TRANSPOWER

Manapōuri Transient Rotor Angle Stability Management

This document outlines the steps the System Operator will take to manage the risk to the power system posed by transient rotor angle stability issues at Manapōuri Power Station.

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Executive Summary

The System Operator has decided to manage the risk of the loss of rotor angle stability at Manapōuri Power Station by applying an export constraint on Manapōuri during an outage of one or more of the MAN-NMA 1/2/3 or INV-MAN 2 220 kV circuits when six or fewer Manapōuri generating units are available to meet station dispatch. The right-hand-side of the existing stability constraint will be set to 700 MW during these local outages, limiting the output of Manapōuri Power Station to a total of 700 MW. This will take effect from 1 July 2026.

The System Operator has taken this decision on the basis of the risk of instability occurring, the impact that such an event would have, the market impact of management options, the deliverability of management solutions, and its risk appetite. Notably, the risk of instability occurring is higher during outages than the annual average, while the market impact of management is reduced given the typically short duration of outages. The System Operator has sought to minimise the impact of management on the market while reducing the risk of instability to an acceptable level.

This analysis and decision builds on the System Operator's System Security Forecast 2024 and System Security Forecast 2025 Update, which identified the risk of the loss of rotor angle stability at Manapōuri, and recommended operationalising the management of this risk. This also builds on a previous System Operator consultation on our approach to Asset Owner fault ride-through non-compliance.

The management of transient rotor angle stability at Manapōuri will be reviewed by the System Operator in January 2027.

Background

The System Operator's 2024 System Security Forecast (SSF) and the 2025 System Security Forecast Update regarding transient rotor angle stability identified that a number of generators presented a risk to the transient stability of the power system under certain system conditions and for certain fault contingencies. One of these identified issues was Manapōuri Power Station. Manapōuri is a known stability risk and a Grid Owner intertrip scheme is already installed. The SSF identified that there is a risk that Manapōuri generation would lose transient rotor angle stability (TRAS) when its units are operating at high power output during some system conditions if a particular fault type were to occur, including while the existing intertrip scheme is active. This represents a risk to the stability of the power system, and to the System Operator's Principal Performance Obligations. These studies recommended operationalising the real-time monitoring and management of rotor angle stability at Manapōuri.

Following this work, the System Operator commenced a project to implement this recommendation. This required investigating the transient rotor angle stability of Manapōuri in more detail to better understand the factors which influence it, assessing and quantifying the risk this poses to the power system based on historical real-time data, and determining how to optimally manage any identified risk.

This project builds on work completed in 2024 around the System Operator's approach to scenario-dependent fault ride-through non-compliance. This included an industry consultation outlining three proposed options available to the System Operator for the management of fault ride-through non-compliance.

Assessment of Risk

Likelihood

This project identified that while a risk of transient rotor angle instability exists at Manapōuri, the low probability of the independent events required to occur to cause the instability is such that the likelihood of instability occurring is, on average, very low. This is because Manapōuri must be operating at a potentially unstable state, an electrical fault must occur on a transmission circuit or busbar near Manapōuri, this fault must involve all three electrical phases, and the protection systems which clear this fault must take longer than they have historically to operate.

The combined probabilities of these events result in an average annual probability of occurrence which is much less than some other contingencies which the System Operator manages, for example a failure of the HVDC bipole link.

Impact

The loss of transient rotor angle stability at Manapōuri is likely to have a significant impact on the power system. It is very likely that the Manapōuri generation units would trip due to generation asset protection, resulting in the immediate loss of the entire power station's power output. It is possible that the loss of stability would result in damage to the Manapōuri generation. The immediate loss of the entire power output of Manapōuri station would result in a severe under-frequency event and would likely result in the tripping of one or more Automatic Underfrequency Load Shedding (AUFLS) scheme blocks in the South Island.

However, any instability event at Manapōuri would also have the potential to cause a cascade failure of the South Island Power System. While the System Operator does plan for the restoration of the power system following a blackout through the contracting of black start services from market participants and regular testing of these services, a blackout of the South Island is expected to have a huge negative economic, human, and social impact.

These potential impacts were monetised using the Value of Lost Load (VoLL) and multiplied by the average likelihood of occurrence to give an expected annual cost of instability. This methodology is consistent with other System Operator work, including the Credible Event Review.

Transmission Outages

The System Operator identified, based on power system simulation and analysis of historical data, that the likelihood that some prerequisite system conditions for instability are met is higher during the outage of any of the four transmission circuits connecting to Manapōuri. Additionally, the nature of the work being carried out during outage periods often means the risk of an electrical fault occurring is higher than average. As a result, the risk of instability occurring during these outage periods is higher than the annual average.

Operational Management

Options

In the operational timeframe, the only option to fully mitigate the risk of transient rotor angle instability is to constrain back Manapōuri generation. This is because generators are least stable when operating at or close to their maximum output, and this has the effect of reducing the loading on generator units, increasing their stability margin. Such a constraint could be applied as a fixed right-hand side or a dynamically updated right-hand side of a constraint equation.

Other operational options are available which do not fully mitigate the risk of instability. These include the constraint of other generation in Southland and changing voltage setpoints or generator transformer tap positions. Neither of these options, alone or in combination, would fully mitigate the risk of instability at Manapōuri.

These options are consistent with those recommended by the System Operator in the previous industry consultation on scenario-dependent fault ride-through non-compliance.

In addition to these operational measures, several other options could be effective mitigation measures in the longer term. These include the upgrade of Grid Owner transmission circuit protection systems on the Manapōuri transmission circuits, the upgrade or development of transmission infrastructure to reduce the apparent impedance between Lower South Island generation and the rest of the power system, or modifications to the existing Grid Owner generator intertrip scheme at Manapōuri. These measures are listed in this document for completeness but are outside the System Operator's scope.

Additionally, the installation of Asset Owner pole-slip protection would prevent damage to generator units.

Cost

The System Operator endeavours to minimise any impact on market outcomes to maximise net social benefit and balance any impact with the expected cost of taking no action. In this case, any operational management option which constrains generation would result in a market impact. This impact is difficult to accurately forecast but historical data was used to estimate the relative impacts of options. Generally, options which result in a greater volume of constrained generation result in a higher market impact, as a greater volume of higher-priced generation must be sourced from other participants.

The constraint of other generation in Southland, which consists of wind generation, would require a much higher level of constraint than if a constraint were applied on Manapōuri to achieve the same reduction in risk of instability. Depending on system conditions this could be up to an order of magnitude difference, resulting in a much greater market impact from constraining non-Manapōuri Southland generation. Additionally, a constraint on non-Manapōuri generation cannot fully mitigate the risk on instability in all system conditions.

The use of a fixed constraint equation right-hand side would result in a greater market impact than a dynamically updating right-hand side which reflects a real-time security limit.

There is negligible cost to changing transformer taps or machine voltage setpoints.

The application of any operational mitigation measure during local transmission outages only would significantly decrease the market impact.

Deliverability

In addition to balancing the impact of mitigation measures with the expected cost of instability, the System Operator must ensure that identified measures are deliverable within the required timeframe and budget.

While the use of a dynamically updated constraint equation right-hand-side was identified as technically feasible, it was determined that this could not be implemented via automated or semi-manual solutions within the desired timeframe to the required standard. These options were discounted as a result.

Operational Management Decision

The System Operator has decided to manage the risk of transient rotor angle stability at Manapōuri Power Station during local transmission outages (the outage of one or more of the MAN-NMA 1/2/3 or INV-MAN 2 220 kV circuits) when six or fewer Manapōuri generating units are available to meet station dispatch[1] by applying an export constraint on Manapōuri generation with a fixed right-hand-side.

When there are no local transmission outages no constraint action will be taken to mitigate the risk of loss of rotor angle stability due to the lower risk of event occurrence. Nonetheless, the System Operator will work with the Asset Owner to implement non-constraint mitigation options to appropriately reduce risk.

The System Operator will continue to monitor the risk posed by transient rotor angle stability at Manapōuri, and the impact of the management of this risk. This monitoring will feed into a System Operator review of this decision in January 2027.

Constraint Equation

The existing manual stability constraint[2] (MAN_INTERTRIP_ENABLED_STABILITY_P_1) in place in the market covering Manapōuri stability will have the right-hand-side value adjusted during outages. The constraint equation limits the total export from Manapōuri Power Station to the right-hand-side value. During outages the right-hand-side will be set to 700 MW. This value was determined based on analysis of historical results from the real-time Transient Stability Assessment Tool (TSAT) as the optimal value considering the impact on stability risk and the impact of the constraint to the market. Following the completion of an outage the right-hand-side of the constraint will be returned to its current value of 880 MW.

This constraint is not expected to eliminate the risk of transient rotor angle instability, but will significantly reduce the risk to the power system. The vast majority of severe stability margin violations will be prevented, while the impact on the market will be minimised.

The 700 MW right-hand-side value will be reviewed as part of the January 2027 review of the management of Manapōuri stability.

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[1] The System Operator will work with the Asset Owner to ensure that generating unit loading is managed to appropriately reduce the risk of instability when operating with seven generating units.

[2] Existing security constraints can be viewed on the Transpower website