently transported from generation sites to areas with high demand, preventing bottlenecks and grid congestion.

The very long lead times required for transmission infrastructure are key feature of our operating context and among the most significant challenges we face as we look ahead to the amount of transmission that will need to be built over the next three or more decades. In the past, significant investments have usually been proposed individually to the Commission. Through NZGP, we will propose tranches of investment to the Commission in a 'staged MCP' process. This will provide efficiencies and recognises the projects enable system-wide network benefits when delivered as a coordinated programme (rather than addressing specific, more localised needs through discrete MCPs). In November 2023, the Commission published their final decision on the MCP for the first staging project.[12] The first stage of this proposal strengthens the existing grid backbone, primarily in the North Island.

Regional development plans

Where a significant number of generation and load enquiries have been received in a particular region, Transpower has made a joint approach with stakeholders to take a broader planning perspective. A Regional Electrification Development Plan provides the opportunity for integrated planning and will result in an efficient approach to upgrade investments on the national grid and the distribution network, rather than a reactive or project-by-project approach to network investments.

This includes, for example, publishing a consultation for exploring options for essential upgrades to the electricity network in the Western Bay of Plenty and a range of investment options for supporting electrification in Southland. In December 2023, Transpower and PowerNet published a Murihiku Southland Electrification Development Plan for electricity infrastructure.[13] The work identifies tactical investment options across the transmission and distribution networks, with some potential major projects that involve transmission infrastructure requiring an MCP approved by the Commission.

[12] Commerce Commission - Commission sees consumer benefit in Transpower's proposed $393m spend on the grid, but questions timing of HVDC upgrade (comcom.govt.nz)
[13] Murihiku Southland Electrification Development Plan | Transpower

Considering the future role of HVDC and subsea interconnectors

We undertake research of the international trend of maximising the use of excess renewable electricity generation through the installation of HVDC links between international markets, including subsea installations. The longest of these subsea connections currently is the Viking Link Interconnector between Denmark and the United Kingdom that was completed in 2023, involving 1,250km of subsea cable at a cost of GBP 1.7billion.

We do have some experience with subsea HVDC assets pertaining to the Cook Strait link. These cables are scheduled for replacement in the early 2030s, and we are currently working with international cable suppliers to scope the project requirements. Transpower is also aware of the increasing interest in offshore wind, and the need for subsea electrical infrastructure to support and connect the turbines. We are in communication with overseas grid owners to help learn and plan for how best to design and deploy similar infrastructure for New Zealand as it becomes needed.

However, New Zealand's geographic location limits consideration of any similar link to a connection to Australia, of which the shortest distance between the two countries is approximately 1700km between Fiordland and Cape Howe. This is over one third longer than the Viking Link Interconnector. In addition to the problem of distance, the depth of the Tasman Sea also presents a significant barrier to interconnection, with average depths of 2,600m (and a maximum depth of over 5,900m). For comparison, the maximum depth of the North Sea where the Viking Link Interconnector lies is 700m. This depth greatly increases the weight of the cable, making it much more technically challenging and expensive to lay a cable at this depth.

We are not actively investigating the potential of an international interconnection due to current infeasibility of this option. This does not preclude third parties from investigating and investing in the project if they consider that it has economic potential, and Transpower may consider this again in the future.

We have been investigating the future of the HVDC link and are planning to publish a thought piece on the role of the HVDC link and the technology more broadly in the future NZ power system.

C) Managing new connections

As discussed above, we are observing and increase in the number of generation enquiries from developers and reported increases in demand growth from our EDB customers. This drives the need to monitor and, when required, replace or upgrade our assets. This includes both our customer-driven work on connection assets and – additional to this – is in interconnection assets that need to be updated due to load demand growth.

In 2022, Transpower implemented the Connection Management Framework (CMF) for managing the connection of new generation and energy storage to the national grid.[14] The CMF introduced a new application stage to the connections process which requires customers to provide evidence of project readiness in an application form, pay a fee, agree to the publication of specified project information, and to meet project milestones to demonstrate progress.

The CMF was developed in response to a rapidly growing number of generation connection requests. It is designed to provide customers with more certainty on where their project is in the pipeline of projects and how their project may interact with other competing projects and to prevent unviable or highly speculative projects from blocking other projects.

Accordingly, our connection process is now more transparent and efficient, focusing resources on well-developed projects and promoting standardisation of end-to-end connection processes, and enabling better decision making by investors. This supports New Zealand's continuing attractiveness as a place to invest in new generation and energy storage and enhances our ability to enable decarbonisation by connecting new renewable generation.

[14] Connection Management Framework

The CMF is applicable to onshore generation connections up to 500 MW and excludes generation projects connected via electricity distribution networks that can be delivered without new or upgraded Transpower assets. While the CMF fee structure incentivises larger connections, it is avowedly a connect-and-manage approach. There are currently 80 projects in the CMF[15], with average size just over 150 MW and a combined capacity of 12,700 MW, which is more than the total current installed capacity of New Zealand's existing generation fleet. Through much of 2023, the average time to proceed from application to investigation was 12 months. The majority of projects in the CMF are for solar farms, which represent some three-quarters of the capacity in MW terms. This does not include generation connection enquiries at an early stage for which an application has not yet been made, or offshore (wind) projects.

More recently, the number of enquiries received for the connection of new industrial and other load has increased. This number is expected to continue to continue to grow as electrification of process heat and transportation progresses in line with projections as set out in WiTMH. A framework for managing non-generation connections has therefore been developed and a list of projects published on the same webpage as the CMF. There are currently 73 projects in this pipeline.[16]

With a total of 150 customer projects at an advanced stage, efficiency is key. The following initiatives are illustrative of Transpower's approach:

- Combining customer projects achieving efficiencies in design engineering, equipment procurement, project management and avoiding duplication of works;
- Aligning customer projects with other Transpower works to deliver on multiple projects;
- Managing customer projects in batches;
- Enabling customers to lead projects and/or project tasks;
- Developing the process for managing multiple connection requests at the same location;
- Standardising solutions;
- Exploring the potential for demand response.

4. Barriers to delivering future security and reliability

The global race to electrify and supply chain challenges

The world's largest economies are taking action to encourage the development of renewables and electrification. This includes Government policies to address the energy crisis and accelerate the transition to renewable energy. The Inflation Reduction Act (IRA) in the US and Europe's REPowerEU plan have both led to investment that boosts long-term energy security through renewables, which is driving up global investment. In the US, a total of 280 energy projects have been announced in the IRA's first year, representing $282 billion (USD) of investment, of which $239 billion (USD) was invested in large and small-scale solar systems. This represents two-thirds of total global renewable energy investment over the first six months of 2023 – a 43% rise compared to the first half of 2022.[17]

The global shift towards renewable electricity has resulted in supply chain issues from increased global demand for transmission assets, that will result in a more challenging environment to procure assets in a timely manner for project delivery in the energy sector, including distribution and transmission. For Transpower, this has necessitated closer management of the performance and sustainability of our key suppliers due to increased supply risk. We are addressing material/equipment supply challenges through standardising and rationalising equipment choice to simplify sourcing options. We also increased the pre-purchase of equipment and are investing in warehousing capacity to ensure that delivery timeframes will not delay work.

The long term benefits of the IRA has material, but short term challenges for reshaping manufacturing and supply chains for clean technologies and inputs such as metals. This requires Transpower's procurement

[15] At the time of writing there are nine generation and storage projects in delivery and 33 in investigation, with 38 at the application stage – in effect in the "queue" for resource allocation.

[16] At the time of writing there are 18 non-generation projects in delivery and 41 in investigation, with 14 investigations requested. This pipeline includes asset relocations.

[17] The US Inflation Reduction Act Is Driving Clean-Energy Investment One Year In (gsam.com)

approach and team to be agile and flexible in our processes and commercial approaches. There is increased emphasis on our international supplier relationship management to seek to gain a space in full manufacturing schedules.

Workforce to deliver on the expected programmes

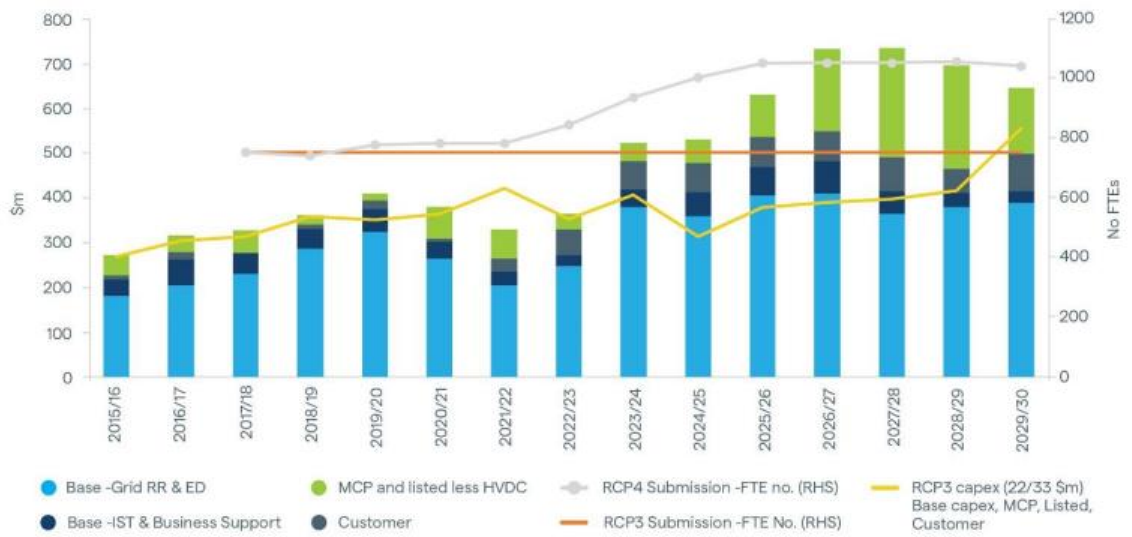
To deliver our base capex and opex work, alongside our major capital projects and customer works, we need a significant increase in our workforce – both Transpower employees as well as active support to encourage the growth of engineering consultants, service providers, and specialist contractors from offshore.

The forecast increase in workload is the result of an ageing asset base and the rapid electrification of our economy to meet necessary decarbonisation goals. In addition to delivery of our existing work programme, we expect the increase in grid work to continue to ramp up now and remain a long-term challenge.

a) Internal Workforce

Figure 6 below shows the projected workforce growth in terms of the full-time equivalents (FTEs), required to deliver our current and forecast work programme. As illustrated, there is a strong correlation between the work programme and the resourcing required to deliver the work programme.

Figure 6: Indicative growth of FTE forecast to 2030 (excludes attrition)



For RCP4, we have several initiatives to support our internal workforce. This includes promoting our business as a place of employment, an internship programme, international recruitment drives, accelerated onboarding of candidates and workforce planning processes and initiatives as part of a transmission sector workforce plan to promote, attract, develop, and retain the sector workforce.

b) External service providers

The growth in the work programme creates a challenge for our service providers, as we expect an associated uplift in workforce required to meet delivery demand of base expenditure, customer, and major capital projects work. The key trades that require growth are line mechanics and power technicians. Figure 7 outlines forecast workforce growth for our service providers to 2030 (excluding attrition). Note these figures are based on the growth (from FY22/23) required to meet the RCP4 work programme.

Figure 7: Resource growth for service providers forecast to 2030 (excludes attrition)

Category	Total growth (percent)	Total growth (number of people)	Months to 'ready to work'
Line mechanics	70 to 85 percent	~145 to 185	18
Power technicians	40 to 45 percent	~30 to 35	42
Substation maintainers	40 to 45 percent	~75 to 85	18
Tower painters	45 percent	~80	18
Maintenance switchers	To grow in line with other trades		18

Our service providers are developing policies, processes, and initiatives to assist in lifting their workforce capacity. We are also proposing initiatives that will enable their workforce growth, including a contribution towards funding for our service providers' field workforce growth initiatives.

Regulatory framework

A range of regulatory changes, including how regulators approach the assessment of investments, is needed to enable the levels of electrification required to meet decarbonisation targets. For example, an optimised transition to a highly electrified economy requires integrated and timely investment as opposed to a just-in-time approach, and transitioning will require coordination between transmission, generation, and distribution.

Our NZGP process has highlighted that the transmission investment test (in the capex IM) may not deal well with anticipatory investment to support an optimal transition path. This is because the uncertainties associated with the transition mean it is difficult to select a single 'best' investment option that maximises net electricity market benefits. Options that may not provide the highest net benefit on their own, but are still net beneficial, may deliver better optionality as the transition evolves. We continue to work with the Commission on changes to the transmission investment test, that would better support anticipatory network investments to be made in alignment with the government's sustainability objectives and commitments.

We could play a much stronger role in co-ordination through integrated transmission planning. This would require changes to the Commission's IMs such that we could better integrate the planning of generation, transmission, distributed resources and demand if it results in lower cost for consumers. This challenge exists under the current settings where transmission upgrades are reacting to the needs of the system as they occur from new generation and demand. Different approaches have been used internationally, such as a a whole of system approach to proactively address this challenge e.g. like AEMO's role in Australia and the 'Actionable projects' that are highlighted in the long-term investment plan.[18]

A significant change to the transmission investment test would be to allow the Commission to reflect benefits outside of the electricity market. While decarbonisation and the drive to electrify should be reflected in demand scenarios, investments to support decarbonisation are likely to generate benefits outside of the electricity market. For example, from overseas experience, a Renewable Energy Zones (REZ) model can accelerate the connection of renewables by coordinating transmission, distribution, and generation investment, and supporting connections of new energy intensive industries. Development of REZs requires policy changes to give effect to the benefits of co-ordinated planning. International REZ models have been successful for the market they operate in. However, a REZ model for New Zealand must be fit for purpose for our market. For example, it is important to note that a REZ does not change fundamental principles of our open access regime. The REZ framework ensures sufficient transmission build to support generation capacity,

[18] For more information see 2022-integrated-system-plan-isp.pdf (aemo.com.au), section 5.4.

but it does not guarantee dispatch into the wholesale market. Secondly, while connection access to the REZ is often managed through tender processes in other jurisdictions, it should not stop competition for access. We see REZ as taking a more co-ordinated planning approach to generation and transmission build.

Property rights and consenting

To meet the country's electrification goals we need to move quickly and responsively, and we will need fast track consenting and other streamlined approvals processes. Changes to environmental and property legislation are needed, to ensure renewable generation and associated transmission can be developed at pace.

Policy barriers in, and time delays created by, the Resource Management Act (RMA) and, and its national direction, and broader environmental legislation must be removed and is no longer appropriate to achieve the pace of change required. For example, the current national direction can lead to consenting processes (for both existing and new assets) that are complex, lengthy, costly and uncertain. If Aotearoa New Zealand is going to meet its emission reduction targets, the environmental authorisation of renewable electricity generation activities, and electricity transmission activities, needs to be more certain and more permissive. This would enable work on our existing assets and construction of new assets (fewer consent requirements). Processes for obtaining other environmental approvals similarly need to be streamlined.

In relation to obtaining property rights, the Public Works Act and/or Electricity Act needs to be fit for purpose. The Electricity Act 1992 provides statutory rights to access, operate, maintain and upgrade our assets. Around 92% of our transmission line assets are subject to these statutory rights, the remainder are subject to registered easements. We need to move toward a regime that authorises a broader range of works and allows the quantum of compensation to be determined separately to the occurrence of the work, in order to speed up the process. For example, New South Wales, with its Land Acquisition (Just Terms Compensation) Act, have introduced an element of standardisation to the compensation paid for the impact of transmission assets on the land, which are also worthy of consideration for New Zealand.

5. Presentation to SRC

In our role as Grid Owner, we play a key role to support future security and reliability in the electricity sector. Our various proposals and initiatives show the increased work required to deliver on the current and expected electricity growth and enable the transition to a highly renewable and electrified economy. This paper has raised several challenges in order to meet our customers' and consumers expectations of the services we provide, now and in the future. The presentation to the SRC will discuss issues of interest.