Summary Report

System Security Forecast 2024

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Executive Summary

The System Security Forecast provides a view of the anticipated challenges and opportunities in maintaining a secure power grid. This forecast is crucial for guiding the System Operator's strategic planning and operational decisions, ensuring that we are prepared to meet the evolving demands of our energy landscape.

In the past year, we have seen significant planned advancements in generation capacity, including the integration of new renewable energy sources and the enhancement of existing infrastructure. These developments will support New Zealand's sustainable and resilient energy future. However, they also bring new complexities to system operations. The increase of variable renewable energy sources required us to adopt innovative approaches to grid management and to enhance our capabilities in areas such as demand response, energy storage, and grid modernisation.

We have responded to changes to the power system by refreshing our approach to the System Security Forecast for 2024. A changing power system means we anticipate potential new risks. While previous forecasts have focused on assessing only thermal, static voltage and voltage stability limits to prevent cascade failure, this forecast additionally examines Transient Rotor Angle Stability risks in the power system.

In summary, the System Security Forecast for 2024 highlights the following system security matters:

- **Thermal**: Future grid projects related to Net-Zero Grid Pathways will resolve critical contingencies for high north flow by increasing the thermal capacity of the 220 kV circuits from Stratford to Huntly and Tokaanu to Whakamaru. Until these projects are completed, we will use measures like Special-Protection-Schemes (SPS) and security constraints.
- **Voltage Limits:** With new reactors and STATCOMs in place, there is now less need to switch off transmission circuits during periods of light load to manage overvoltage in the upper North Island.
- **Voltage Stability**: Voltage stability in the upper North Island remains challenging despite new reactive compensation devices. We will monitor this in real-time, and if stability issues arise, we will implement operational measures like increasing local generation and managing load.
- **Transient Rotor Angle Stability**: We identified unstable generators in the North Island's 110 kV network, but we do not expect any unmanageable issues as most units are small or have mitigations in place. In the South Island, Manapouri generation is unstable for worst-case contingencies on 220 kV circuits. We can manage this long-standing vulnerability with market and operational measures, and further propose to work with the asset owner to improve risk management strategies.

1 New Zealand System Security Overview

As the System Operator, one of our main purposes is to maintain system security to meet our principal performance obligations. Through the System Security Forecast (SSF), we examine projections of the power system to affirm the extent to which we can maintain system security over a period of at least three years. This involves performing power system studies while considering existing and future assets.

Our studies allow us to understand the risks in the power system: what causes them, when they appear, who is affected, and how we can mitigate them with the controls available. Risks typically appear when assets operate near their rated capacity. Moreover, the available assets influence the level of risk–how they are utilised, the load, and any disturbances in the power system. In the event of a power system disturbance, we dispatch assets that prevent cascade failures, thereby protecting our customers from electricity loss.

1.1 New Zealand Power System

The New Zealand power system has unique features that make system security challenging. The system consists of two separate networks, one in the North Island and one in the South Island, and these are connected via an HVDC link. There is no interconnection to other grids. The lower half of the South Island predominantly hosts the country's hydroelectric power, whereas the North Island mainly consists of geothermal and wind power, along with several thermal generation plants. Most electricity demand also stems from the North Island, particularly in the Auckland region, which is the largest load centre.

A familiar challenge the system faces is delivering power from the South Island to the load centre in the North Island, or vice versa when the hydro lakes in the south have low inflows. Additionally, as the share of variable renewable energy sources like wind and solar grows, dispatch dynamics change, and it becomes more difficult to maintain the balance of supply and demand. What compounds the complexity further is the shift from synchronous machines to inverter-based resources. Collectively, these factors make maintaining the security and reliability of New Zealand's power system a delicate act.

1.2 System Security Forecast Refresh

We have refreshed the SSF in 2024 to assess the new and emerging security risks posed by the changing energy landscape, particularly the introduction of more inverter-based resources. Our previous forecasts focused on avoiding cascade failure on thermal, static voltage and voltage stability limits only. However, the new landscape has triggered us to expand the scope of the SSF to include the new risks.

The scope of the 2024 SSF therefore covers:

1. **N-1 thermal and voltage study**: this study examines the N-1 thermal and voltage limits security checks as well as voltage stability and overvoltage management during troughs; it encompasses the committed projects for at least the next three years.
2. **Transient rotor angle stability (TRAS)**: this study is the first assessment of its kind in the SSF and provides an initial 'screening' assessment of potential TRAS issues.

This summary document provides an overview of these studies' results. See the accompanying reports for more detail, especially about contingencies and mitigations.

2 Results of the Security Studies

2.1 N-1 Thermal and Voltage Study

The SSF's N-1 contingency studies have identified critical contingencies that require attention to prevent thermal, Code voltage limits, and voltage stability issues. For these contingencies, the report notes both future grid projects that will resolve the issues, and operational measures that the System Operator can apply to mitigate the issues and enhance the security of the power system. We published our report on the N-1 thermal and voltage security issues in July 2024, and have updated this report in December 2024.

North Island 220 kV backbone: critical contingencies for a high north flow involve circuits from Stratford to Huntly, and Tokaanu to Whakamaru. Future grid projects related to Net-Zero Grid Pathways will resolve these contingencies, increasing the thermal capacity of the affected 220 kV circuits. Until these projects are completed, we have in place operational measures such as Special-Protection-Schemes (SPS) and security constraints.

Contingencies affecting the 220 kV backbone and the HVDC south transfer involve circuits between Bunnythorpe, Tokaanu, and Whakamaru. The severity of a potential thermal overload depends on the power injected by the Stratford and lower North Island wind farms, as well as the local load in Wellington. We will continue to manage this challenge operationally by constraining the HVDC south flow.

South Island 220 kV backbone: the major contingencies here remain the 220 kV circuits between Aviemore and Benmore. For high HVDC north transfer, we mitigate the risk through an existing SPS on these circuits. For high HVDC south transfer, the mitigation is to increase the generation in the lower South Island by applying existing constraints.

Grid zones: within various grid zones, contingencies could lead to overloading or voltage issues. Such scenarios could impact Hamilton's 220/110 kV interconnecting transformers and 110 kV network, Redclyffe's interconnecting transformers, Bunnythorpe and Whanganui's circuits, and Timaru's 110 kV network. We have specific mitigations in place for each of these.

Voltage stability: voltage stability remains a challenge in the upper North Island due to contingencies involving Huntly Unit 5 or 220 kV circuits towards Auckland. Meeting the stability requirements with the forecast load will require all reactive compensation devices. We will monitor this in the real-time and should voltage stability become a concern, we will increase local generation and manage load as an operational mitigation.

We do not foresee any issues with managing the upper South Island load under intact network conditions. We expect the new Frankton supply transformers to sufficiently increase the voltage stability limit for contingencies involving 220 kV circuits between Clyde-Cromwell-Twizel.

Impact of new committed generation: nearly 90% of new committed generation are inverter-based resources, giving about 900 MW of additional capacity. The N-1 contingency studies show that new connections have not caused any significant thermal violations or voltage stability issues. We will be closely assessing new connections as they are confirmed and will provide updates if required.

Overvoltage management over troughs: in the previous SSF, our assessments indicated that we would need to remove several transmission circuits from service to mitigate any overvoltages in the Northland and Auckland regions during low load periods. With the commissioning of new reactors and STATCOMs, the need to switch off transmission circuits during light load has decreased.

2.2 Transient Rotor Angle Stability Study

This is the first time we have assessed Transient Rotor Angle Stability (TRAS) for both North and South Islands in the SSF. TRAS is a synchronous machine's ability to remain synchronised under normal operating conditions and to regain synchronism after a disturbance.

North Island: the study found that all generators maintained synchronism for 220 kV contingencies under intact and outage conditions. However, instability risks appeared under certain generation scenarios for some 110kV contingencies, particularly the Kawerau (KAW) 110 kV bus and the Taranaki region 110 kV network.

From a system security perspective, we do not anticipate any unmanageable situations to arise from the identified TRAS issues in the North Island. The affected generation units are either small or we have granted them dispensations against "Fault Ride Through" obligations. For the latter, the System Operator has previously assessed the system impacts of losing these units and established mitigations to manage the risk. The potential for a wider security event from these studied faults is unlikely due to the locations of these faults. However, we will engage with affected asset owners to discuss the need for suitable protection for their asset and confirm the models we have based our assessment against.

South Island: the study found that all generators maintained synchronism for 220 kV contingencies under intact and outage conditions, with the exception of Manapouri generation for some contingencies in the lower South Island. The lower South Island presents TRAS challenges due to the remote location and size of the Manapouri generation.

The stability issues concerning the Manapouri generation are not new, and they are exacerbated by the load reduction at Tiwai Aluminium Smelter. This is a long-standing vulnerability of the system in the South Island, and as such, we have market and operational measures put in place to mitigate the risk. These can manage the identified TRAS risk effectively. However, we will engage with the affected asset owners to further discuss refining management strategies and improve current practices.

Impact of Renewable Energy: wind and new inverter-based resources are increasing as part of our energy landscape, and this could alter the dynamics of rotor angle stability. The report tested high and low wind conditions based on conventional dispatch patterns; we found no significant correlation between the wind generation dispatch and TRAS.

2.3 What's next?

We will update the system security forecast for major changes in the power system and will include assessments of new and emerging risk in the power system as these emerge.