Appendix 7. Power system security

June 2022

Appendix to 2022 ISP for the National Electricity Market

Important notice

Purpose

This is Appendix 7 to the 2022 *Integrated System Plan* (ISP), available at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp.

AEMO publishes the 2022 ISP under the National Electricity Rules. This publication has been prepared by AEMO using information available at 15 October 2021 (for Draft 2022 ISP modelling) and 19 May 2022 (for 2022 ISP modelling). AEMO has acknowledged throughout the document where modelling has been updated to reflect the latest inputs and assumptions. Information made available after these dates has been included in this publication where practical.

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Version control

Version	Release date	Changes
1.0	30/6/2022	Initial release.

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ISP Appendices

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A7.1 Introduction

As the power system transitions, AEMO is considering the impact of emerging trends on system services for the secure operation for the future energy system. These trends include the ongoing uptake of both utility and distributed IBR, a decline in commitment of synchronous generation, increasing uptake of DER, and lowering of minimum demands. These changes will permanently change the way in which power system security is maintained.

The NEM is continuing its rapid transformation to world-leading levels of renewable energy penetration. The current instantaneous renewable penetration[1] record across the NEM is 61.8%, set on 15 November 2021.

These increasingly high instantaneous renewable energy penetration in the NEM give further urgency to the need to consider associated system security requirements such as system strength, inertia, and other security services. In this report, AEMO explores the system strength and inertia implications of the *Step Change* outlook.

The implications of the instantaneous renewable energy penetration projections vary from NEM region to NEM region:

- Tasmania has already achieved long periods of 100% instantaneous penetration of renewable energy, due to its generation fleet comprising mostly hydro and wind generation.
- South Australia has also achieved periods of high VRE output, with flexible operation of gas-fired generation observed at periods of high VRE penetration.
- The remaining NEM regions will also soon need to prepare for very high VRE penetration and associated reduction in synchronous generation availability.

This ISP projects that existing and new-build renewable energy capacity will be such that there will be periods of time as early as 2025 when all customer electricity demand in some half-hour periods could be met by renewable generation, subject to market dispatch and the required system security services also being available. This underscores AEMO's priority to develop grids that are capable of running at up to 100% instantaneous renewable penetration by 2025.

This Appendix 7 focuses on the needs for system strength and inertia:

- **A7.2 Relationship to other planning work** – AEMO assesses power system security shortfalls and gaps in the NEM over the coming five years through its annual system strength, inertia and Network Support and Control Ancillary Services (NSCAS) reviews. In addition, AEMO's Engineering Framework will help provide the right toolkit to meet the operational, technical and engineering requirements to deliver the future power system. This section explains these work areas in the context of the power system security needs described in this report.
- **A7.4 System strength outlook** – AEMO has defined minimum three phase fault level requirements that need to be maintained at specific fault level nodes across the NEM to ensure the network is operated in a stable and secure manner. This section details projections and anticipated shortfalls of system strength, as well as the drivers of these shortfalls.

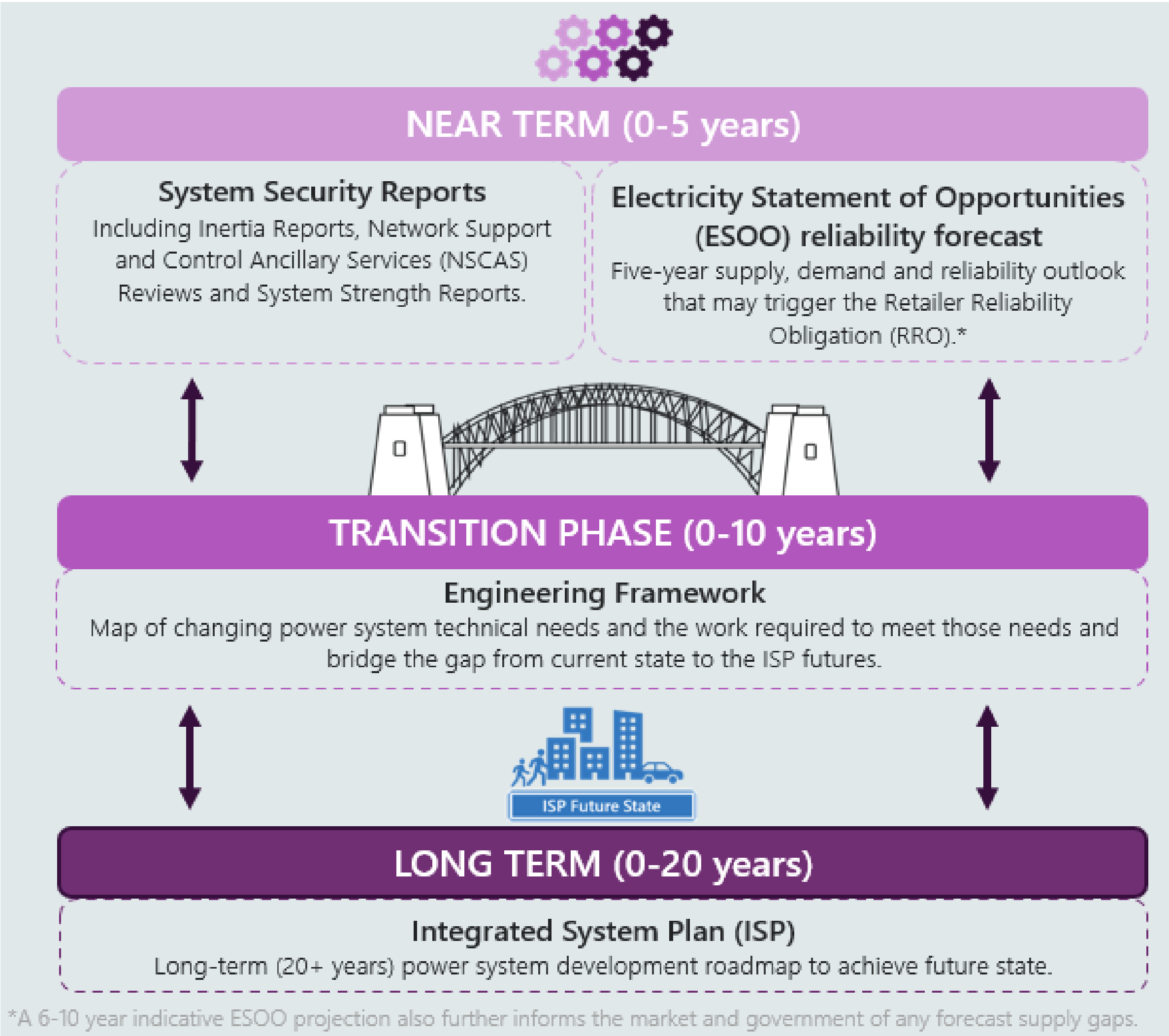
[1] Instantaneous renewable penetration is calculated as the renewable generation share of total large- and small-scale generation. The measure is calculated on a half-hourly basis, because this is the granularity of estimated output data for historical distributed PV output. For this calculation, renewable generation includes grid-scale wind and solar, hydro generation, biomass, battery generation and distributed PV, and excludes battery load and hydro pumping. Projected data has been adjusted to account for outages, constraints and time resolution differences.

- **A7.5 Inertia outlook** – AEMO has defined minimum and secure inertia levels that need to be available in each NEM region during periods when that region is islanded from the remainder of the NEM. Projections and anticipated shortfalls of inertia are detailed, as well as drivers.

A7.2 Relationship to other AEMO planning work

AEMO is required to annually assess system security for each region of the NEM for the coming five years and declare any shortfalls or gaps to be addressed by TNSPs[2]. AEMO also prepares the Engineering Framework to map the work required to meet the changing power system technical needs and bridge the gap between the current state and the ISP futures. Figure 1 describes the linkage between other planning reports and the ISP, including this Power System Security Appendix.

Figure 1 Linkages between AEMO planning reports



A7.2.1 Near-term power system security assessments

AEMO undertakes annual power system security assessments to identify the need for additional services in relation to inertia, system strength and NSCAS for the next five years. The *2021 System Security Reports*[3], released in December 2021 and updated in May 2022, found:

[2] NER Version 174, Clauses 5.20.3, 5.20.5 and 5.20.7

[3] AEMO. *2021 System Security Reports: System Strength, Inertia and NSCAS*, at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/planning-for-operability.

- Declining minimum demand and changing synchronous generator dispatch are projected to push our power system to its limits over the coming five years.
- System strength, inertia and NSCAS shortfalls and gaps have been identified across the NEM for the coming five-year period.

AEMO expects further system security needs to be identified as we transition to 100% instantaneous renewable energy penetration and as the regulatory frameworks change.

System strength

System strength is a measure of the ability of a power system to maintain and control the voltage waveform under normal conditions and to return to a steady state condition following a system disturbance[4]. AEMO published an update to the *2021 System Strength Report*, under the *2021 System Security Reports*[5], in May 2022. The updated *2021 System Strength Report* assessed system strength over the five-year outlook and declared shortfalls based on the *Step Change* scenario.

The regional TNSP[6] is required to make system strength services available to address shortfalls declared by AEMO at a fault level node. Generators that are subject to system strength remediation arrangements are required to fund system strength remediation to ensure the generator does not have an adverse system strength impact.

The AEMC's final determination on the 'Efficient management of system strength on the power system' will change these responsibilities for AEMO's 2022 system strength assessment[7], to be published in December 2022.

Inertia

A minimum level of inertia is required in the power system to suppress and slow frequency deviations so automatic controls can respond to sudden changes in the supply-demand balance[8]. AEMO published an update to the *2021 Inertia Report*, under the *2021 System Security Reports*[9], in May 2022. The updated *2021 Inertia Report* assessed inertia over the five-year outlook and declared shortfalls based on the *Step Change* scenario.

The regional TNSP[10] is required to make inertia network services or inertia support activities available to address shortfalls declared by AEMO for inertia sub-network. Shortfalls are assessed against the minimum threshold level of inertia, which is prepared for when the sub-network is islanded or at credible risk of being separated, and for the secure operating level of inertia which is prepared for when the sub-network is islanded. AEMO must consider the likelihood of an inertia sub-network becoming islanded when determining whether there are inertia shortfalls.

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[4] Further information can be found in AEMO's Power System Requirements report, June 2020, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf.

[5] AEMO, *Update to 2021 System Security Reports*, May 2022 at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/update-to-2021-system-security-reports.pdf?la=en.

[6] The jurisdictional planning body is the responsible party if there is more than one TNSP in a region.

[7] AEMC, *Efficient management of system strength on the power system*, at https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system.

[8] Further information can be found in AEMO's *Power System Requirements* report, June 2020, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf.

[9] AEMO, *2021 System Security Reports: System Strength, Inertia and NSCAS*, May 2022 at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/update-to-2021-system-security-reports.pdf?la=en.

[10] The jurisdictional planning body is the responsible party if there is more than one TNSP in a region.

The completion of the ESB's Post-2025 electricity market design program[11] and the implementation of the fast frequency response ancillary service[12] can be expected to affect the outcomes delivered under the existing inertia framework.

NSCAS

NSCAS[13] are non-market ancillary services that may need to be procured to address the following needs:

- Maintain power system security and reliability of supply of the transmission network in accordance with the power system security standards and the reliability standard[14].
- Maintain or increase power transfer capability of the transmission network to maximise the present value of net economic benefit to all those who produce, consume or transport electricity in the market[15].

AEMO must, at least annually, identify any NSCAS need forecast to arise in the next five years. The NER give TNSPs the primary responsibility for acquiring NSCAS. If AEMO is required to procure NSCAS under its last resort responsibility, it can only do so to meet the first of the NSCAS needs – for power system security and reliability. AEMO published the *2021 NSCAS Report*, under the *2021 System Security Reports*[16], in December 2021, identifying the NSCAS gaps over the five-year horizon.

A7.2.2 Enabling transition through the Engineering Framework

The Engineering Framework[17] is a toolkit to define the full range of operational, technical and engineering requirements needed to prepare the NEM power system for six identified future operational conditions, including preparation for 100% instantaneous penetration of renewables. The framework seeks to facilitate an orderly transition to a secure and efficient future NEM system.

In July 2021, AEMO released the operational conditions summary[18], describing the generation mix and loading combinations projected to occur five to 10 years in the future that will necessitate changes to current operational practices. Building on this summary, AEMO published an initial roadmap[19] in December 2021 to inform preparation of the NEM for operation under the six identified operational conditions.

Stakeholder feedback in early 2022 highlighted a strong desire to understand the specific actions that will be prioritised in the near term to start addressing the most pressing gaps and decisions identified in the Initial Roadmap. In June 2022, AEMO published the priority actions report[20] to catalogue these actions alongside AEMO's commitment to progress each of them during the 2022-2023 financial year. The Engineering Framework is an ongoing, iterative process that requires close collaboration between AEMO and stakeholders. The next update report is targeted for Q4 2022.

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[11] At https://esb-post2025-market-design.aemc.gov.au/.

[12] AEMC, 'Fast frequency response ancillary service' rule change, at https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

[13] The NSCAS definition is in the Chapter 10 Glossary of NER Version 174.

[14] NER Version 174, Clause 3.11.6 (a)(1)

[15] NER Version 174, Clause 3.11.6 (a)(2)

[16] AEMO, *2021 System Security Reports: System Strength, Inertia and NSCAS*, will be available in December 2021 at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/planning-for-operability.

[17] AEMO. Engineering Framework at https://aemo.com.au/en/initiatives/major-programs/engineering-framework.

[18] See https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/nem-engineering-framework-july-2021-report.pdf

[19] See https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/nem-engineering-framework-initial-roadmap.pdf

[20] See https://aemo.com.au/-/media/files/initiatives/engineering-framework/2022/nem-engineering-framework-priority-actions.pdf

A7.3 System strength outlook

Synchronous machines have traditionally provided, and continue to provide, a source of system strength, while grid-following IBR generally require a level of system strength to be provided at the location they connect to, in order to be able to operate.

This section:

- Notes the importance of system strength and the roles and responsibilities (A7.3.1).
- Discusses the efficient management of system strength rule change (A7.3.2).
- Provides a NEM-wide system strength outlook (A7.3.3).
- Provides a regional system strength outlook (A7.3.4).

A7.3.1 Importance of system strength, roles and responsibilities

A minimum level of system strength is needed for the power system to remain stable under normal conditions and to return to a steady state condition following a system disturbance.

In the NEM, the present division of responsibilities for the provision of system strength is as follows:

- AEMO, in consultation with the TNSP or jurisdictional planning body, is required to determine the location of fault level nodes.
- AEMO is required to determine the minimum three phase fault level at each node and identify whether a shortfall is likely to exist at any node over the five-year horizon.
- The regional TNSP or jurisdictional planning body is required to ensure that system strength services are available to address any fault level shortfall declared by AEMO at a fault level node.
- Generators subject to the system strength remediation requirements must implement or fund system strength remediation to ensure the generator does not have an adverse system strength impact.

This report considers the methodology and provisions under the current system strength rules.

A7.3.2 Efficient management of system strength rule change

In October 2021, the AEMC made its final determination on the 'Efficient management of system strength on the power system' rule change[21]. As a result, from December 2022 onwards:

- AEMO will set a system strength standard for each system strength node, including a three phase fault level required for a secure system and a forecast of future inverter-based connections at the node, and
- Responsible TNSPs will use reasonable endeavours to plan system strength services to meet the standard at each node.

Responsible TNSPs will need to meet the new system strength standard from December 2025 onwards, per the December 2022 declarations, and in the interim the shortfall framework will continue to apply.

[21] AEMC, 'Efficient management of system strength on the power system', accessed in November 2021 at https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system.

In April 2022, AEMO began public consultation[22] on amending its system strength instruments to implement the rule change – that is, the System Strength Requirements Methodology, the System Strength Impact Assessment Guidelines, and the Power System Stability Guidelines. AEMO's implementation of the final rule determination is ongoing.

In the *2021 System Security Reports*, and the *Update to the 2021 System Security Reports* released in May 2022, the existing framework is applied, meaning some shortfalls are declared for periods which will ultimately be covered by the system standard under the new framework.

In the ISP timeframe, it can be expected that TNSPs will act consistent with the AEMC's final determination and take reasonable endeavours to fully meet the system strength standard at each system strength node.

A7.3.3 NEM-wide system strength outlook

For this ISP, AEMO used the Available Fault Level calculation methodology[23] to perform high level system strength impact assessments showing where generator proponents may be required to remediate their system strength impact under the current framework. AEMO notes that the new system strength framework will apply from December 2022 onwards. Snapshot periods from the market modelling outputs have been analysed across the NEM.

Figure 2 shows areas that already have low system strength, and projects where system strength is expected to decrease unless investments are made:

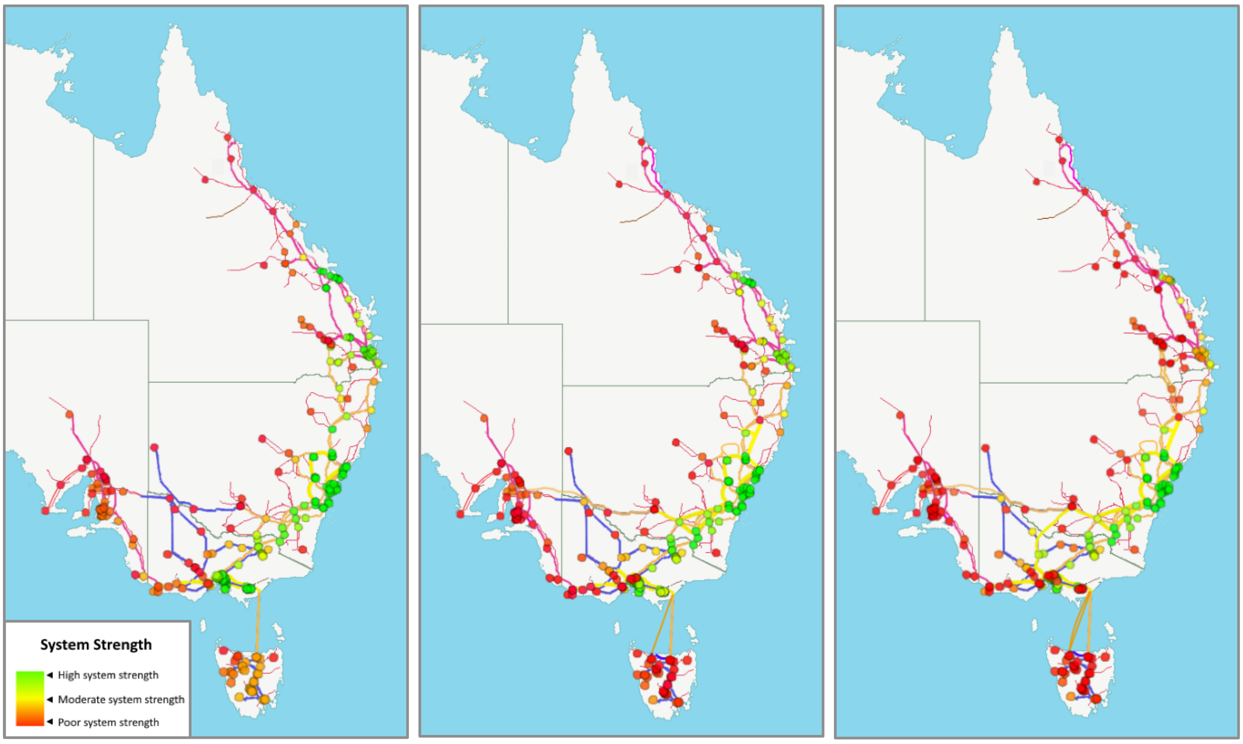
- In 2022-23:
  - Areas of existing low system strength include Western Victoria, South-West New South Wales, Northern Queensland, and Tasmania.
- In 2030-31:
  - System strength in Tasmania and South-West Victoria is forecast to reduce further, driven by forecast increases in VRE.
  - The Western Renewables Link improves the system strength outlook in Western Victoria.
  - Project EnergyConnect improves the system strength outlook in South-West NSW and Northern Victoria.
- In 2034-35:
  - Due to large projections of VRE in nearby REZs, system strength is forecast to further decline in Central Queensland, Southern Queensland, Northern New South Wales, South-West Victoria and South Australia.

This assessment is based on the *Step Change* scenario, with fault level nodes being held at their minimum requirement levels. The *Step Change* scenario has accelerated uptake of VRE and withdrawal of some coal generation, bringing forward the need and increasing the size of system strength remediations.

[22] AEMO, System Strength Requirements Methodology and System Strength Impact Assessment Guidelines amendments consultation, at https://aemo.com.au/consultations/current-and-closed-consultations/ssrmiag.

[23] AEMO. System Strength Impact Assessment Guidelines, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/System_Strength_Impact_Assessment_Guidelines_PUBLISHED.pdf.

Figure 2 NEM-wide system strength outlook 2022-23 (left), 2029-30 (centre), 2034-35 (right), *Step Change* scenario



Cost of system strength remediation

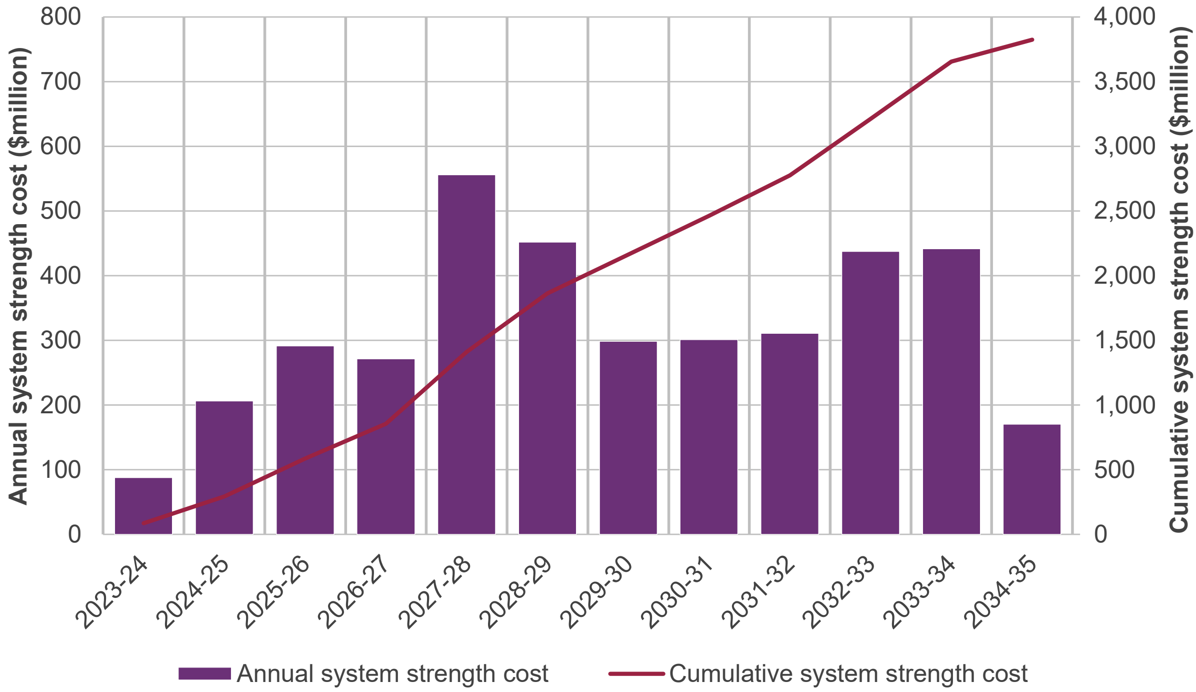
For information purposes, AEMO has prepared high-level cost estimates for provision of system strength services in the REZs across the NEM. System strength service requirements are based on assessment of existing synchronous generation dispatch, potential network upgrades, and the potential scale of local IBR.

AEMO has estimated costs based on existing technologies that are commercial and have been demonstrated at a large scale – that is, synchronous condensers are assumed to provide the system strength service. Over time, AEMO expects that alternative technologies such as grid-forming inverters will become available to provide system strength services once demonstrated at scale. As such, the cost estimates represented here are intended to consider an upper bound for system strength costs.

Figure 3 shows the cumulative system strength remediation costs to address system strength remediation for VRE projected under the *Step Change* scenario across the NEM. These estimates assume a cost of $106,000/MW[24]. Approximately $4 billion is required out to 2035 for system strength remediation for the forecast IBR generation connection in REZs.

[24] For more information on the cost for system strength remediation, refer to section 5.2 of the *2021 Transmission Cost Report*, August 2021, at https://aemo.com.au/-/media/files/major-publications/isp/2021/transmission-cost-report.pdf?la=en.

Figure 3 Projected system strength remediation costs for REZs for the *Step Change* scenario



A7.3.4 Regional system strength outlook

In 2018, AEMO published the system strength requirements for nodes across the NEM. In determining the requirements, AEMO applied the System Strength Requirements Methodology[25] in each region of the NEM by selecting fault level nodes and then assessing the minimum three phase fault level required at each node. Updates to some regions have been progressively published, considering changes in network conditions. Fault level requirements shown in these ISP projections are based on these latest studies.

To date, AEMO has published[26] fault level shortfalls:

- In **South Australia**, AEMO declared inertia and fault level shortfalls in 2018, which ElectraNet has addressed, mainly by installing major high-inertia synchronous condensers. In 2020, AEMO revised the inertia requirements for the South Australia region to reflect findings from the South Australia islanding event in early 2020, anticipated levels of embedded generation and the implication of declining minimum demand in the region. With the revised inertia requirement, AEMO declared an additional inertia shortfall in South Australia above the shortfall already declared in 2018, extending until end of June 2023. ElectraNet is developing a solution to address this shortfall. In December 2021, AEMO declared the extension and increase of the inertia shortfall out until the completion of Project EnergyConnect.
- In **Tasmania**, AEMO declared inertia and fault-level shortfalls in November 2019, for which TasNetworks has procured a solution. In May 2021, AEMO declared an additional inertia and system strength shortfall, above those already addressed by TasNetworks to meet the November 2019 shortfall, for which TasNetworks has again procured a solution until April 2024. In December 2021, AEMO declared inertia and fault-level shortfalls for the period beyond April 2024.

[25] AEMO, System Strength Requirements Methodology, July 2018, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/System_Strength_Requirements_Methodology_PUBLISHED.pdf.

[26] AEMO system strength assessments are available on the 'Planning for operability' webpage at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/planning-for-operability.

- In **Victoria**, AEMO declared a fault-level shortfall in north-west Victoria in December 2019. In August 2020, AEMO, in its role as system strength service provider for the Victorian region, secured a short-term solution effective until 31 July 2022. In December 2021, AEMO announced that a longer-term solution had been engaged to address the shortfall out until the commissioning of Project EnergyConnect. In May 2022, in the five-year system strength outlook, AEMO declared system strength shortfalls for Hazelwood, Moorabool and Thomastown from July 2026, for which a solution is to be provided.
- In **Queensland**, AEMO declared a fault-level shortfall in north Queensland in April 2020, for which Powerlink developed a solution. In December 2021, AEMO declared a system strength shortfall at Gin Gin, and in May 2022 the shortfall was increased. AEMO has requested Powerlink to provide services to address this shortfall by 31 March 2023. In May 2022, AEMO rescinded a previous shortfall for inertia which had been declared, but noted a possible future shortfall from July 2026, subject to market assessments.
- In **New South Wales**, AEMO declared fault level shortfalls at Sydney West and Newcastle in December 2021, and updated the shortfall declaration dates in May 2022. These shortfalls are declared for July 2025 onwards, and AEMO has requested that Transgrid make services made available from 1 July 2025.

Procurement of system strength mitigation such as large synchronous condensers is expected to take at least two years; there is a risk of being caught out by early generation retirements or failures, because these are aspects not easily forecast. In some locations, network upgrades may also be required to facilitate integration of synchronous condensers due to (local) increases in fault level.

Other technical solutions, such as advanced inverters with grid-forming capabilities at strategic sites in the NEM, have the potential to reduce the system's reliance on synchronous plant, enabling further decarbonisation and delivering benefits to consumers. However, at present this potential is not demonstrated at the necessary scale, and focused engineering development is urgently needed to address the remaining issues and realise the promise of this technology.

The inverters that interface IBR generation with the grid can include advanced functionality to support power system operation, and have the potential to provide some of the stability capability that has previously been delivered by synchronous generators. With sufficient attention, focus, and investment, advanced inverter technology may be able to address many of the challenges facing the NEM today for the integration of renewable (inverter-based) resources[27].

Future fault level nodes definitions and fault level requirements

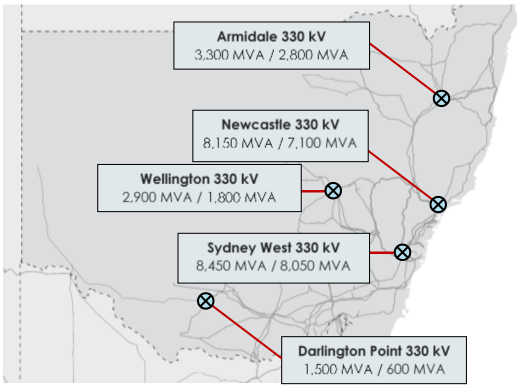
Projections of fault levels have been assessed using the latest fault level node and minimum fault level requirements for the *Step Change* scenario. System strength projections have been provided for the nodes currently defined in each region and compared against the existing requirements. As the generation and transmission systems develop, both the fault level nodes and fault level requirements will change.

Results for 2024-25, 2029-30 and 2034-35 are shown in the following sections.

[27] AEMO, *Application of Advanced Grid-scale Inverters in the NEM*, at https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/application-of-advanced-grid-scale-inverters-in-the-nem.pdf.

New South Wales system strength outlook

System strength requirements (pre/post contingent) and summary



A forecast trend of decreasing system strength across New South Wales is due to the accelerated forecast retirements of synchronous generation in the *Step Change* scenario.

Network upgrades to facilitate REZ expansions and to facilitate interconnection can increase fault levels at surrounding nodes.

Network expansions include:

- Project EnergyConnect in South-west New South Wales.
- Central-West Orana transmission link.
- HumeLink.
- New England REZ transmission link.
- Sydney Ring*.
- QNI Connect.

Projections – *Step Change* scenario

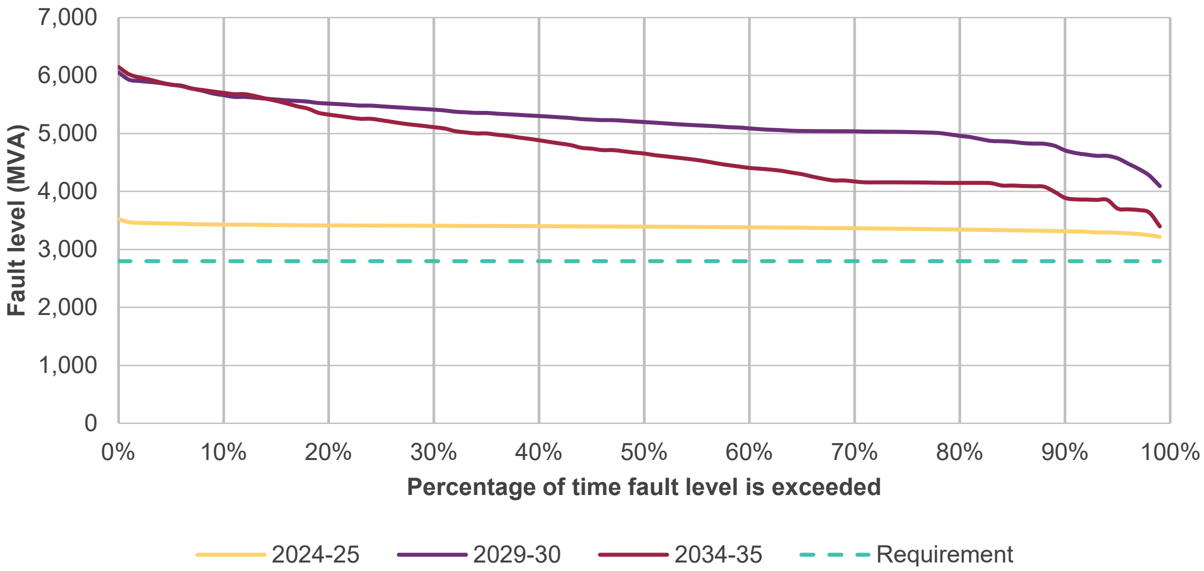
Node	Current requirement met			Comment
	2024-25	2029-30	2034-35	
Armidale 330 kV	Yes	Yes	Yes	Network expansions, including New England REZ transmission link and Sydney Ring, are expected to increase the fault level at this node.
Newcastle 330 kV	Yes	2,600 MVA potential shortfall†	3,650 MVA potential shortfall†	The closure of units from Vales Point or Eraring power stations is expected to result in decreased system strength at these nodes, in the absence of further actions. System strength would be further reduced with the closure or decommitment of Bayswater Power Station units.
Sydney West 330 kV	Yes	3,150 MVA potential shortfall†	4,400 MVA potential shortfall†	
Wellington 330 kV	Yes	Yes	Yes	
Darlington Point 330 kV	Yes	Yes	Yes	

* The northern part of this project is named the *Hunter Transmission Project* and may include the *Waratah Super Battery* and related upgrades.

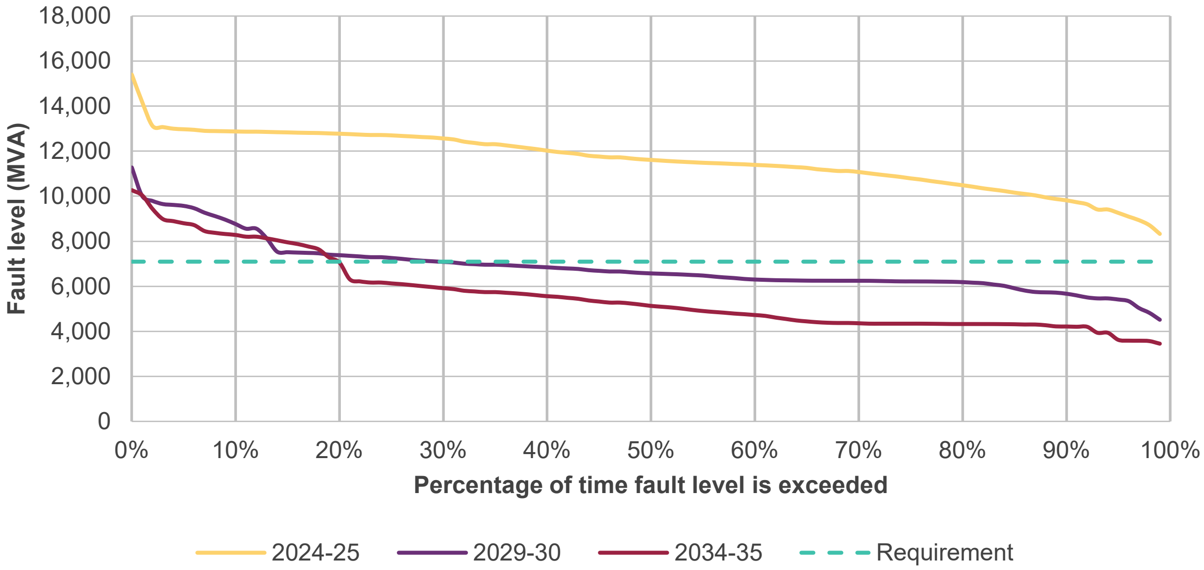
† AEMO, in the *Update to the 2021 System Security Reports*[28], declared shortfalls for these nodes. Although AEMO projects in this ISP that these shortfalls may increase, an increase in fault level shortfall is not formally declared. AEMO will continue to assess declaration of system shortfalls through the annual assessments under the existing framework, as well as considering the system strength standard under the new framework. From 2025 onwards, the local TNSP or jurisdictional planning body will be required to meet the new system strength standard under the new rules framework.

[28] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/update-to-2021-system-security-reports.pdf?la=en.

Armidale 330 kV

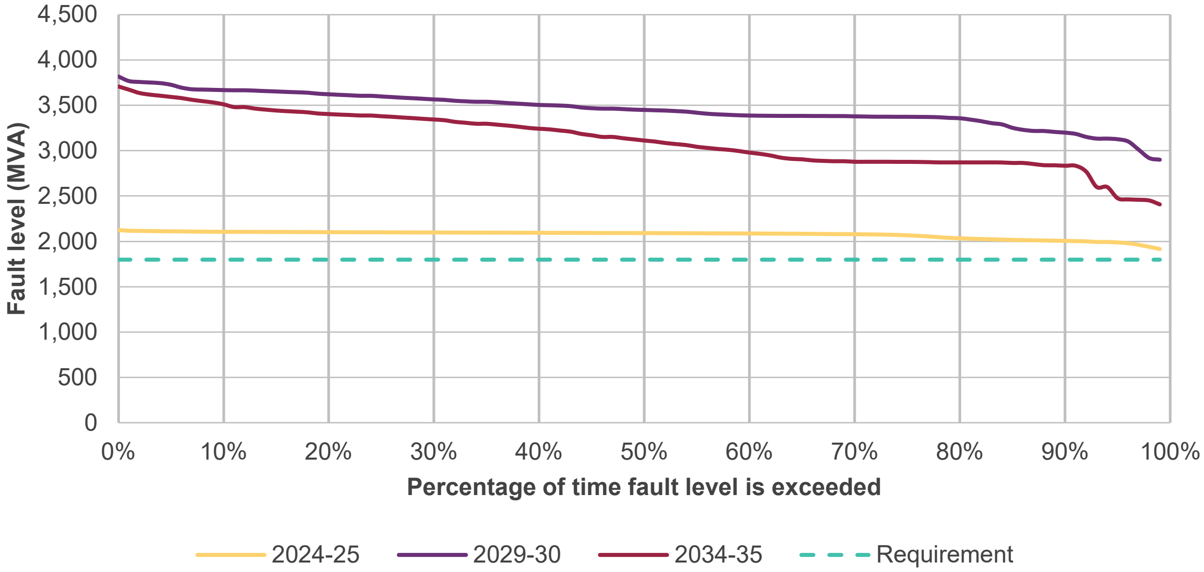


Newcastle 330 kV

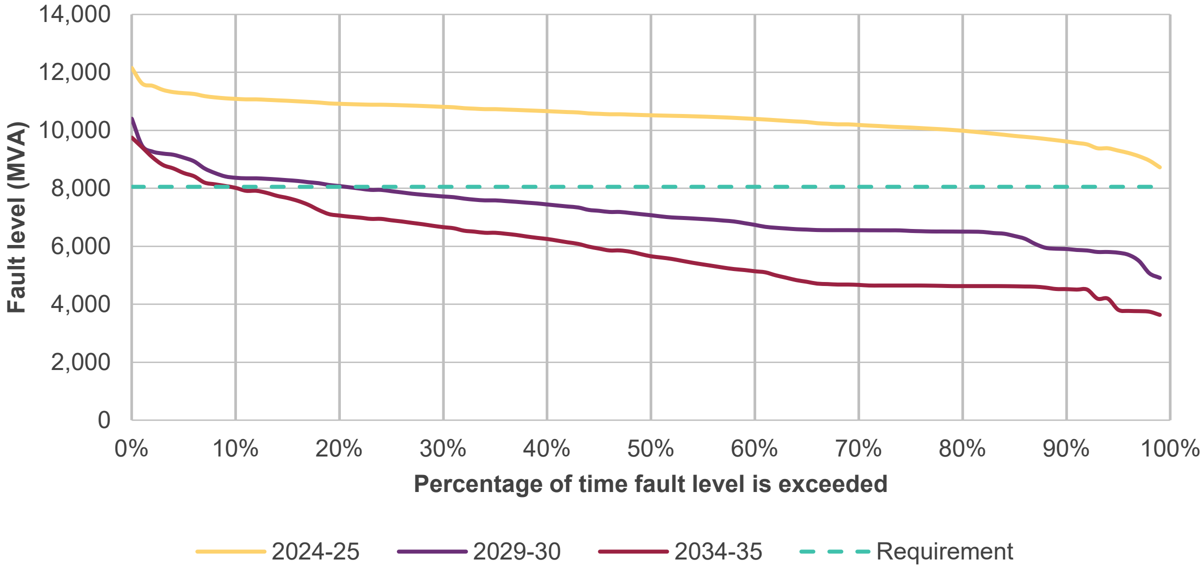


Consistent with the *Update to the 2021 System Security Reports*, no shortfall is seen in 2024-25 and a shortfall is seen from 2025-26 following the announcement of the potential early retirement of Eraring Power Station for August 2025 and after the application of the *Step Change* scenario. Fault levels at this node continue to decline below the fault level requirement from 2025-26 out to 2034-35.

Wellington 330 kV

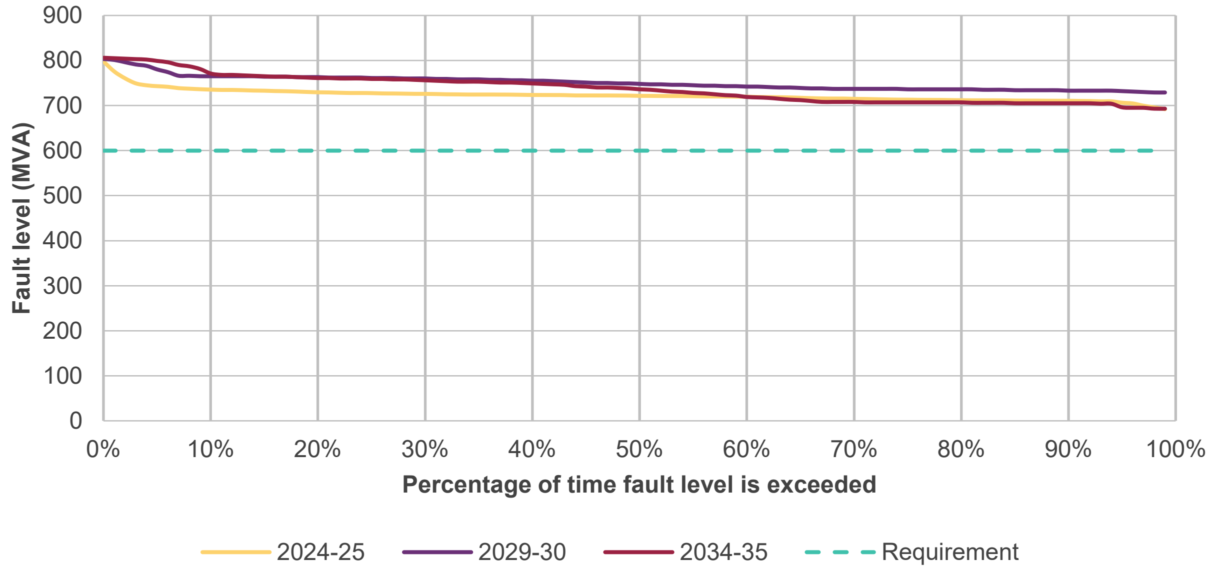


Sydney West 330 kV



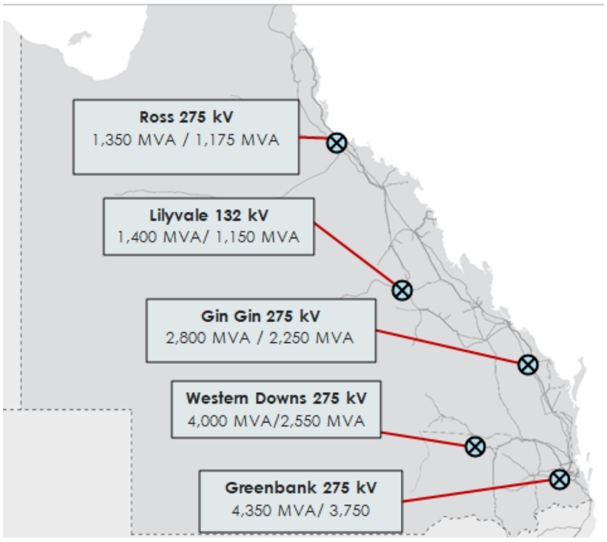
Consistent with the *Update to the 2021 System Security Reports*, no shortfall is seen in 2024-25 and a shortfall is seen from 2025-26 following the announcement of the potential early retirement of Eraring Power Station for August 2025 and after the application of the *Step Change* scenario. Fault levels at this node continue to decline below the fault level requirement from 2025-26 out to 2034-35.

Darlington Point 330 kV



Queensland system strength outlook

System strength requirements (pre/post contingent) and summary



These system strength studies have found that across Queensland, there is a projected trend of decreasing system strength due to the projected decline in the number of synchronous machines online and the transition to IBR.

Future network investments such as QNI Connect increase fault levels at nodes in close proximity to the network upgrades.

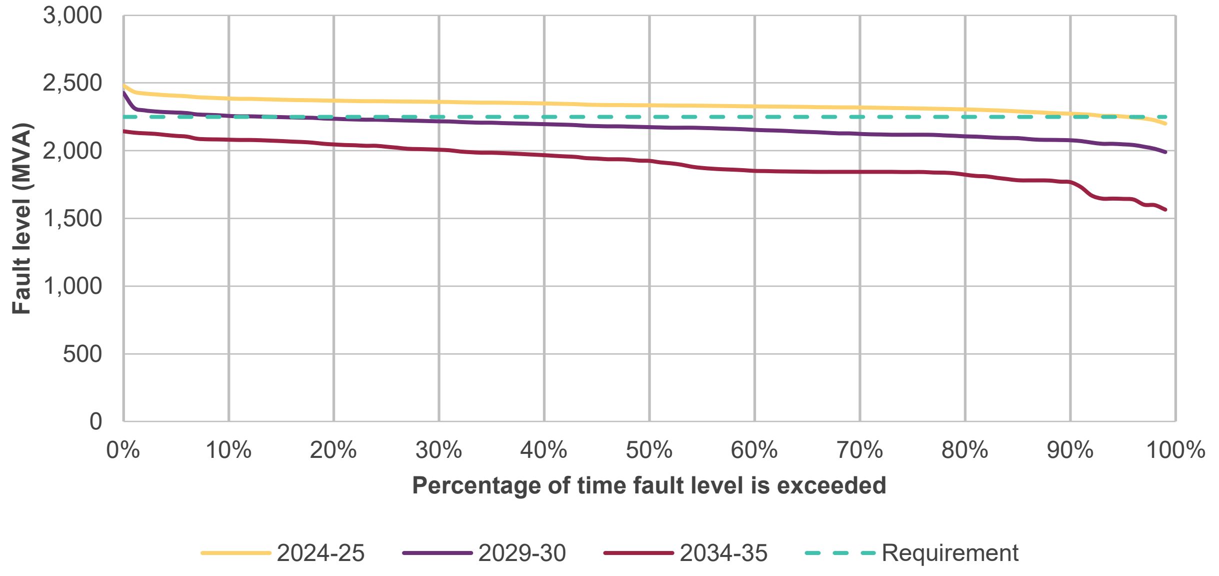
Projections – *Step Change* scenario

Node	Current requirement met			Comment
	2024-25	2029-30	2034-35	
Gin Gin 275 kV	50 MVA potential shortfall†	250 MVA potential shortfall†	700 MVA potential shortfall†	Closure of Callide B and Gladstone power stations is expected to reduce fault level at Gin Gin in the absence of further action.
Greenbank 275 kV	Yes	1,150 MVA potential shortfall ‡	1,550 MVA potential shortfall‡	Potential early closure and/or decommitment of coal-fired power stations in Queensland is expected to reduce fault levels at Greenbank and Western Downs in the absence of further action.
Lilyvale 132 kV	Yes	Yes	200 MVA potential shortfall‡	
Ross 275 kV	Yes	Yes	200 MVA potential shortfall‡	
Western Downs 275 kV	Yes	500 MVA potential shortfall‡	Yes	Potential early closure and/or decommitment of coal-fired power stations in Queensland is expected to reduce fault levels at Greenbank and Western Downs from 2029-30 in the absence of further action. The forecast step increase in fault level at Western Downs in 2034- 35 is due to the projected commissioning of the second 330 kV Queensland to New South Wales interconnector forecast for 2032-33

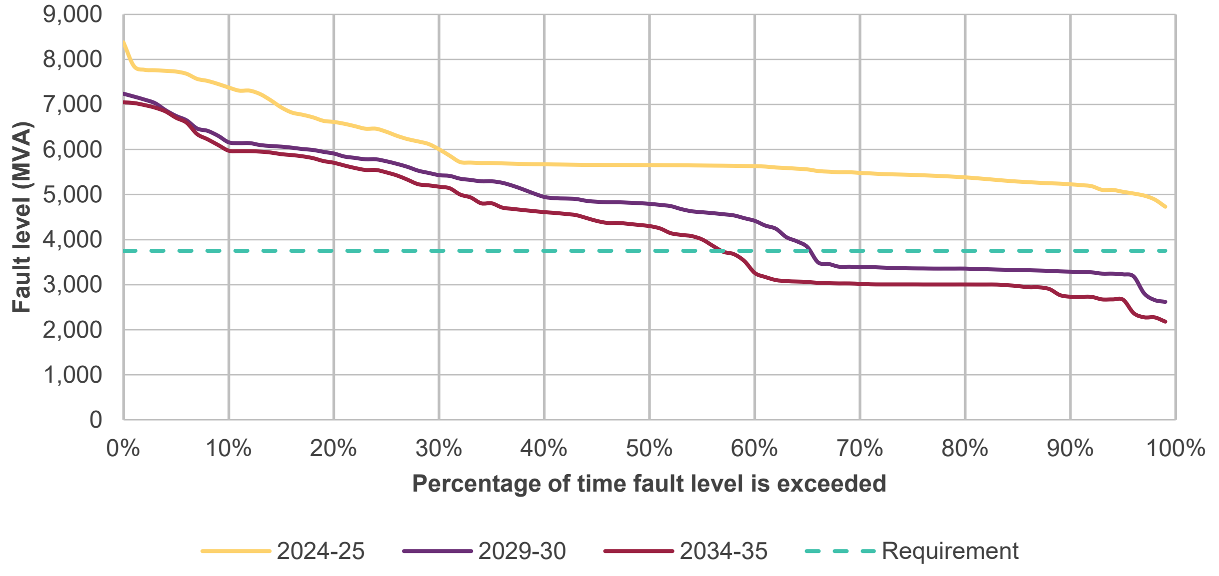
† AEMO, in the *Update to the 2021 System Security Reports*[29], declared a shortfall Gin Gin fault level node. Although AEMO in this ISP projects that this shortfall may increase, an increase in fault level shortfall is not formally declared. AEMO will continue to assess declaration of system shortfalls through the annual assessments under the existing framework, as well as considering the system strength standard under the new framework. From 2025 onwards, the local TNSP or jurisdictional planning body will be required to meet the new system strength standard under the new rules framework.
‡ Although AEMO projects that a shortfall may arise, a fault level shortfall is not formally declared. AEMO will continue to assess declaration of system shortfalls through the annual assessments under the existing framework, as well as considering the system strength standard under the new framework. From 2025 onwards, the local TNSP or jurisdictional planning body will be required to meet the new system strength standard under the new rules framework.

[29] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/update-to-2021-system-security-reports.pdf?la=en.

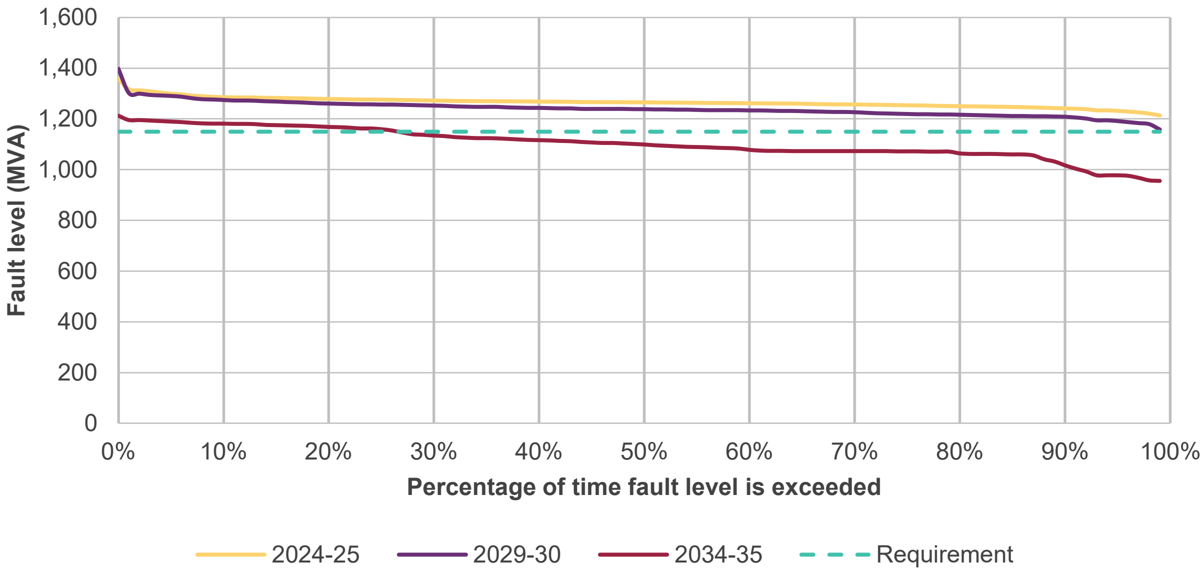
Gin Gin 275 kV



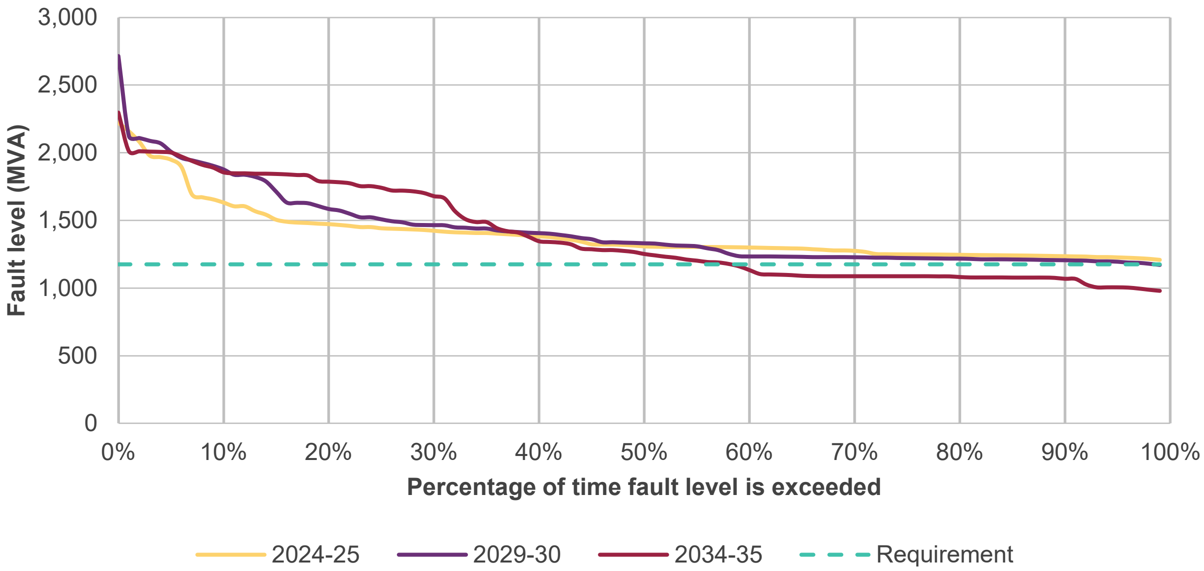
Greenbank 275 kV



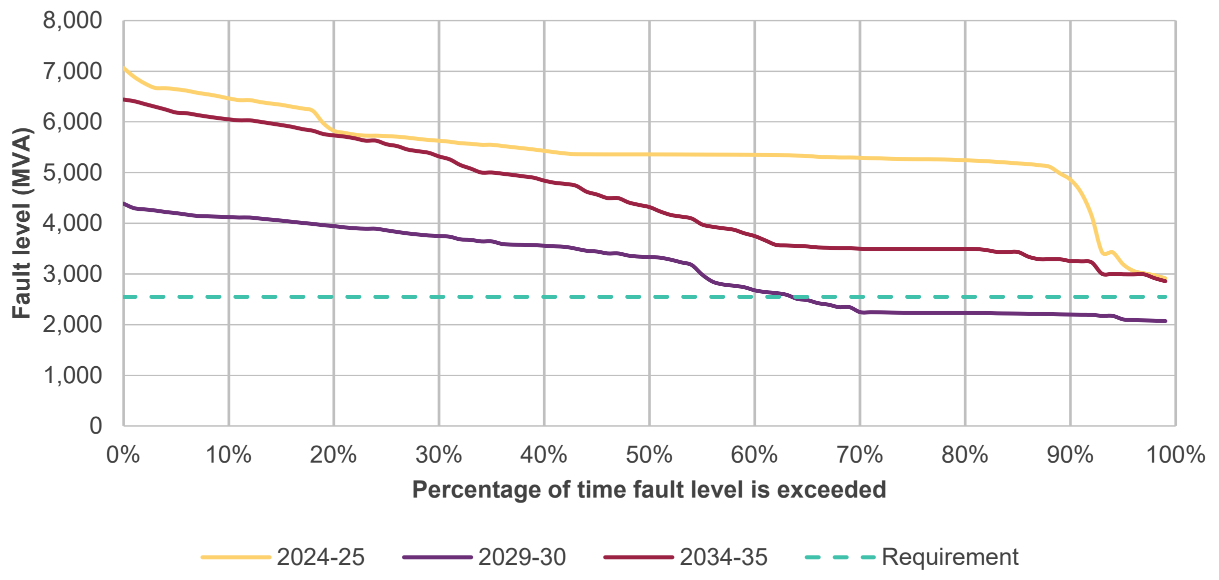
Lilyvale 132 kV



Ross 275 kV

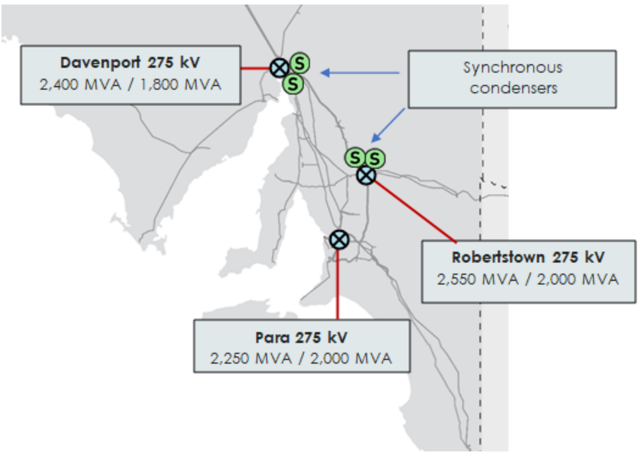


Western Downs 275 kV



South Australia system strength outlook

System strength requirements (pre/post contingent) and summary



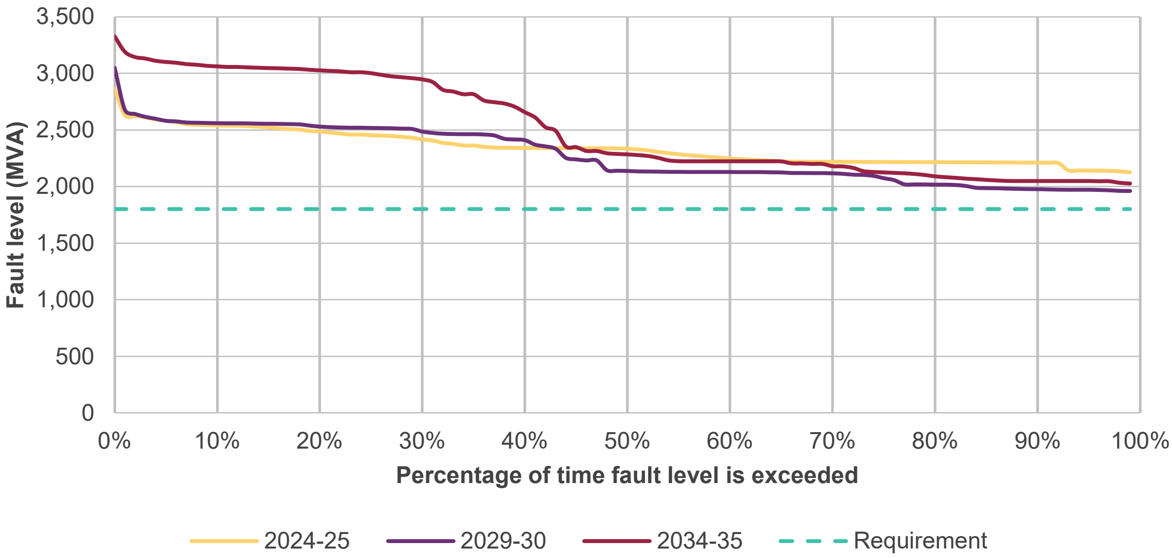
ElectraNet has commissioned four synchronous condensers, two at Davenport and two at Robertstown, to address the fault level shortfall declared by AEMO in October 2017. The synchronous condensers improve system strength and inertia in South Australia.

The analysis incorporates the AEMO planning assumption that at least two large synchronous generating units remain online for system security purposes until the commissioning and testing of Project EnergyConnect is complete[30].

Projections – *Step Change* scenario

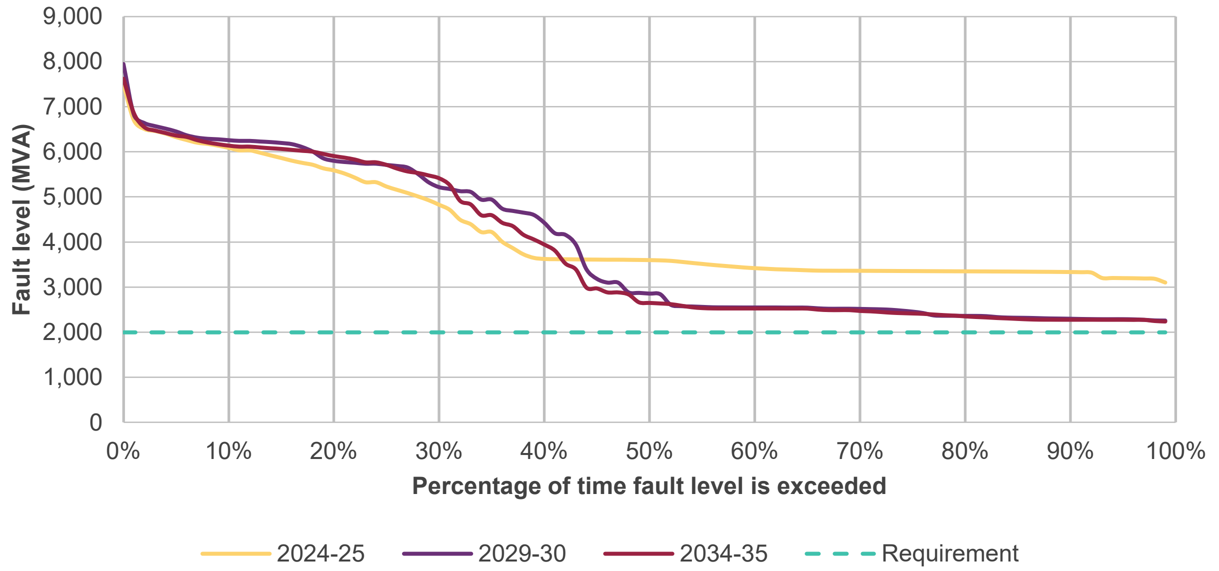
Node	Current requirement met			Comment
	2024-25	2029-30	2034-35	
Davenport 275 kV	Yes	Yes	Yes	With the four synchronous condensers installed in South Australia, the projected system strength for all nodes in South Australia is expected to meet the current system strength requirements in the future.
Para 275 kV	Yes	Yes	Yes	
Robertstown 275 kV	Yes	Yes	Yes	

Davenport 275 kV

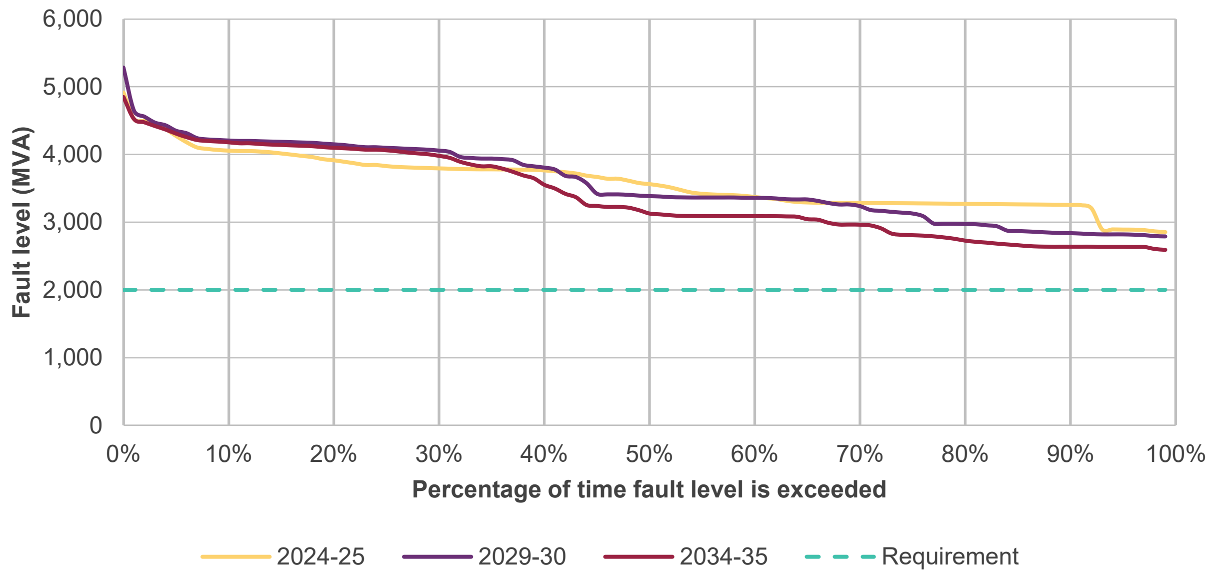


[30] AEMO is continuing to assess ongoing power system requirements for South Australia, including the requirement to keep two synchronous generating units online, and will provide quarterly updates on this work plan in 2022.

Para 275 kV

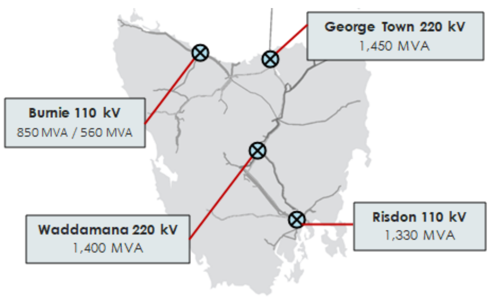


Robertstown 275 kV



Tasmania system strength outlook

System strength requirements (pre/post contingent) and summary



TasNetworks has entered into a contract for system strength and inertia services to address system strength and inertia shortfalls declared in May 2020, which were later revised and increased in May 2021. This contract expires in 2024. Without the continuation of this contract or other system strength services, ISP modelling shows that shortfalls are likely to re-emerge – consistent with findings in the *2021 System Security Reports*.

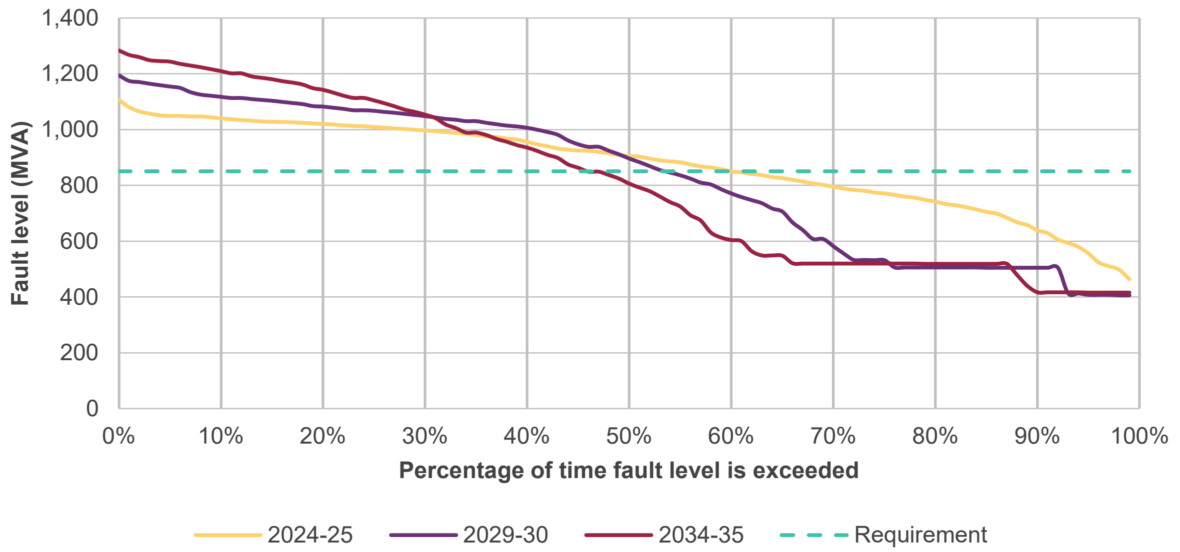
Projections – *Step Change* scenario

Node	Current requirement met†			Comment
	2024-25	2029-30	2034-35	
Burnie 110 kV	386 MVA potential shortfall‡	450 MVA potential shortfall‡	450 MVA potential shortfall‡	Consistent with the *2021 System Security Reports*, AEMO notes that shortfalls are likely in Tasmania without additional system strength services. AEMO has declared shortfalls from April 2024 onwards.
George Town 220 kV	750 MVA potential shortfall‡	900 MVA potential shortfall‡	950 MVA potential shortfall‡	
Risdon 110 kV	505 MVA potential shortfall‡	700 MVA potential shortfall‡	700 MVA potential shortfall‡	
Waddamana 220 kV	519 MVA potential shortfall‡	750 MVA potential shortfall‡	750 MVA potential shortfall‡	

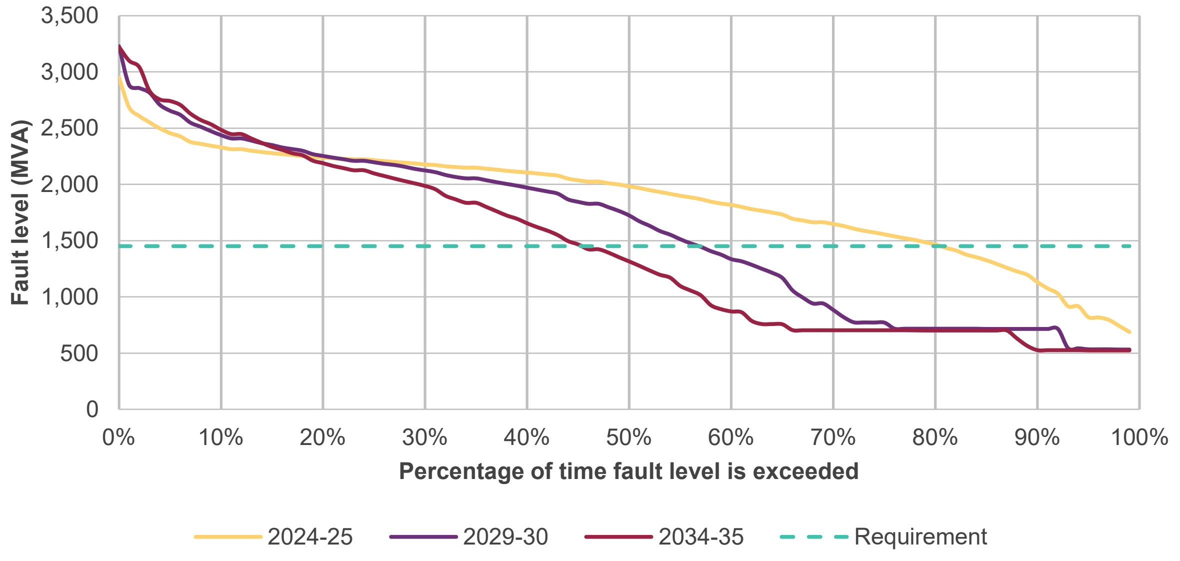
† AEMO and TasNetworks use pre-contingency values to inform the operational arrangements for system strength requirements in Tasmania. These nodes have specific local requirements which must be met for the pre-contingent levels, namely requirements to do with maintaining Basslink requirements, switching requirements for local reactive plant, and some power quality requirements for metropolitan load centres.

‡ Although AEMO projects that a shortfall may arise, a fault level shortfall is not formally declared from these results. AEMO will continue to assess declaration of system shortfalls through the annual assessments under the existing framework, as well as considering the system strength standard under the new framework. From 2025 onwards, the local TNSP or jurisdictional planning body will be required to meet the new system strength standard under the new rules framework.

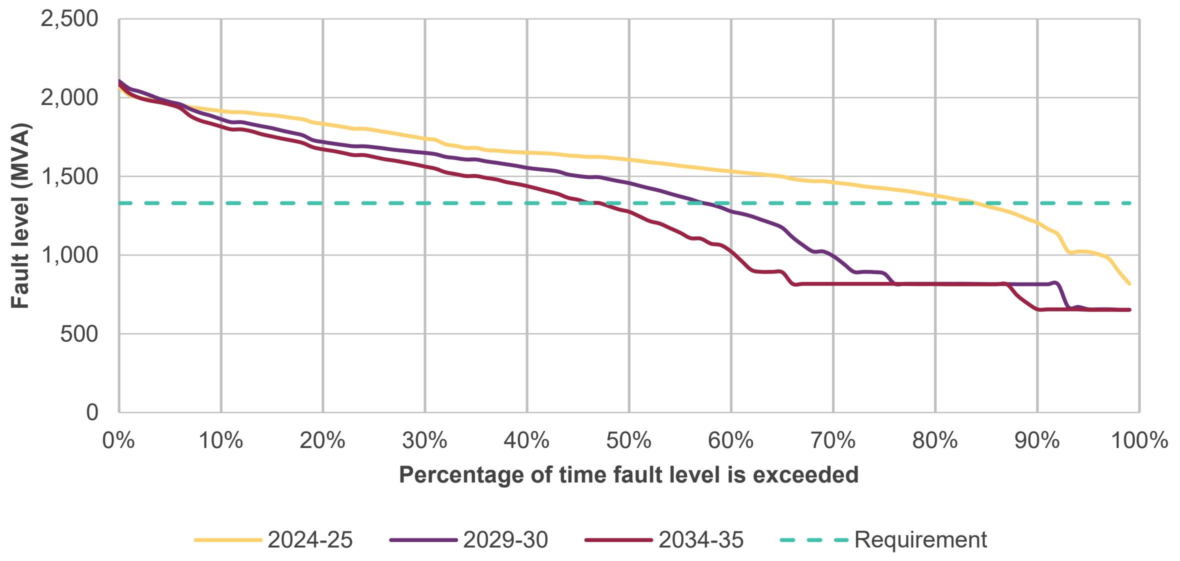
Burnie 110 kV



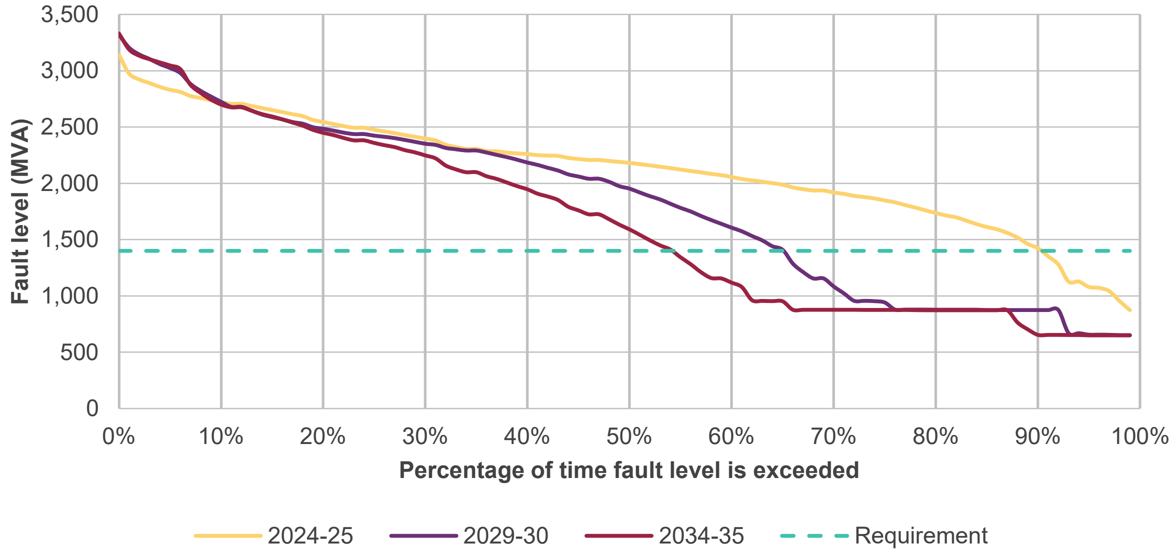
George Town 220 kV



Risdon 110 kV

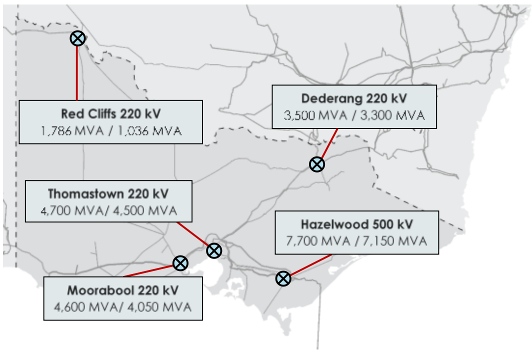


Waddamana 220 kV



Victoria system strength outlook

System strength requirements (pre/post contingent) and summary



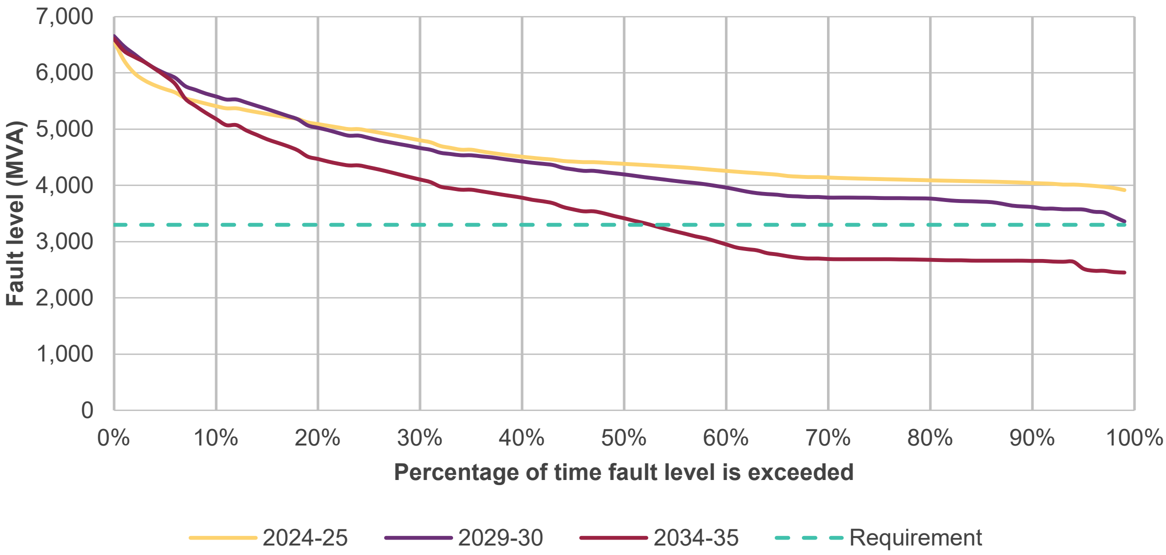
These system strength studies have found that across Victoria, there is a projected trend of decreasing system strength due to the projected decline in the number of synchronous machines online and the transition to IBR.

Projections – *Step Change* scenario

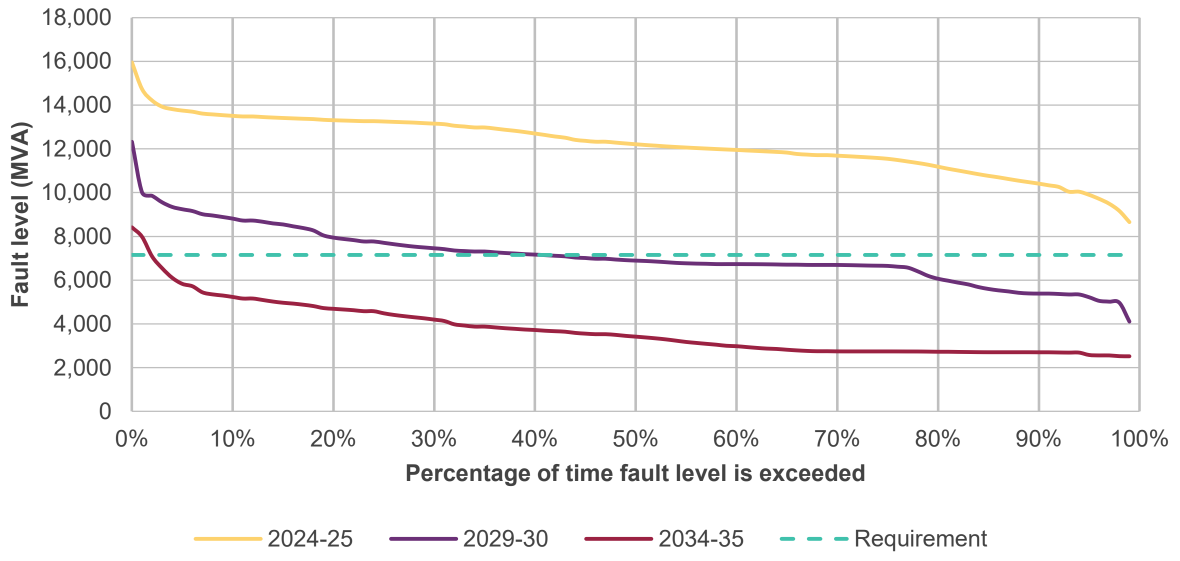
Node	Current requirement met			Comment
	2024-25	2029-30	2034-35	
Dederang 220 kV	Yes	Yes	850 MVA potential shortfall†	
Hazelwood 500 kV	Yes	3,050 MVA potential shortfall†	4,650 MVA potential shortfall†	Yallourn Power Station's retirement, with the forecast decline in synchronous generation in Victoria, is expected to reduce fault level at these nodes in the absence of further action.
Moorabool 220 kV	Yes	900 MVA potential shortfall†	1,600 MVA potential shortfall†	
Thomastown 220 kV	Yes	1,200 MVA potential shortfall†	2,050 MVA potential shortfall†	
Red Cliffs 220 kV	Yes	Yes	Yes	Red Cliffs fault levels are forecast to increase with the commissioning of Project EnergyConnect.

†Although AEMO projects that a shortfall may arise, a fault level shortfall is not formally declared. AEMO will continue to assess declaration of system shortfalls through the annual assessments under the existing framework, as well as considering the system strength standard under the new framework. From 2025 onwards, the local TNSP or jurisdictional planning body will be required to meet the new system strength standard under the new rules framework.

Dederang 220 kV

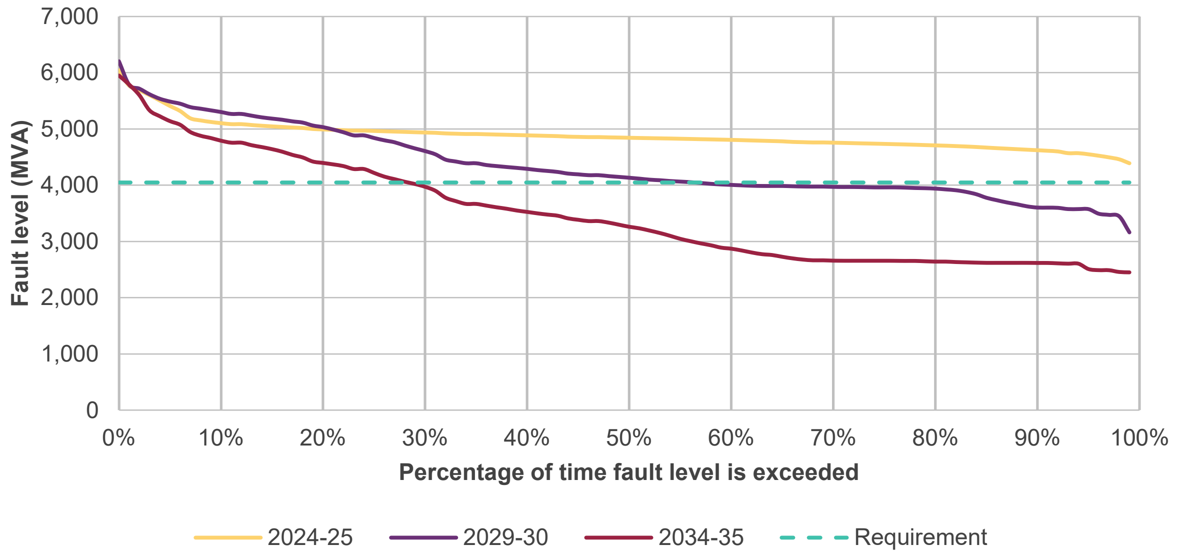


Hazelwood 275 kV



AEMO declared a shortfall for this node in the *Update to the 2021 System Security Reports*[31], consistent with the *Step Change* scenario which forecasts earlier coal generation retirements and greater VRE penetration compared to the *Progressive Change* scenario.

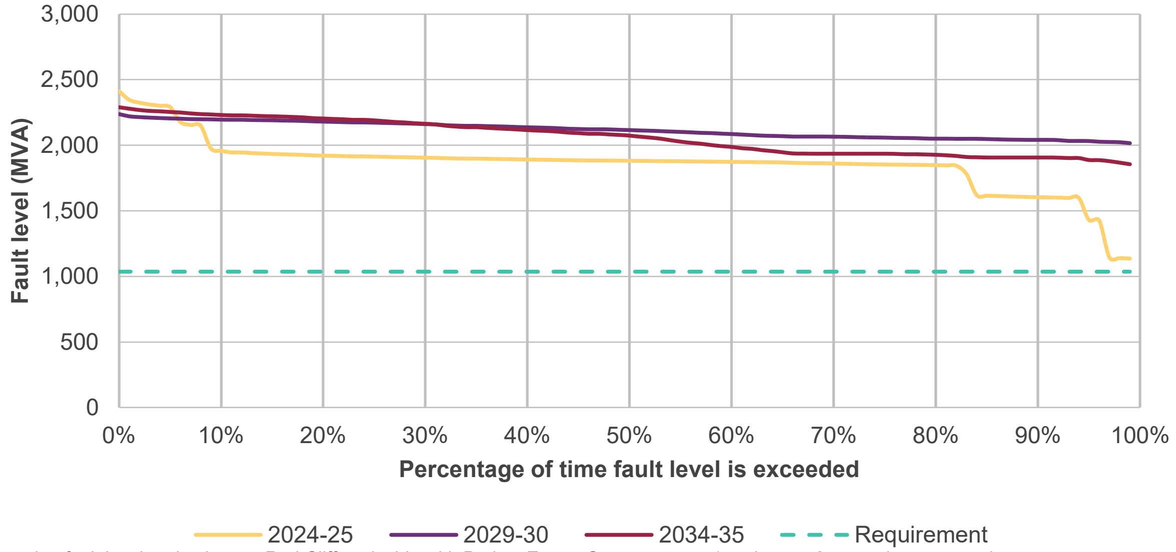
Moorabool 220 kV



AEMO declared a shortfall for this node in the Update to the 2021 System Security Reports[31], consistent with the *Step Change* scenario which forecasts earlier coal generation retirements and greater VRE penetration compared to the *Progressive Change* scenario.

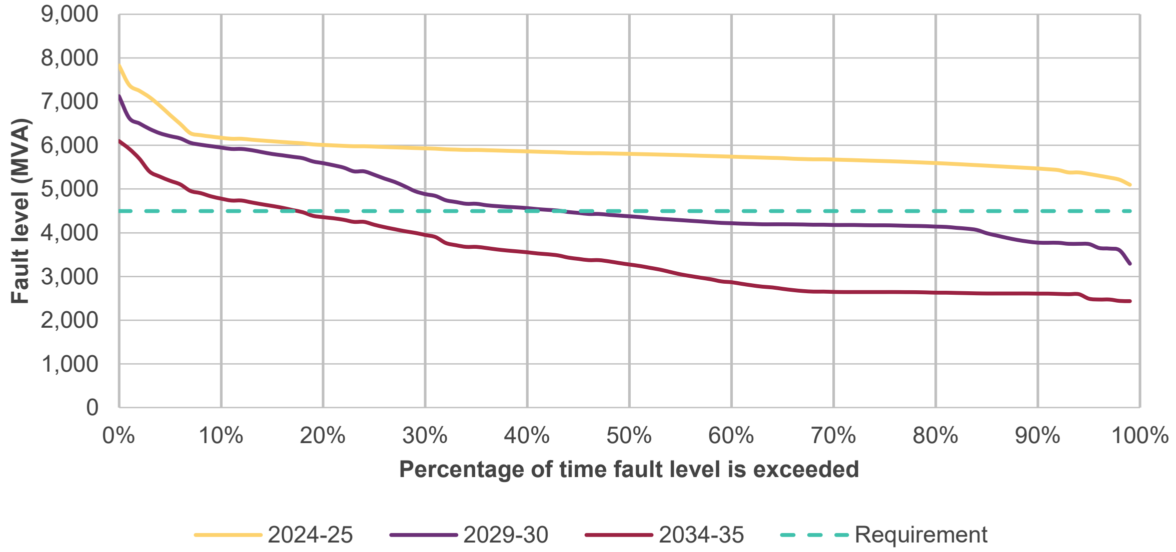
[31] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/update-to-2021-system-security-reports.pdf?la=en.

Red Cliffs 220 kV



Increasing fault level projections at Red Cliffs coincide with Project EnergyConnect stage 1 and stage 2 network augmentations.

Thomastown 220 kV



AEMO declared a shortfall for this node in the *Update to the 2021 System Security Reports*[32], consistent with the *Step Change* scenario which forecasts earlier coal generation retirements and greater VRE penetration compared to the *Progressive Change* scenario

[32] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/update-to-2021-system-security-reports.pdf?la=en.

A7.4 Inertia outlook

A minimum level of inertia is required in the power system to suppress and slow frequency deviations so that automatic controls can respond to sudden changes in the supply-demand balance. Experience from already declared inertia shortfalls in South Australia and Tasmania has demonstrated the procurement of diverse types of inertia services due to the differences of available services within the two regions:

- In Tasmania, existing synchronous generation (predominantly hydroelectric generation) can be utilised either at low output levels or placed in synchronous condenser mode when required.
- In South Australia, flywheels were added to new synchronous condensers that were initially being installed for system strength remediation. Contracting with proponents for Fast Frequency Response (FFR) can also address or partially address inertia shortfalls.

A7.4.1 Importance of inertia, roles, and responsibilities

Maintaining an appropriate level of synchronous inertia, or its equivalent, is crucial for ensuring overall power system security.

NER 5.20B sets out the division of responsibilities in the NEM:

- AEMO is required to determine the boundaries of inertia sub-networks (either a region or a sub-region of the NEM), and inertia requirements for each inertia sub-network.
- AEMO must identify whether a shortfall is likely to exist for the inertia sub-region over the five-year horizon. AEMO must consider the likelihood of an inertia sub-network becoming islanded when determining whether there are inertia shortfalls for the sub-network.
- The regional TNSP is required to ensure that inertia network services (or inertia support services) are available to address any inertia shortfall declared by AEMO for the inertia sub-network.

AEMO is required to operate the power system in a secure state. This includes using services provided by the local TNSP for the purpose of meeting the minimum threshold level of inertia and the secure operating level of inertia. In 2018, AEMO determined two levels of inertia for each NEM region that must be available for dispatch:

- The Minimum Threshold Level of Inertia is the minimum level of inertia required to operate an islanded region, or a region at credible risk of islanding, in a satisfactory operating state.
- The Secure Operating Level of Inertia (SOLI) is the minimum level of inertia required to operate the islanded region in a secure operating state.

These requirements are solely focused on regional requirements when the region is at risk of islanding or operating as an islanded system. AEMO has from time to time updated the requirements for some regions[33].

A7.4.2 Impact of FFR markets on inertia and requirements

Two key regulatory changes are expected to affect future inertia assessments in the NEM – the post-2025 electricity market design program and the implementation of FFR markets.

[33] AEMO inertia assessments are available on the 'Planning for operability' webpage at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/planning-for-operability.

Market reforms for essential system security services are under consultation

The AEMC is consulting on rule change requests concerning valuing, procuring and scheduling essential system services to ensure the power system remains secure[34]. These rule changes are being progressed consistent with the broader ESB post-2025 electricity market design program[35].

Any market changes resulting from these rule changes can be expected to affect the five-year outlook for the system strength, inertia and NSCAS assessments, given that the essential system services under review include inertia, frequency control and system strength. AEMO is working closely with the AEMC on the delivery of these rule change requests and will incorporate their final outcomes in future system security assessments and ISP projections.

AEMO will implement a fast frequency response ancillary service market in 2023

In July 2021 the AEMC published a rule requiring that AEMO introduce two new market ancillary services to help control system frequency and keep the future electricity system secure – namely, fast raise and fast lower markets for fast frequency response.

AEMO will implement these markets in 2023. For the purposes of the *2021 System Security Reports*, AEMO has chosen to assume that these new ancillary service markets will not necessarily have services available in the near term to meet regional needs for secure operating levels of inertia. It will take time for these new market services to be established and understood. Rather, AEMO is declaring inertia shortfalls where they are identified and where fast frequency response may address these shortfalls. AEMO expects that TNSPs will seek to procure those services from providers.

In the longer term, AEMO expects to be able to better project how the existing inertia requirements framework and the future fast frequency response ancillary service markets will interface with one another.

[34] AEMC, ‘Capacity commitment mechanism for system security and reliability services’, accessed in November 2021 at https://www.aemc.gov.au/rule-changes/capacity-commitment-mechanism-system-security-and-reliability-services, and AEMC, ‘Synchronous services market’, accessed in November 2021 at https://www.aemc.gov.au/rule-changes/synchronous-services-markets..

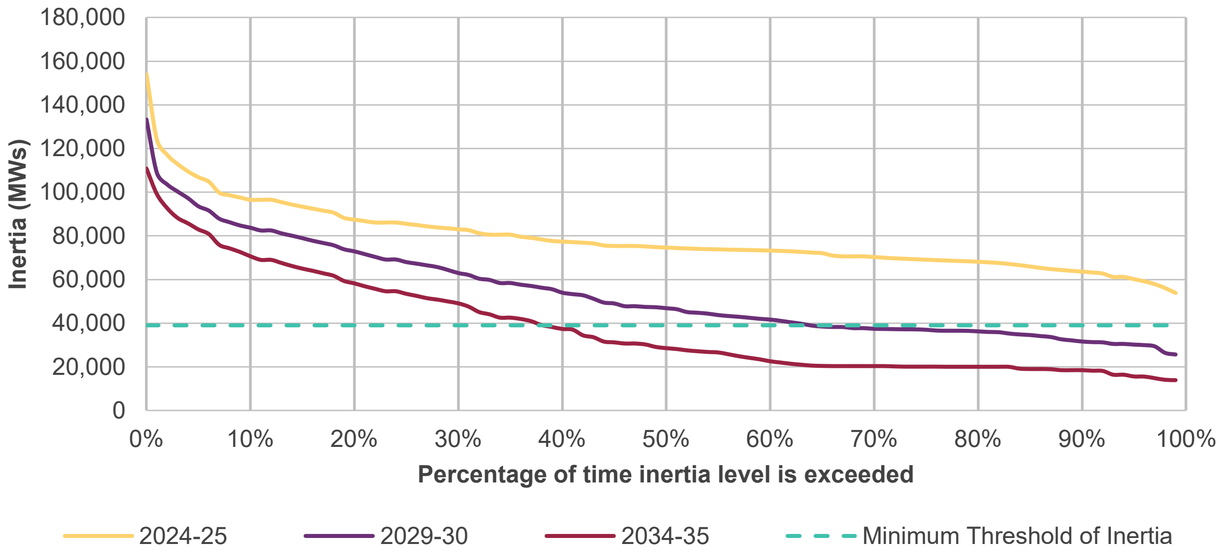
[35] Energy Security Board, ‘Post 2025 electricity market design’, accessed in November 2021 at https://esb-post2025-market-design.aemc.gov.au/.

A7.4.3 NEM Mainland inertia outlook

NEM mainland
The inertia requirements define the minimum levels of inertia required to operate each NEM region as an island. Critically, these defined levels of inertia are only required to be online when a region is at risk of synchronously islanding or is islanded – the NEM is based on the concept that synchronous connection to the rest of the NEM provides a strong inertia base. This concept is increasingly being challenged and will require review, as the ISP projects that inertia will fall in most regions as existing coal generation retires. Substantial amounts of IBR (both VRE and DER) are projected to replace the energy and capacity from synchronous generation such as coal plant when it retires. This will lead to reducing synchronous inertia across the NEM overall. By 2029-30, the available inertia at 99% of the time across the NEM mainland is projected to half when compared to 2024-25 falling below the minimum threshold of inertia, which is determined by the sum of each region's threshold of inertia (excluding Tasmania). While islanded, the FOS allow the frequency to deviate between 49.0 Hz and 51.0 Hz for the largest credible contingency, and the inertia requirements for each region have been calculated on this basis. When NEM regions are interconnected, the FOS require that the frequency be maintained between 49.5 Hz and 50.5 Hz for the largest credible contingency. This can only be maintained with sufficient levels of FCAS and inertia online. As coal units retire, total inertia reduces across the NEM, and the amount of FCAS required is anticipated to increase. The ability of FFR and grid-forming controls to provide a fast injection of active power will increasingly be an important feature for secure operation at lower inertia levels, minimising the need for synchronous inertia and traditional FCAS, and potentially also reducing the proposed minimum inertia requirement. AEMO is required to design and put in place the new FFR market ancillary service arrangements by October 2023[36]. The current inertia framework does not provide for assessing the inertia requirements and shortfalls across the NEM. AEMO has previously noted consideration of inertia across the NEM is a priority for future years. For this outlook, the inertia requirements of the individual states are summed across the mainland, and mainland inertia projections are plotted for comparison.

Inertia projections (*Step Change* scenario)

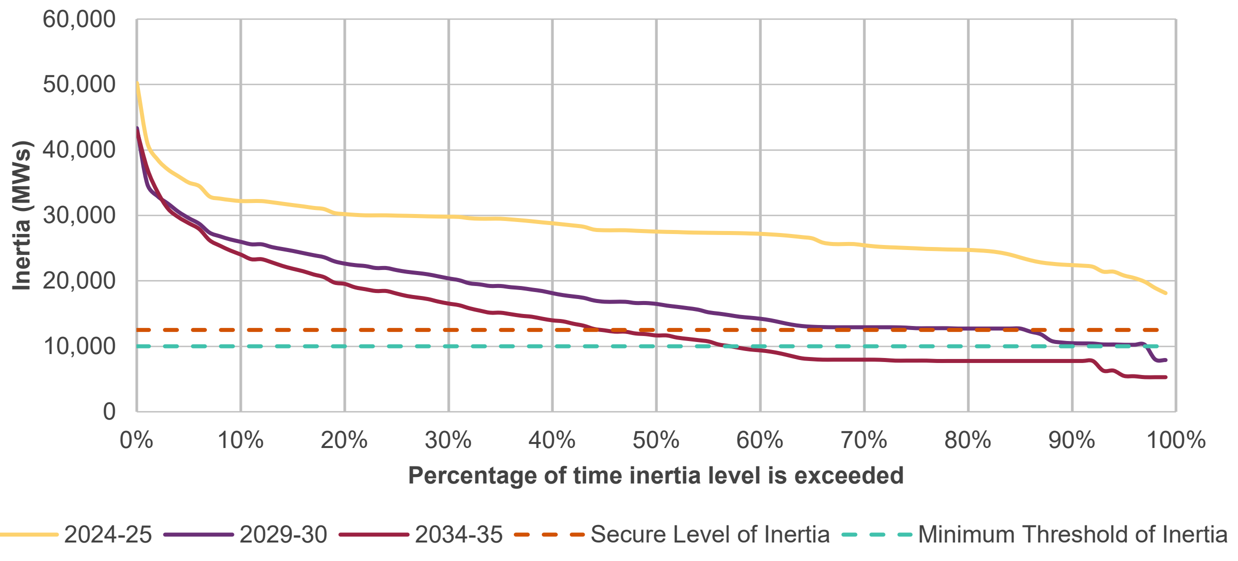
	2024-25	2029-30	2034-35	Comments
Available inertia 99% of the time (MWs)	53,950	25,700	13,850	The projections show that the NEM mainland inertia is expected to decline significantly by 2029-30 compared to 2024-25, decreasing below the minimum threshold of inertia.



[36] AEMC, Fast Frequency Response market ancillary service, at https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

A7.4.4 New South Wales inertia outlook

New South Wales				
Available inertia is projected to decline below the secure level of inertia and the minimum threshold of inertia in New South Wales due to accelerated forecast in closure of coal stations.				
Inertia requirements†				
	2021 Inertia requirements			New South Wales islanding from the NEM is considered unlikely, and as a result no shortfall is declared under the current application of the existing framework. AEMO will continue to assess declaration of potential future shortfalls after considering inertia available from adjacent regions. Net distributed PV trip has not been incorporated in the assessment of the New South Wales requirements, and the secure operating level is not provided as a ratio of synchronous inertia and fast frequency response or Fast FCAS, because islanding is considered unlikely and so a shortfall will not be declared at present.
Secure operating level of inertia (MWs)	12,500			
Minimum operating level of inertia (MWs)	10,000			
Net distributed PV Trip (MW)	-			
Risk of islanding	Not Likely			
Inertia projections (*Step Change* scenario)				
	2024-25	**2029-30**	**2034-35**	**Comments**
Available inertia 99% of the time (MWs)	18,116	7,900	5,300	Retirements of Vales Point and Eraring power stations are expected to lead to a reduction of available inertia. There is a further reduction projected following the retirement of Bayswater Power Station.
Projected decline below SOLI (MWs)	No shortfall	4,650‡	7,250‡	
‡Unlikely to island. Although projected below SOLI, shortfalls are not formally declared. AEMO will continue to assess declaration of inertia shortfalls through the five-year horizon considered in the annual inertia assessments.				



† FFR from inverter-based devices may reduce the need for traditional FCAS and associated synchronous inertia, highlighting alternative options that are now becoming available through the use of advanced inverter control systems. AEMO will continue to explore this relationship.

A7.4.5 Queensland inertia outlook

Queensland
Queensland inertia outcomes are heavily influenced by the potential changes in coal-fired generation operational profiles. An increase in net distributed PV contingency size, due to large uptakes of rooftop PV, has increased inertia requirements in Queensland. The PV contingency size was not expected to increase after the new inverter standard came into effect 18 December 2021. This is reflected in the inertia requirements. However, preliminary analysis now indicates that approximately 80% of distributed inverters installed between January and March 2022 are not compliant with the new standard. This means contingency sizes related to distributed PV will continue to increase until compliance rates are significantly improved. AEMO will continue to monitor this and make updates where necessary to the inertia requirements. Due to the physical nature of interconnection with New South Wales, Queensland is still considered to have a 'likely' risk of islanding. This finding is largely driven by Queensland having only one double-circuit AC interconnection to New South Wales via the QNI‡. This however may change with additional interconnection. In this ISP, AEMO has identified a future project to develop a second Queensland to New South Wales interconnector consisting of a 330 kV double-circuit line, strung with one circuit, from the locality of Armidale South to Braemar via Bulli Creek.

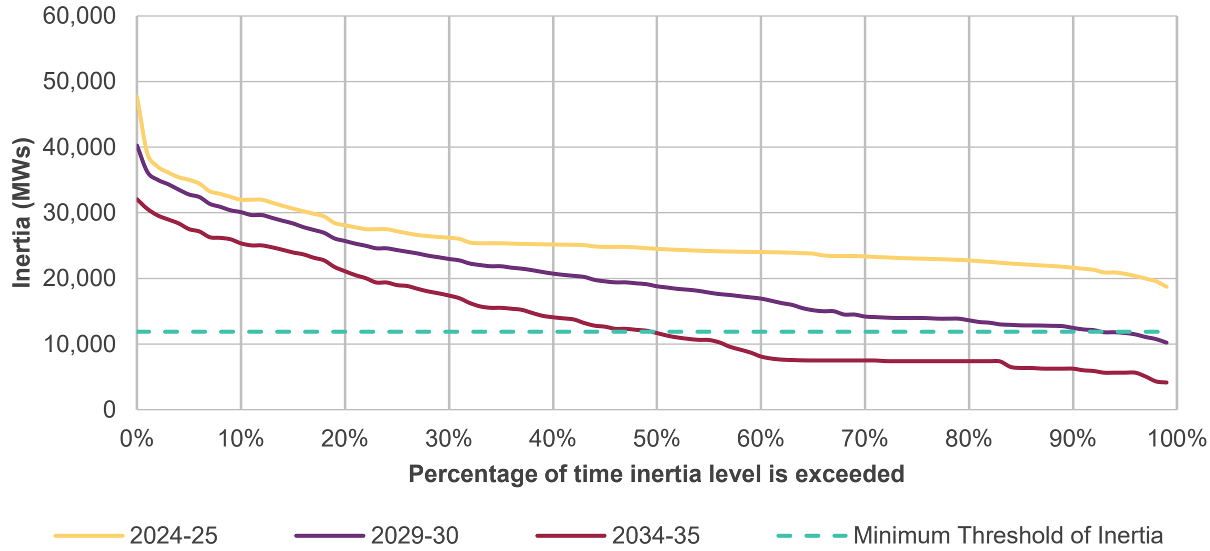
Inertia requirements*

	2021 inertia requirements	
Secure operating level of inertia (MWs)**	24,100 MWs at 390 MW Fast FCAS 16,600 MWs at 455 MW Fast FCAS	In the *2021 System Security Reports*, AEMO revised the secure operating level of inertia requirement for Queensland from 14,800 MWs to a ratio of inertia and Fast FCAS as shown here. This considers the increase in net distributed PV trip contingency size due to the increased forecast uptake of distributed PV, and the relationship between inertia and Fast FCAS.
Minimum operating level of inertia (MWs)	11,900	
Net distributed PV trip (MW)	270	
Risk of islanding	Likely	

Inertia projections (*Step Change* scenario)

	2024-25	2029-30	2034-35	Comments
Available inertia 99% of the time (MWs)	18,754	10,250	4,200	Forecast closures of coal-fired power stations in Central and Southern Queensland are expected to lead to the reduction of available inertia in Queensland.
Projected decline below SOLI (MWs) †	No shortfall	7,800	13,850	

†With additional interconnection, the Queensland region may be unlikely to island. Although projected below SOLI, shortfalls are not formally declared. AEMO will continue to assess declaration of inertia shortfalls through the five-year horizon considered in the annual inertia assessments. For the purposes of accessing projected decline, available inertia has been compared against a proxy value of 18,000 MWs.

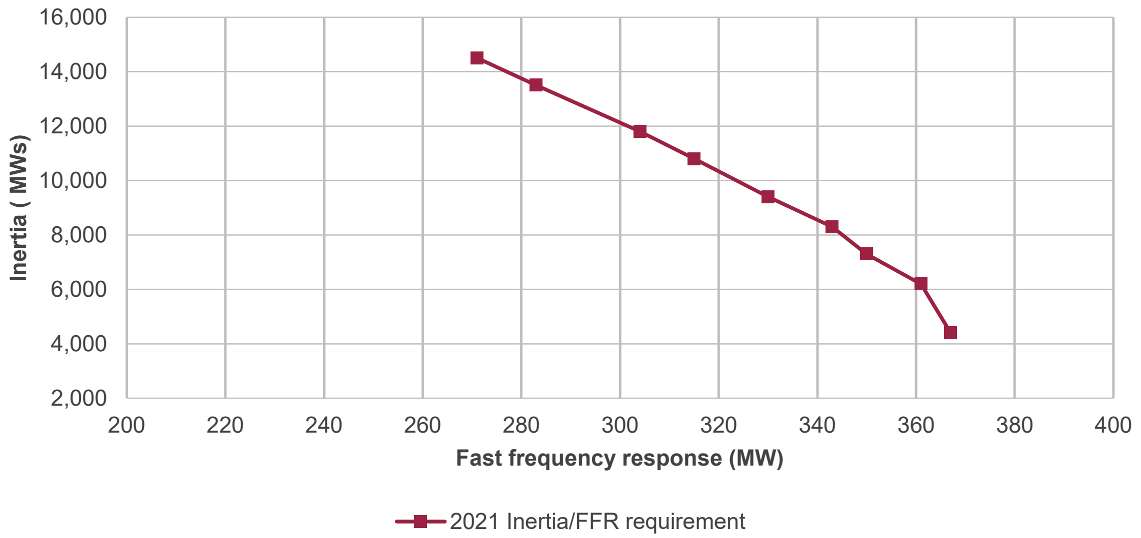


‡ While Directlink converters allow for power transfer between New South Wales and Queensland, as it is HVDC technology, it is not a synchronous interconnection.
* FFR from inverter-based devices may reduce the need for traditional FCAS and associated synchronous inertia, highlighting alternative options that are now becoming available through the use of advanced inverter control systems. AEMO will continue to explore this relationship.
** The secure operating level of inertia in Queensland is represented as a relationship between inertia (MWs) required and Fast FCAS (MW) required. Fast FCAS represents 6 second FCAS.

A7.4.6 South Australia inertia outlook

South Australia		
In 2021, ElectraNet commissioned four synchronous condensers to address a system strength shortfall declared by AEMO in October 2017 and the subsequent inertia shortfall declared in South Australia as part of the 2018 *National Transmission Network Development Plan* (NTNDP). To partially meet this gap, high inertia fly wheels were included in the design of the synchronous condensers. The need to ensure sufficient inertia is online currently applies when the region is operating as an island for the secure operating level, or during a credible risk of islanding or when islanded for the minimum threshold level*. For South Australia, this currently occurs for contingencies impacting the Heywood Interconnector circuits or nearby 500 kV circuits in Victoria. This includes periods during single circuit outages and double circuit contingency reclassifications, and may also apply during declared protected event periods such as the proposed protected event for the loss of Heywood**. AEMO considers that islanding remains likely until the commissioning of Project EnergyConnect (PEC).		
Inertia requirements‡		
	2021 inertia requirements	In the *2021 System Security Reports*, AEMO revised the SOLI requirements for South Australia. The SOLI in South Australia has been declared relative to the amount of inertia support activities provided, including FFR. Provision of more FFR (MW) can offset the requirement for synchronous inertia (MWs). The requirements were updated to include the increase in net distributed PV contingency size due to the increased forecast uptake of distributed PV. However, preliminary analysis now indicates that approximately 80% of distributed inverters installed between January and March 2022 are not compliant with the new standard. This means contingency sizes related to distributed PV will continue to increase until compliance rates are significantly improved. AEMO will continue to monitor this and make updates where necessary to the inertia requirements. South Australia's secure level of inertia requirements are represented as a combination of synchronous inertia (MWs) and FFR (MW). Less synchronous inertia is required if more FFR is available.
Secure operating level (MWs inertia and MW FFR)	6,200 MWs with 360 MW FFR 4,400 MWs with 367 MW FFR	
Minimum operating level of inertia (MWs)	4,400	
Net distributed PV trip (MW)	300	
Risk of islanding	Likely until PEC	

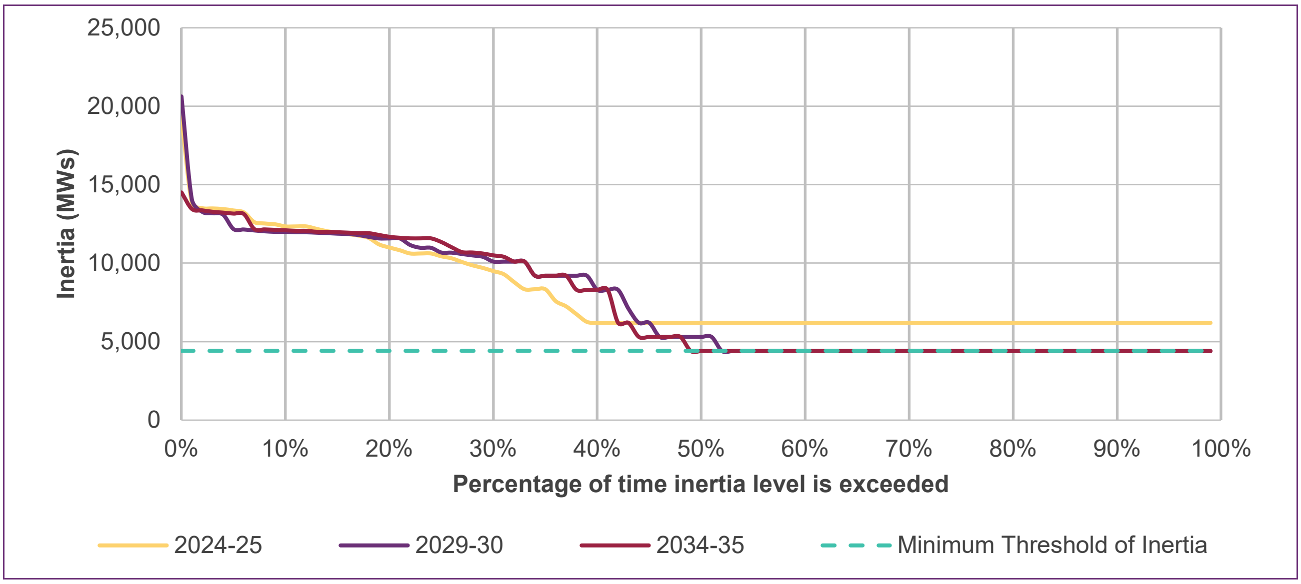
This chart shows the inertia requirements (MWs) with varying availability of FFR and assumes 4,400 MWs is available from the four synchronous condensers.



Inertia projections (*Step Change* scenario)

	2024-25	**2029-30**	**2034-35**	**Comments**
Available inertia 99% of the time (MWs)	6,200	4,400	4,400	367 MW of FFR is required with 4,400 MWs of inertia available from synchronous condensers. If 270 MW of FFR is available, an additional 10,100 MWs of synchronous inertia is required to meet the secure level of inertia in South Australia.
Projected decline below SOLI (MWs)	Depends on FFR available			

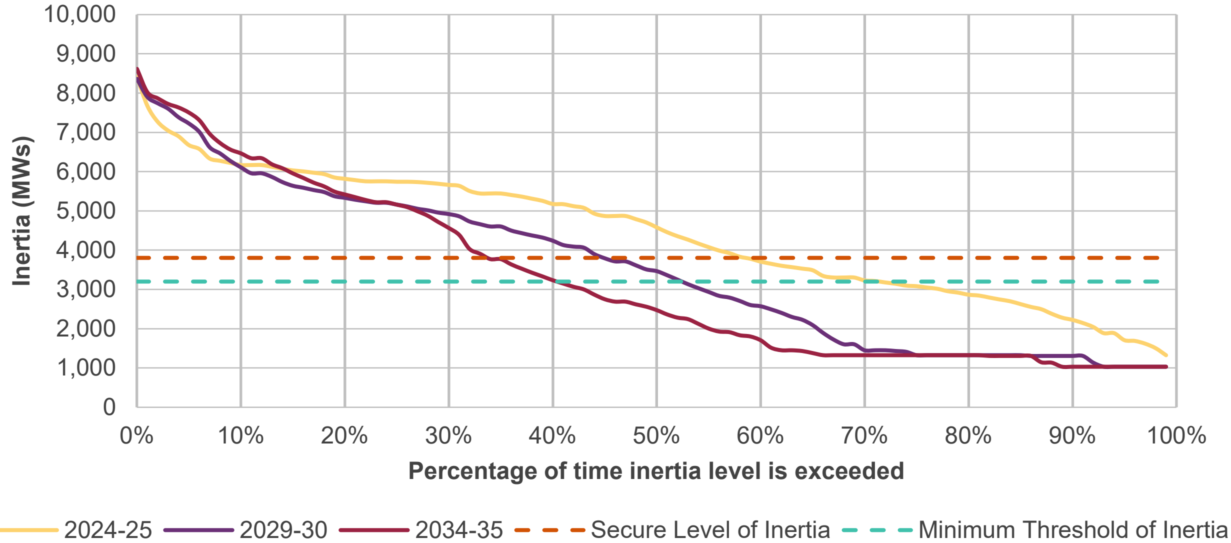
† After the commissioning of PEC, islanding in South Australia is expected to be remote. Although projected below SOLI, shortfalls are not formally declared. AEMO will continue to assess declaration of inertia shortfalls through the five-year horizon considered in the annual inertia assessments



* AEMO Inertia Requirements Methodology and Inertia Requirements and Shortfalls at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-security-market-frameworks-review/2018/inertia_requirements_methodology_published.pdf?la=en.
**AEMO 2022 *Draft Power System Frequency Risk Review* at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/power-system-frequency-risk-review
‡ FFR from inverter-based devices may reduce the need for traditional FCAS and associated synchronous inertia, highlighting alternative options that are now becoming available through the use of advanced inverter control systems. AEMO will continue to explore this relationship.

A7.4.7 Tasmania inertia outlook

Tasmania				
In 2020, AEMO declared a system strength and inertia shortfall in Tasmania which was further increased in May 2021. TasNetworks entered into a contract for system strength and inertia services which is sufficient to fulfil this identified shortfall. This contract expires in 2024. Without the continuation of this contract or other inertia services, the ISP results under *the Step Change* scenario projections show that the inertia available 99% of the time is below the current requirements. These projections show inertia online when dispatched for the energy market and highlight that inertia services are likely to be required in Tasmania for the long term.				
Inertia requirements*				
	2021 inertia requirements			Tasmania is connected to Victoria by an asynchronous HVDC link, so for the purposes of inertia assessments is considered to be operated as an island at all times. This means the inertia requirements also need to be met at all times.
Secure operating level of inertia (MWs)	3,800			
Minimum operating level of inertia (MWs)	3,200			
Contracted inertia network services until 2024 (MWs)	2,620			
Risk of islanding	Likely			
Inertia projections (*Step Change* scenario)				
	2024-25	**2029-30**	**2034-35**	**Comments**
Available inertia 99% of the time (MWs)	1,327	1,050	1,050	The available inertia 99% of the time is expected to decrease by roughly 25% between 2024-25 and 2029-30. Although 2029-30 available inertia is not much lower than the 24-25 inertia, the time inertia will fall below the secure level of inertia is expected to increase from approximately 25% to 45% by 2029-30 and 60% by 2034-35.
Projected decline below SOLI (MWs)	2,473	2,800	2,800	
† Although AEMO projects that a shortfall may arise, an inertia shortfall is not formally declared.				



* FFR from inverter-based devices may reduce the need for traditional FCAS and associated synchronous inertia, highlighting alternative options that are now becoming available through the use of advanced inverter control systems. AEMO will continue to explore this relationship.
‡ AEMO, 2021 *System Security Reports: System Strength, Inertia and NSCAS*, will be available in December 2021 at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/planning-for-operability.

A7.4.8 Victoria inertia outlook

Victoria

Under the *Step Change* scenario, inertia in Victoria is projected to decline below the minimum threshold and secure level of inertia. By 2034-35, Victoria is forecast to operate for approximately 55% of the time without any synchronous generating units in service. Synchronous generating units provide many system security services required for frequency management, voltage management and system restoration. Without synchronous generating units, Victoria will need to find alternative sources for these services.

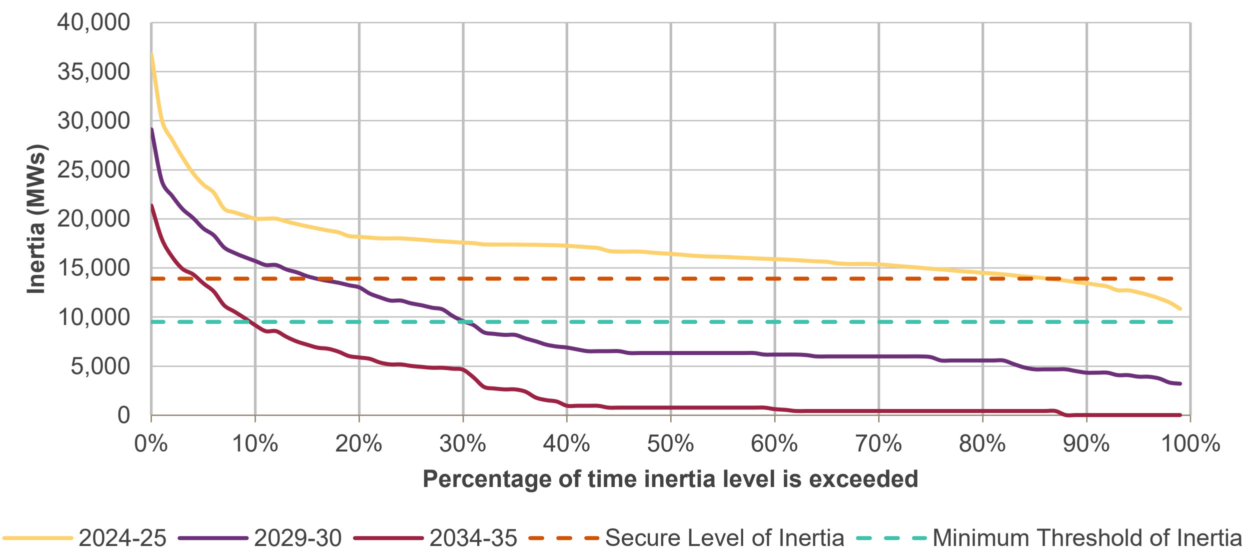
Inertia requirements*

	2021 inertia requirements	
Secure operating level of inertia (MWs)	13,900	Victoria islanding from the NEM is considered unlikely and as a result no shortfall has been declared under the current application of the existing framework. AEMO will continue to assess declaration of potential future shortfalls after considering inertia available from adjacent regions. Net distributed PV trip has not been incorporated in the assessment of the Victoria requirements, and the secure operating level is not provided as a ratio of synchronous inertia and fast frequency response or Fast FCAS, because islanding is considered unlikely and so a shortfall will not be declared at present.
Minimum operating level of inertia (MWs)	9,500	
Net distributed PV trip (MW)	-	
Risk of islanding	Not Likely	

Inertia projections (*Step Change* scenario)

	2024-25	2029-30	2034-35	Comment
Available inertia 99% of the time (MWs)	10,854	3,250	0	
Projected decline below SOLI (MWs)	2,750	10,700	13,900	

† Unlikely to island. Although projected below SOLI, shortfalls are not formally declared under the current application of the framework. AEMO will continue to assess declaration of inertia shortfalls through the five-year horizon considered in the annual inertia assessments.



* FFR from inverter-based devices may reduce the need for traditional FCAS and associated synchronous inertia, highlighting alternative options that are now becoming available through the use of advanced inverter control systems. AEMO will continue to explore this relationship.