RELIABILITY PANEL AEMC

REVIEW

Reliability Panel AEMC

Issues Paper

Review of the System Restart Standard

12 December 2024

Inquiries

Reliability Panel
Australian Energy Market Commission
Level 15, 60 Castlereagh Street
Sydney NSW 2000

E aemc@aemc.gov.au
T (02) 8296 7800

Reference: REL0091

About the Reliability Panel

The Panel is a specialist body within the Australian Energy Market Commission (AEMC) and comprises industry and consumer representatives. It is responsible for monitoring, reviewing and reporting on reliability, security and safety on the national electricity system, and advising the AEMC in respect of such matters. The Panel's responsibilities are specified in section 38 of the National Electricity Law.

Acknowledgement of Country

The AEMC acknowledges and shows respect for the traditional custodians of the many different lands across Australia on which we all live and work. We pay respect to all Elders past and present and the continuing connection of Aboriginal and Torres Strait Islander peoples to Country. The AEMC office is located on the land traditionally owned by the Gadigal people of the Eora nation.

Copyright

Citation

To cite this document, please use the following:
AEMC, Review of the System Restart Standard, Issues Paper, 12 December 2024

Reliability Panel members

Summary

The Panel is commencing a review of the system restart standard

1 The system restart frameworks are an important element in the broader arrangements that support the resilience of the national electricity system. In a general sense, power system resilience is the ability to avoid, survive, recover, and learn from severe disturbances, including high impact low probability (HILP) events. The restart frameworks, including the system and network preparedness and the availability of black start generation support the recovery phase following a severe disturbance. During this recovery phase the Australian Energy Market Operator (AEMO), works with network service providers (NSPs) and market participants to re-energise and restore the power system to a pre-event level of functionality.

2 In the NEM, system restart capability is provided by system restart ancillary services (SRAS) which provide the capability to re-energise parts of the power system affected by a major supply disruption or black system event. SRAS are procured by AEMO from participants in the National Electricity Market (NEM)in accordance with the system restart standard (the Standard) and have historically been provided by large synchronous generating units (coal, gas and hydro power). As the system transitions from one that is synchronous-based to one that is dominated by inverter-based resources (IBR), the supply mix and the physics of the power system are changing. This requires a rethink of how system restart capability is delivered. Emerging factors, like the state of charge of batteries, will also need to be considered.

3 AEMO's has recently identified challenges in procuring sufficient SRAS to meet the Standard, in some NEM regions, due to reduced availability of traditional SRAS providers and a shortage of alternative options. In the most recent SRAS procurement round AEMO was able to acquire sufficient SRAS to meet the Standard for New South Wales, Victoria, Tasmania and South Australia, however it was not able to fully meet the requirements of the Standard for the Queensland sub-region north of Bundaberg from 1 July 2024. This outcome for Queensland is due to changes on the possible restart pathway which result in the "north of Bundaberg" requirement to restore 825MW of supply within 4 hours not being met outside of business hours [1]

4 In addition to challenges associated with SRAS procurement, AEMO has also identified several challenges for the provision of SRAS and system restart planning due to ongoing changes in the power system:[2]

- high concentrations of distributed photovoltaic (PV) generation at consumer locations can impact the ability to stabilise restart islands
- resiliency and flexibility is required in restart pathways as the power grid becomes inherently more complex.

5 The Australian Energy Market Commission (AEMC) has provided the Panel with a terms of reference requesting a review of the system restart standard (Standard).[3] The AEMC considers that it is timely for the Panel to consider the Standard and associated frameworks and as such, has requested that the Panel perform a two stage review that:

- **Stage one:** makes recommendations on the appropriateness of the system restart regulatory framework in the context of the future power system envisaged in the AEMO integrated system plan.

1 AEMO, 2024. *Non Market Ancillary Services (NMAS) report 2023-24*. p.8.
2 AEMO, 2024. *2024 General Power System Risk Review – Report*. 25 July 2024. p.124-125.
3 Available at: *Review of the System Restart Standard 2025*.

- **Stage two:** sets the Standard to reflect an up-to-date understanding of the power system, that is informed by stage one and includes consideration of the risks of a major supply disruption and the costs and availability of SRAS.

6 This paper forms part of the stage one scope of work and aims to seek stakeholder views on the SRAS frameworks, including those that are broader than the Standard itself.

7 The Panel developed a broad framework to systematically consider issues within this paper. The Panel has divided related issues in the system restart regulatory framework into three key categories: restart preparedness and governance, SRAS sufficiency, and transparency and reporting.

The Panel is interested in stakeholder views on how system restart planning may need to evolve to support a transitioning system

8 Restart preparedness refers to the readiness of the power system to be re-energised following a major supply disruption. This includes the capabilities and constraints related to physical network infrastructure and the capabilities of key organisations responsible for system restoration.

9 AEMO's 2024 Integrated System Plan (ISP) highlights the significant change in the transmission system, which is expected to continue and intensify over the coming decades. The Panel notes in particular, the following changes set out in AEMO's 2024 ISP as being relevant to the consideration of the arrangements for restart preparedness in the NEM:

- projected new transmission network augmentations, including intra-regional network strengthening and expansions and new inter-regional interconnectors.
- the development of renewable energy zones (REZs), which are coordinated concentrations of new renewable energy generation and associated network infrastructure intended to streamline and accelerate the development process.

10 The Panel is interested in stakeholder views related to restart preparedness on:

- the appropriateness of the current roles and responsibilities for system restart
- opportunities for the design and development of REZs to support future restart preparedness
- transmission network changes that may support system restart through the transition
- how the network augmentations projected under the ISP may interact with the system restart framework and the system restart standard
- the potential future role of battery technologies in system restart, and what complementary changes would support batteries to provide system restart services
- managing risks to system restart from changes occurring at the distribution level of the power system
- identifying opportunities for improved restart preparedness from changes at the distribution level of the power system.

The Panel is seeking to understand the technical and commercial challenges for the development of new system restart capability

11 SRAS has historically been provided by black start services from large synchronous generating units, including thermal, hydro and gas. Large thermal generation units form a significant portion of the current available system restart capability in the NEM and by 2030, the majority to thermal generation will exit the system. AEMO will need to plan for the retirement of thermal generation, including investigating the involvement of asynchronous technologies for system restart.

12 Asynchronous technologies such as IBR have historically not been widely used as system restart capability in the NEM. IBR sources are in many ways not a like-for-like replacement for thermal generation and may require additional restoration support services, such as inertia and frequency control capability, to enable system restart. AEMO has noted in its Engineering Roadmap FY2025 priority actions report that it will be investigating the requirements for system restart for periods where large synchronous generators are not available[4]

13 AEMO has flagged in its GPSRR that there are limited investment signals and incentives for the development of new transmission level restart capability in existing and emerging IBR generation sources in the NEM.[5] As the provision of thermal generation based SRAS continues to decline, the appropriate investment signals and incentives need to be provided for existing SRAS generation to continue providing services and new SRAS generation to make the necessary augmentations to meet the technical requirements to provide SRAS generation. Therefore, the Panel is interested to investigate whether the current SRAS reporting arrangements provide sufficient information to support investment in restart capability to meet future SRAS requirements.

14 The AEMC previously considered issues related to the retirement of synchronous-based restart assets in the system restart services, standard and testing Rule 2020 (*SRAS Rule 2020*). [6] The Panel considers, the *SRAS Rule 2020* has provided AEMO flexibility under the NER to seek out a range of current and emerging technologies to satisfy the requirements for system restart, including the procurement of support services that AEMO can define within the SRAS Guidelines. The Panel considers:

- The expanded definition for SRAS provides AEMO with the flexibility to engage with a range of technologies in its procurement of SRAS, thereby potentially expanding the pool of providers considered for the provision of SRAS services.
- AEMO has the flexibility to engage directly with a range of technology providers and amend the technical requirements in the SRAS Guideline to cater for currently available services.
- AEMO has flagged that the Standard may need revision to reflect the current capacity of the power system.

15 However, the Panel also recognises that greater flexibility for AEMO to procure the necessary resources alone may not address the full suite of issues and that while such changes may be outside the scope of the Standard, the Panel is interested in considering whether these issues could be addressed through changes to the Standard and guidelines as well as potential changes to the related rules framework to support the supply of restart sources into the future.

16 AEMO has identified that it is timely for the Panel to review the Standard such that it reflects the actual capacity of the power system. The Panel would like to better understand how the Standard may contribute to restricting AEMO's ability to procure SRAS, in light of the risks it highlights in the 2024 General Power System Risk Review (GPSRR). The Panel understands that the current Standard was set based on the SRAS availability and restart pathways at the time it was determined.[7] As such,the Standard may not align with the characteristics of the power system as it transitions from a synchronous thermal dominated system towards an inverter based renewable dominated system over the coming decade. Therefore, the Panel is interested in stakeholder views on how the standard could be revised to better support the provision of sufficient restart capability for the future power system.

4 AEMO, 2024. *Engineering Roadmap – FY2025 priority actions report*. 15 August 2024. p.42, Priority Action FY25-21

5 AEMO, 2024. *2024 General Power System Risk Review – Report*. 25 July 2024. p.124.

6 AEMC, 2020. *Final determination system restart services, standards and testing rule 2020.*

7 The quantitative elements of the standard for Tas, NSW, Vic & SA were determined in 2016 and for Qld in 2020.

17 This review has been designed for the Panel to seek stakeholder views beyond the Standard and on the current restart framework to better understand whether it promotes the right incentives for both investing in new restart technology. This includes considerations for capital expenditure for new transmission and generation assets and the costs associated with the operational and maintenance activities to maintain restart capability.

18 While such changes may be outside the scope of the Standard, the Panel is interested in considering whether there are rule changes that it could submit to the AEMC that could enhance the supply of restart sources in the future. The Panel encourages stakeholders to consider this when making their submission to this paper.

19 The Panel is interested in stakeholder views to inform:

- an understanding of the technical challenges related to the provision of SRAS from new generation, including the role of battery energy storage systems (BESS) and other inverter connected resources.
- an understanding of commercial challenges related to investment in system restart capability.
- ways to improve the signals and incentives for investment in new system restart capability in the future generation fleet.
- whether changes can be made to the Standard to support AEMO's procurement of sufficient SRAS. This may include a fresh approach to the form of the standard and the related analysis that underpins it.

Improving reporting arrangements could drive further investment in system restart capability

20 Transparency and reporting of SRAS sufficiency and emerging system restart risks could provide insights to revise restart planning and signal for new investment. AEMO is required under the NER to report system restart preparedness and sufficiency through the non-market ancillary services (NMAS) annual report, where AEMO reports on the process followed to acquire SRAS, costs of procuring SRAS and whether AEMO has been unable to meet the Standard and reasons for this.

21 While not obligated, AEMO also reports on system restart preparedness and sufficiency through:

- GPSRR, where AEMO reports on priority risks to the power system over a five-year planning horizon. Whilst there are no explicit NER requirements for reporting of SRAS , AEMO's 2024 GPSRR highlighted risks related to the future provision of SRAS.
- Engineering roadmap, which presents AEMO's view of the technical, engineering, and operational actions required to remove the barriers to high renewables contribution. AEMO is currently considering system restart capability and options during periods where large synchronous generation is offline.
- Transition plan for system security, that sets out how AEMO plans to maintain system security through the system transition. AEMO noted in its plan that it is undertaking future-focused analysis as part of the Engineering Roadmap on options for a system restart to prepare for both the upcoming 2026-29 SRAS procurement round and longer-term procurement from 2030 onwards, which will be published in a paper next year.
- Electricity statement of opportunities (ESOO), which highlights the opportunities for market participants, investors, governments and other jurisdictional bodies to invest in new assets and systems to maintain a reliable supply of electricity in the NEM. 2024 ESOO broadly notes the need for investment in new SRAS technologies to replace the retirement of existing service providers.

22 The Panel is interested in stakeholder views on the current arrangements for transparency and reporting, and whether stakeholders require further information to inform changes to planning provisions within the current framework and investment decisions for new investment in system restart capability.

This paper provides context for this review

23 As part of the review, the AEMC requests that the Panel publish the following documents by 30 December 2025:

- an Issues Paper (this paper) for stakeholder consultation at the commencement of the review
- a Draft Determination and undertake a second round of stakeholder consultation
- a Final Determination with the Panel's recommendations and Final Standard.

24 The Panel invites comments from interested parties in response to this Consultation Paper by **30 January 2025**.

Contents

Tables

Figures

1 Introduction

The Reliability Panel (the Panel) has commenced this review in response to terms of reference issued to the Panel by the Australian Energy Market Commission (AEMC). As per the terms of reference, the Panel is undertaking this work in two stages:

- **Stage one**: review and consider the appropriateness of the standard and the system restart regulatory framework for the future power system.
- **Stage two**: review and set the standard to reflect an up-to-date understanding of the emerging power system.

This chapter provides an overview of the scope, objectives and timing for this review as well as an introduction to the role of system restart as part of the power system security and resilience frameworks.

1.1 System restart frameworks support restoration following a black system event

While the National Electricity Market (NEM) and its regulatory frameworks are designed to avoid the occurrence of a major supply disruption or black system event, they are still possible.[8] Following a major supply disruption or black system event, a process referred to as system restart is undertaken to commence the restoration of customer supply. Events that require system restart are typically rare, unpredictable and occur suddenly. Specially procured resources referred to as system restart ancillary services (SRAS) are called on to:

- supply energy to restart power stations
- assist the process of re-energising the power system
- restoring customer supply.

In the history of the NEM, there have only been two black system events. The most recent of these occurred on September 28, 2016, in South Australia.[9] It has been estimated that the event came at a total cost to South Australian businesses of approximately $AUD367 million.[10] This affected all of South Australia's homes and businesses - approximately 800,000 customers. Most supplies were restored in 8 hours, however some areas were without power for days.[11] While rare, the severe impact of these events means that the procurement of a specific number of SRAS by AEMO is critical to the resilience of the system, as it enables timely restoration of supply following a black system event.

SRAS can be provided by generators with black start capability or the ability to support the re-energisation of the power system (system restoration support). Black start generators initiate the restoration process and must be capable of delivering electricity to a connection point as well as control for frequency and voltage during the restart process. Once a black start SRAS provider has restarted its own plant, it provides energy to restart other generators and progress the system restoration. This typically involves re-energising parts of the transmission system to restart subsequent generators, followed by blocks of customer load being brought on to stabilise the

8 Chapter 10 of the NER defines a major supply disruption as the unplanned absence of voltage on a part of the transmission system affecting one or more power stations and which leads to the loss of supply to one or more loads. Under Chapter 10 of the NER, when the absence of voltage from a major supply disruption extends to a significant part of the transmission system affecting a significant number of customers, this is referred to as a black system.

9 The other event occurred in the Northern sub-region of Queensland in 2009 and was less severe than the South Australian event of 2016.

10 AEMO, 2017. *Integrated final black system incident report*. March 2017, p. 5.

11 AER, 2018. *The Black System Event Compliance Report*. p.5.

voltage and frequency of the electricity in the grid. The number of generators and blocks of customer load brought on are gradually increased until the full electricity system is restored.[12]

The responsibilities for system restart are set out in the NER

The National Electricity Rules (the Rules) set out the general requirements applying to the procurement, testing and deployment of SRAS. The Rules also allocate responsibilities for determining more specific requirements of the system restart framework between AEMO and the Reliability Panel (the Panel), establishing clear governance arrangements that appropriately reflect the roles and expertise of these parties.

The key responsibilities of AEMO and the Panel in relation to SRAS include:

- **Reliability Panel:** The Panel is responsible for determining the system restart standard (the Standard).[13] The parameters included in the Standard are the maximum time in which a specified level of generation capability must be restored in each sub-network, and the aggregate level of reliability of restart services in each sub-network, (i.e. the overall reliability of the SRAS procured for the sub-network rather than just for any individual source of SRAS). The content of the Standard is discussed further in chapter 5. The requirements set out in the Standard guide AEMO's procurement of SRAS. In determining the Standard, the Panel undertakes technical and economic analysis to consider the trade-offs between the ongoing cost of the provision of SRAS and the potential cost of an extended outage, in accordance with the relevant governance frameworks including the value customers place on reliability.
- **AEMO:** AEMO is responsible for procuring SRAS from plant with the capability to provide that service. In doing so, AEMO is subject to the SRAS Procurement Objective, which requires AEMO to use reasonable endeavours to acquire SRAS to meet the requirements set out in the Standard at lowest long term cost.[14]

1.2 The AEMC has tasked the Panel to review the Standard

The AEMC has provided the Panel with terms of reference[15] nd requested that the Panel commence a review of the Standard given the transition underway in the national electricity system and challenges identified by AEMO in procuring SRAS and preparing for system restart.

AEMO has identified that it is becoming increasingly challenging to secure the necessary SRAS resources to meet the Standard. The associated challenges include an increasing reliance on a limited and shrinking pool of SRAS providers and a scarcity of SRAS capability amongst new transmission-level generation. At the same time, high levels of distributed photovoltaic (PV) generation connections, are presenting growing risks to system restoration.

In light of this, the AEMC considers that it is timely for the Panel to consider the system restart standard and associated frameworks. The AEMC requests that the Panel provide recommendations on the issues that fall outside of the Standard, but which may arise within the broader SRAS framework. The challenges suggest the existing framework may need to evolve to provide the appropriate investment signals and enable a competitive market in the efficient provision of system restart services in a transitioning system that promotes good outcomes for consumers in accordance with the SRAS objective and the National electricity objective (NEO).

12 During a major supply disruption, control and protection systems may cause various assets in the system to island from the grid. As part of the restoration process, AEMO will work to resynchronise any islands that have formed.

13 NER, clause 8.8.1(1a).

14 NER, clause 3.11.7(a1)

15 Available at: *Review of the System Restart Standard 2025*

In the context of the changing power system, the AEMC has set out for the Panel that the objectives for this review are to:

- review and make recommendations on the appropriateness of the system restart regulatory framework in the context of the future power system envisaged in the AEMO integrated system plan. In particular, the Panel is asked to consider:
  - the ability for AEMO and transmission network service providers (TNSPs) to manage the restoration of the power system following a major supply disruption.
  - measures to support the efficient and reliable provision of sufficient system restart services, including the future investment in black start capable resources.
  - the interaction of renewable energy zones (REZs) with system restart.
  - the impact of distributed PV and the role of distribution network service providers (DNSPs) in system restart.
  - the role of load in system restart and the implications for the restoration of sensitive loads within critical timeframes.
- review and set the Standard to reflect an up-to-date understanding of the power system including the risk of a major supply disruption and the costs and availability of SRAS. The Panel's review of the Standard should be informed by the Panel's considerations on the system restart regulatory framework.

The AEMC has requested that the Panel deliver its final report and recommendations by **30 December 2025.** This will allow for a period of at least 18 months from the date the revised Standard is determined to the date that AEMO's next SRAS procurement round is planned to be completed, which we understand to be 30 June 2027.

1.3 The Panel will initially focus on its review of the system restart framework before shifting focus to the Standard

Consistent with the terms of reference issued to it by the AEMC, the Panel will undertake this review in two stages:[16]

Stage one commences with the publication of this Issues paper and involves consideration of the challenges and opportunities for system restart and the appropriateness of the system restart regulatory framework in the context of the future power system scenarios envisaged in the AEMO's ISP. The Panel will consider whether the current Standard remains appropriate for the emerging power system conditions and what actions may be necessary to support future restart preparedness and SRAS sufficiency.

Stage two will include the publication of a draft determination and a final determination for a revised standard to reflect an up-to-date understanding of the power system including the risk of a major supply disruption and the costs and availability of SRAS. The Panel will also consult on any additional recommendations for reforms to other elements of the regulatory framework to support system restoration in the future power system.

1.4 We are seeking submissions on the issues raised in this paper

The Panel invites comments from interested parties in response to this Consultation Paper by **30 January 2025**.

16 Available at: *Review of the System Restart Standard 2025*

Electronic submissions must be lodged online through the AEMC's website using the link entitled 'lodge a submission' and reference code 'REL0091'. Submissions will generally be published in full on the AEMC's website, subject to any claims of confidentiality. Our treatment of the content of your submission is further explained on that page.

The submission must be on letterhead (if submitted on behalf of an organisation), signed and dated. If choosing to make a submission by mail, the submission must be on letterhead (if submitted on behalf of an organisation), signed and dated, and posted to:

Reliability Panel

c/- Australian Energy Market Commission

PO Box A2449

SYDNEY SOUTH NSW 1235

2 Context for the review

This chapter provides background and context to the issues being considered by the Panel in its review of the Standard. It provides an overview of:

- emerging risks impacting system restart as identified by AEMO and its related work programs
- previous work related to the system restart frameworks

2.1 The transition introduces several emerging challenges for system restart now and into the future

The NEM is rapidly transforming. The 2024 ISP forecasts coal power stations to exit the NEM by 2038, five years earlier than previously expected. To help replace retiring coal, variable renewable energy (VRE) capacity will need to triple by 2030.[17]Batteries will play an important role in firming with the NEM requiring this capacity to almost quadruple by 2050.[18]

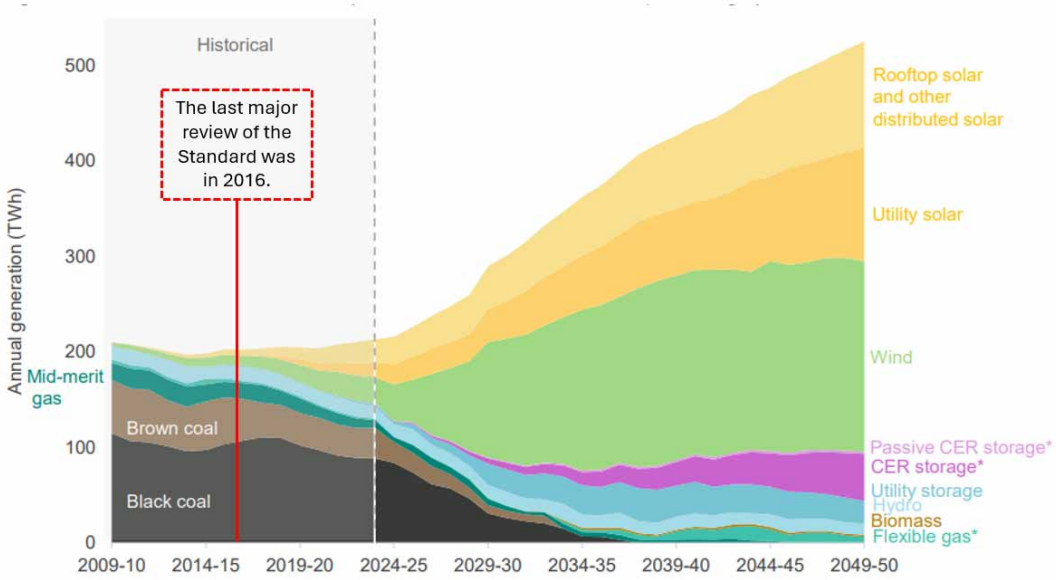
2.1.1 A renewable power system may demand different considerations for system restart

Australia's transition to renewables is well underway, with investments in renewable generation and storage accelerating and looking to stay ahead of expected coal closures. The 2024 ISP highlighted that renewables accounted for almost 40 per cent of the total electricity delivered through the NEM in 2023. The NEM recently had a new record of instantaneous renewable penetration at any one time: reaching 75.6 per cent on 6 November 2024. [19]

At the time of the last major review of the Standard in 2016, synchronous generation from thermal coal units accounted for the majority of generation. In the past decade alone, 10 major coal-fired power stations have retired, starting with Munmorah in 2012 through to Liddell in 2023. This dramatic change to the generation mix is expected to accelerate in the next ten years, as highlighted in Figure 2.1.

17 AEMO, 2024. *2024 Integrated System Plan*. 1 May 2024. p.6.
18 AEMO, 2024. *2024 Integrated System Plan*. 1 May 2024. p. 12.
19 AEMO, 2024. *NEM Data Dashboard*. Date accessed 14 November 2024.

Figure 2.1: 2024 ISP projected generation mix



Source: AEMC based on AEMO ISP 2024 Figure 9.

There are also significant planning considerations for transmission and distribution, including new transmission infrastructure and the introduction of renewable energy zones. These changes and its implication for system restart planning is discussed further in chapter 4.

SRAS services have typically been provided by synchronous generating units such as thermal, hydro and gas, that can consistently provide active power and provide inertia to maintain stability. IBR and storage will likely be needed in the future to help replace the system restart capability currently provided by retiring thermal restart sources. The Panel will seek advice from AEMO as to what role IBR and storage can play in providing system restart services. We also welcome stakeholder views on this point.

As described in the following section, the ongoing changes in the generation mix and the physics of the power system introduces several emerging challenges for system restart.

2.1.2 AEMO has identified several challenges due to ongoing changes in the generation mix and the physics of the power system

AEMO has recently identified challenges in procuring sufficient SRAS to meet the Standard, in some NEM regions, due to reduced availability of traditional SRAS providers and a shortage of alternative options. In the most recent SRAS procurement round AEMO was able to acquire sufficient SRAS to meet the Standard for New South Wales, Victoria, Tasmania and South Australia, however it was not able to fully meet the requirements of the Standard for the Queensland sub-region north of Bundaberg from 1 July 2024. This outcome for Queensland is due

to changes on the possible restart pathway which result in the "north of Bundaberg" requirement to restore 825MW of supply within 4 hours, not being met outside of business hours [20]

AEMO 2024 General Power System Risk Review (GPSRR) identified a number of emerging risks relating to the provision of system restart services and challenges related to the viability of system restart plans.[21] As a result of some of these challenges, AEMO has identified that it is becoming increasingly challenging to secure the necessary level of SRAS sources with the appropriate reliability across the NEM.

- AEMO notes that a lack of available resources for providing system restart services is impacting the ability to meet the Standard
- AEMO is aware that high concentrations of distributed PV generation at consumer locations can impact the ability to stabilise restart islands
- AEMO has identified that resiliency and flexibility are required in restart pathways as the power grid becomes inherently more complex

We have provided further discussion on these risks in chapter 5.

AEMO discusses system restart in several related reports including:

- Non market ancillary service annual report
- AEMO engineering roadmap
- Transition plan for system security.

We have provided further discussion on these reports in chapter 6.

2.2 This review follows on from previous work on the system restart frameworks

The Panel and the AEMC have considered system restart frameworks more extensively since the 2016 South Australia black system event including in:

- 2016, the Panel conducted a fulsome review of the Standard
- 2020 *System restart ancillary services standard and testing Rule* (*SRAS Rule 2020*)
- 2021 the Panel made a minor update to the Standard that was set in 2016 to reflect the outcomes of the rule made in 2020.

2.2.1 The Panel has reviewed the Standard twice since 2016

Prior to 2016, the Panel was required to set a Standard that included the timeframes for the standalone restoration of each sub-network under conditions that would be expected under a NEM-wide black system event.[22]

In 2016, the Panel performed a major review of the Standard and published a final determination and final standard, which defined more stringent requirements for the procurement of SRAS tailored to the specific requirements of each electrical sub-network, including:[23]

- the level and time components were tailored for each electrical sub-network to reflect the speed at which the generation can be restored, the characteristics of the transmission network and the economic circumstances that apply to the sub-network

20 AEMO, 2024. *Non Market Ancillary Services (NMAS) report 2023-24*. p.8.
21 AEMO, 2024. *2024 General Power System Risk Review*. 25 July 2024. p.124-125.
22 Reliability Panel, 2015. *Review of the System Restart Standard Issues Paper*. 19 November 2015. p.36-38.
23 Reliability Panel, 2016. *Review of the System Restart Standard Final Determination*. 15 December 2016. p.6-7.

- minimising the costs of the SRAS that will need to bought by specifying the minimum level of generation and transmission capacity to be restored by SRAS in each sub-network in accordance with detailed economic assessment of procuring different levels SRAS
- an aggregate reliability of the SRAS procured for each of the electrical sub-networks. This requirement of the Standard better specifies the performance of the procured SRAS, and included a requirement for AEMO to consider the reliability and damage to the transmission network, following a major supply disruption, when it calculates aggregate reliability.

In 2021, the Panel performed a minor review of the Standard set in 2016 and published a final determination and final standard which included requirements for an additional sub-region in Queensland, north of Bundaberg.[24]

In the Panel's final determination in 2021, it was noted:

- that an increasing scope of technologies eligible to provide SRAS may, over time, change the economically efficient level of SRAS procured by AEMO for a particular sub-network.
- a tension exists between the Standard acting to drive investment in new SRAS capability and Standard settings reflecting existing power system capabilities.

At the time of the 2021 review, the Panel did not consider it possible to identify economically efficient Standard settings that account for new technologies in the absence of experience in their procurement and information on their cost.

2.2.2 In 2020 AEMC made changes to the existing frameworks governing the definition, procurement, testing and deployment of SRAS

The *SRAS Rule 2020* made a number of changes to the NER to enhance the frameworks for system restart and restoration. These included:

- revised and expanded definitions of SRAS and black start capability, to allow AEMO to procure the services needed to effectively and promptly restore supply to consumers
- clarification that AEMO can take overall costs into account when procuring SRAS (including both short-term and long-term costs)
- establishment of a transparent framework for the physical testing of system restart paths
- clarification of the roles of the different parties involved in system restoration and the communication processes they must follow with respect to SRAS.

The update to the frameworks responded to rule change requests proposed by AEMO and the AER, which identified a number of challenges arising under the existing frameworks governing the procurement, testing and deployment of SRAS. The issues identified in the rule change requests included:[25]

- there were fewer traditional sources of SRAS available in some NEM regions, and those that remained were potentially less capable of restoring the power system. This issue could be at least partly addressed by expanding the definition of SRAS, to allow new parties and new technologies to offer these services.
- the definition of SRAS only encompassed black start capability and did not refer to other ancillary services that may be needed to support the stable restoration of the power system. Defining these new services allowed AEMO to source them as necessary to deliver an effective restoration of the power system.

24 Reliability Panel, 2021. *System Restart Standard Review 2020 Final Report*. 28 January 2021. p.5-6.

25 AEMC, 2020. *National Electricity Amendment (System restart services, standards and testing) rule 2020 Rule Determination*. 2 April 2020. p.4-5.

- existing modelling and generator-level testing of restart paths was only sufficient for the scenarios tested.
- the NER did not provide sufficient clarity and delineation between the roles of AEMO, TNSPs and other parties involved in system restoration, particularly in relation to the communication processes needed to facilitate an effective response to a major supply disruption. Clarifying these roles and responsibilities will enhance the effectiveness of the system restoration process generally.

The Panel noted in its final determination of its 2020 review of the Standard, that the next fulsome review of the Standard should incorporate changes made in the *SRAS Rule 2020* in its determination of quantitative Standard settings. These include modelling restoration including restoration support services and black start SRAS from non-generation providers. The Panel may also elect to assess efficiency over a forward horizon as the *SRAS Rule 2020* provided AEMO with the scope to enter into longer-term contracts for SRAS as a means of incentivising investment in new SRAS capabilities.

3 Approach to this review and the assessment framework

This chapter outlines the Panel's approach to the review of the system restart standard (the Standard). This includes how:

- the Panel will be guided by the NER and the NEO
- the important role of AEMO advice in informing the Panel's consideration of the Standard
- associated regulatory frameworks function
- an overview of this paper and the key issues that the panel is seeking stakeholder input on.

3.1 The Panel will be guided by the SRAS objective and the NEO

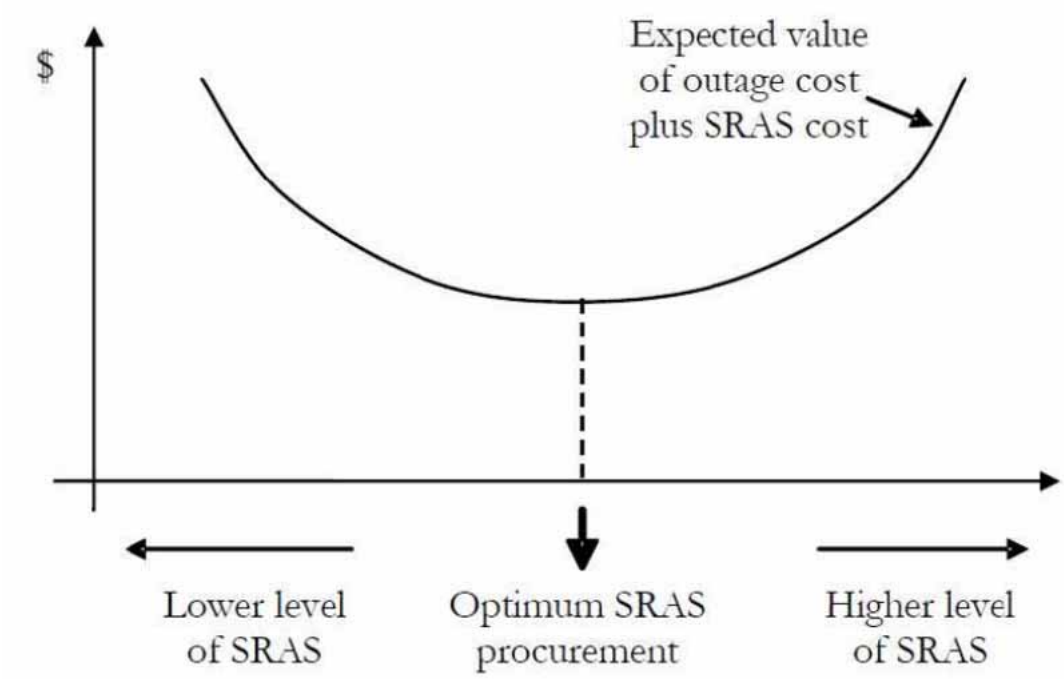
The NER requires the Panel to determine the Standard in accordance with the SRAS Objective set out below:

> The objective for system restart ancillary services is to minimise the expected costs of a major supply disruption, to the extent appropriate having regard to the national electricity objective.

The SRAS Objective requires a Standard that minimises the expected cost of a major supply disruption. The SRAS Objective requires the Panel to determine the Standard on the basis of an economic assessment of different levels of, and options for, AEMO's SRAS procurement.

In the current Standard, the Panel has determined the economically efficient, or 'optimum', SRAS procurement level as that which minimises the total costs of procuring SRAS plus the economic costs to society of a prolonged disruption to electricity supply. The efficient level of SRAS that minimises total costs is conceptually illustrated in Figure 3.1.

Figure 3.1: Diagramatic representation of the efficient level of SRAS



Source: Reliability Panel, 2020.

The SRAS objective also requires the Panel to have regard to the National Electricity Objective (NEO) in determining the Standard. The NEO is set out in Section 7 of National Electricity Law as follows:

> to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system; and
>
> (c) the achievement of targets set by a participating jurisdiction:
>
> (i) for reducing Australia's greenhouse gas emissions; or
>
> (ii) that are likely to contribute to reducing Australia's green house gas emissions.

The Panel considers that the relevant aspects of the NEO for this review are more efficient investment in, and operation of, electricity services, particularly with respect to the price of SRAS and the reliability, safety and security of supply.

The system restart frameworks and the Standard provide for a black start capability to restore the power system following a major non-credible contingency resulting in a full or partial black system. The primary considerations for this are:

- the availability of effective restart capability
- the expected speed of system restoration, the relative costs of unserved energy under different restart scenarios
- the associated costs of SRAS procurement and testing.

This Panel will consider various economic factors, including the trade-offs that exist between the ongoing cost of procuring SRAS against the probability weighted costs of delayed system restoration following the rare event of a major supply disruption. As such the Panel's analysis to inform a revised standard will include:

- an estimate of the costs and range of new and existing technologies that may provide SRAS in the coming years.
- an estimate of the costs and characteristics of system restart support services likely to be needed for a successful restart.
- consideration of the probability of future black system conditions given the risks and uncertainties in a NEM undergoing a disruptive technological transition.

Consideration of emissions

With respect to the consideration of the emissions element of the NEO, the Panel notes that the direct emissions as a result of system restart activities are not likely to be significant, due to the short time window and low frequency of such events. At the same time, the Panel's focus for this review is to consider how the Standard and broader restart frameworks may be adapted to reflect the changing nature of the power system - which is rapidly decarbonising.

While consideration of direct emissions is not likely to be a primary determinant in the Panel's review, the Panel considers it critical that the Standard and related regulatory frameworks are not a barrier to achieving decarbonisation of the NEM and the contribution of this to broader emissions reduction targets. The review itself is part of a broader programme of work by the market bodies to adapt the electricity market frameworks to support a decarbonising power system.The Panel will work closely with AEMO to identify how the system restart frameworks will operate in a future power system that is dominated by inverter based renewable generation and storage, including the contribution that such plant types can make to the system restart capabilities.

3.2 The Panel must consider whether the relevant requirements in the NER have been met

When determining the Standard, the Panel must consider whether the relevant requirements in the NER have been met. The NER requirements applying to the Panel's determination of the Standard are described below.

NER clause 8.8.1 (a)(1A) sets out that the Reliability Panel must on the advice of AEMO, determine the Standard.

NER clause 8.8.3(aa)(1) sets out that the Reliability Panel must review and determine the Standard in accordance with the SRAS Objective.

Clauses 8.8.3(aa)(2) to (7) of the NER state that the Standard must:

1. *identify the maximum amount of time within which system restart ancillary services are required to restore supply in an electrical sub-network to a specified level, under the assumption that supply (other than that provided under a system restart ancillary services agreement acquired by AEMO for that electrical sub-network) is not available from any neighbouring electrical sub-network;*
2. *include the aggregate required reliability of system restart ancillary services for each electrical sub-network;*

3. *apply equally across all regions, unless the Reliability Panel varies the system restart standard between electrical sub-networks to the extent necessary:*
   a. *to reflect any technical system limitations or requirements; or*
   b. *to reflect any specific economic circumstances in an electrical sub-network, including but not limited to the existence of one or more sensitive loads;*
4. *specify that a system restart ancillary service can only be acquired by AEMO under a system restart ancillary services agreement for one electrical sub-network at any one time;*
5. *include guidelines to be followed by AEMO in determining electrical sub-networks, including the determination of the appropriate number of electrical sub-networks and the characteristics required within an electrical sub-network (such as the amount of generation or load, or electrical distance between generation centres, within an electrical sub-network); and*
6. *include guidelines specifying the diversity and strategic locations required of system restart ancillary services.*

We are interested in stakeholder views on whether or not these clauses remain appropriate. This is discussed in more detail in the remaining chapters.

3.3 The Panel will seek advice from AEMO on system restart for the future power system

In accordance with clause 8.8.1(a)(1A) of the NER, the Panel will review the Standard on the advice of AEMO.[26] At the same time, the Panel's review is part of a collaborative work programme to respond to the emerging system restart challenges identified by AEMO and described in chapter 5. As such the Panel's review will be informed by technical advice from AEMO to inform how system restoration will work in a future power system dominated by renewable and distributed generation technologies. The Panel expects that AEMO's advice will include:

- General advice to inform an understanding of how system restoration will work under the power system scenarios envisaged in the 2024 ISP. This will include describing and assessing:
  - the exit and reduced availability of existing coal-fired black start capable resources
  - the range of technological and locational options for new black start capability in the national electricity system
  - the potential role of renewable generation and renewable energy zones in supporting or initiating black start
  - the potential role of batteries and storage in supporting or initiating black start
  - the potential role of the distribution system during system restoration along with the technical challenges and opportunities for re-energisation of the transmission network via distribution level power islands.
  - the potential role of non-black start equipment and plant (SRAS support services) in supporting stable restoration.
  - options for restart during daylight hours and high distributed PV output
  - the role of AC interconnectors for system restart and the resilience benefits of interconnectors for each of the NEM regions with respect to system restoration
  - the potential role of HVDC transmission elements to facilitate future system restoration.

26 NER clause 8.8.1(a)(1A).

- Consideration of how changes in the system might influence the likelihood of a major supply disruption or black system event in the future in a qualitative manner, and identify how low risk, resilient restart approaches could be built to mitigate potential issues.
- Consideration of how the current regulatory framework, including the Standard, may be restricting supply of new sources of SRAS and identify potential high-level changes that may resolve any such restriction.
- Specific advice to inform the Panel determination of a revised Standard, including
  - potential procurement options for black start services and restoration support services likely to be available in 2027-2032, accounting for:
    - The exit and reduced availability of existing black start capable resources
    - Renewable energy zone development and the NEM's changing generation and network footprint
    - The range of technological and locational options for new investment in new black start capable SRAS, including relative cost estimates
  - a projection of the changing restart pathways and associated restoration timeframes based on the potential SRAS sources.

The Panel understands that AEMO formal advice to this review will be delivered as part of AEMO's System restart insights paper related to Engineering roadmap action FY25_21 – to evaluate system restart capability and options during periods when large synchronous generation is offline.[27] The Panel expects AEMO's advice to be made available in Q2 2025.

It is critical that system standards and market settings are consistent with and informed by the relevant engineering requirements, not the other way around. The Panel is therefore seeking technical advice from AEMO on how system restart services will be provided in the future if and when existing service providers are unavailable. This will be critical to inform an understanding of the efficient level of SRAS (Section 3.1) and identify any potential changes to the Standard that would be required to enable that.

The Panel may also consider seeking additional external technical engineering and economic advice as it sees fit, to support the objectives of this review. This may include advice on system restart arrangements and learnings from major power system incidents internationally.

3.4 The Panel may make recommendations on further actions to support a system restart framework that meets the needs of the future power system

The Panel may make recommendations for actions to address any relevant issues identified through the review. These may include recommendations for potential changes to the NER and/or AEMO's procedures to support the capability to restore and re-energise the future power system following a major supply disruption.

In particular, the AEMC in its terms of reference to the Panel has requested it consider:

- The ability for AEMO and TNSP's to manage the restoration of the power system following a major supply disruption.
- Measures to support the efficient and reliable provision of sufficient system restart services – including the future investment in black start capable resources.

27 AEMO, 2024. *Engineering Roadmap – FY2025 priority actions report*. 15 August 2024. p.42, Priority Action FY25-21

- The interaction of Renewable energy zones with system restart.
- The impact of distributed PV and the role of DNSP's in system restart.
- The role of load in system restart and the implications for the restoration of sensitive loads within critical timeframes.

3.5 The Panel invites stakeholder feedback on the key issues presented in the paper which are explored in the following chapters under three categories

The Panel developed a broad framework to systematically consider issues within this paper. The Panel has divided related issues in the system restart regulatory framework into three key categories: restart preparedness and governance, SRAS sufficiency, and transparency and reporting.

Chapter 4 discusses the governance arrangements that support restart preparedness.

- Restart preparedness refers to the readiness of the power system to effectively restore the power system following a major supply disruption. This includes the capabilities and constraints related to the physical network infrastructure and the planning and processes undertaken by the system operator and NSPs.
- Restart governance covers the NER frameworks that establish the processes, roles and responsibilities for system restart.

The Panel is interested in stakeholder views related to restart preparedness on:

- the appropriateness of the current roles and responsibilities for system restart, including the contributions that could be made by inverter connected plant
- opportunities for the design and development of REZs to support future restart preparedness
- transmission network changes that may be required to support system restart through the transition
- the potential future role of battery technologies in system restart, and what complementary changes would support batteries to provide system restart services
- managing risks to system restart from changes occurring at the distribution level of the power system
- identifying opportunities for improved restart preparedness from changes at the distribution level of the power system.

Chapter 5 discusses restart sufficiency which refers to the availability of black start capability required to restart the power system following a black system event. The Standard defines the operational planning objective for system restart and guides AEMO's procurement of SRAS to deliver restart. The Panel is interested in stakeholder views to inform:

- an understanding of the technical challenges related to the provision of SRAS from new generation, including the role of battery energy storage systems and other inverter connected resources
- an understanding of commercial challenges related to investment in SRAS capability
- ways to improve investment incentives to enable future SRAS technologies and whether the Standard can be revised to enable stronger responses to system restart
- whether the form of the Standard requires change and how this might impact the methodology used to determine the Standard's settings.

Chapter 6 explores transparency and reporting in relation to SRAS sufficiency and emerging system restart risks. We propose to investigate whether the current reporting arrangements provide sufficient transparency to signal the need for investment in new SRAS capability.

The Panel is interested in stakeholder views on the current arrangements for transparency and reporting, and whether stakeholders require further information to inform changes to planning provisions within the current framework and investment decisions for new investment in SRAS.

4 Restart preparedness

Restart preparedness refers to the readiness of the power system to be re-energised following a major supply disruption. This includes the capabilities and constraints related to the physical network infrastructure and the capabilities of key organisations responsible for system restoration.

This chapter describes the existing system restart frameworks that support restart preparedness and discusses a number of related issues arising from changes to the power system associated with the energy transition. This chapter does not discuss issues related to the provision of SRAS, which are discussed in chapter 5.

- Section 4.1 describes the current arrangements for system restart planning and asks questions related to the appropriateness of these arrangements.
- Section 4.2 describes issues related to system restart arising from changes in the transmission system projected in the ISP.
- Section 4.3 describes issues related to system restart and the distribution system.

4.1 The NER frameworks for system restart planning and preparedness

Under the NER, AEMO has the primary responsibility for system restart planning through the requirement for it to procure SRAS and prepare a system restart plan in order to be able to restore the power system following a major supply disruption.[28] This includes coordinating activities with market participants, including the testing of SRAS and other related equipment to prepare for the implementation of the system restart plan.

This system restart plan is informed by local black start procedures(LBSPs) that each generator and NSP are required to develop and provide to AEMO.[29] Local black start procedures are an important set of documents used by AEMO to develop its regional restoration options. The Rules require these procedures to:[30]

- provide sufficient information to enable AEMO to understand the likely condition and capabilities of plant following any major supply disruption, such as a black system event, so that AEMO is able to effectively co-ordinate the safe implementation of the system restart plan
- include any action the Generator, Integrated Resource Provider or Network Service Provider must take following any major supply disruption prior to energisation and synchronisation
- appropriately incorporate any energy support arrangements to which a generator or NSP may be a party.

AEMO has an obligation to develop and publish guidelines for the preparations of local black start procedures and is responsible for approving any procedures submitted by generators and NSPs.[31] The local black start procedures Guidelines set out the information to be provided to AEMO covering the technical requirements and limitations in a restart environment regarding generation and network plant.[32]

Under the NER, there is an obligation for local black system procedures to be consistent with SRAS agreements. There is also an obligation for NSPs, integrated resource providers and

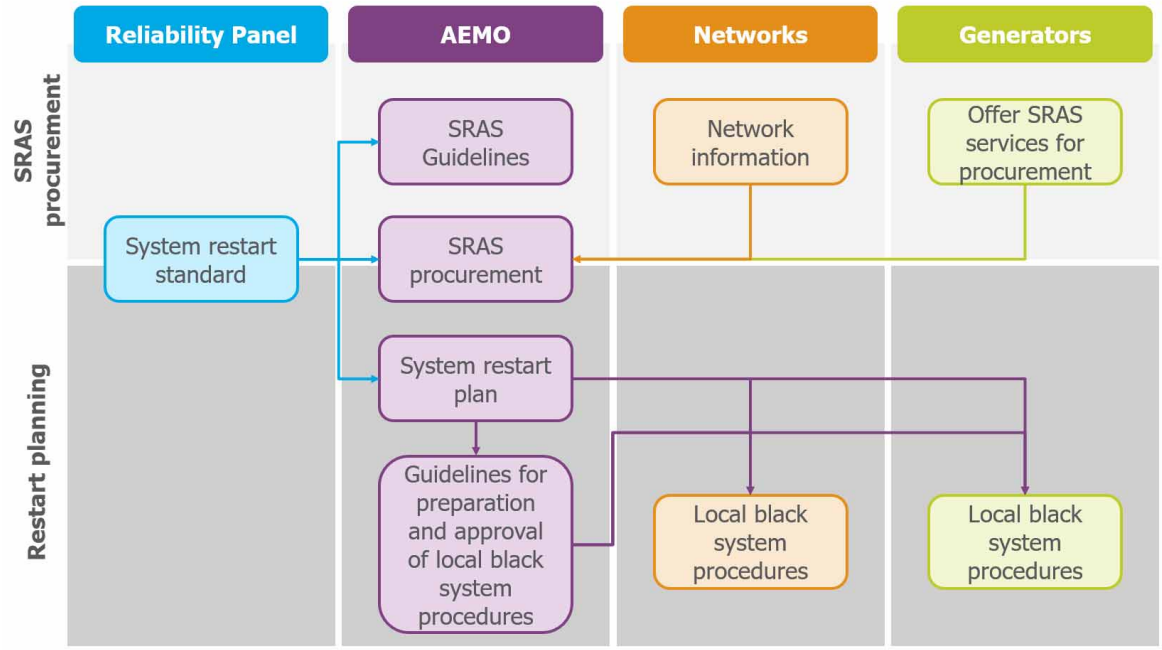
28 NER cl.4.3.1(p)
29 NER, clause 4.8.12(d)
30 NER, clause 4.8.12(f)
31 NER, clause 4.8.12(g).
32 AEMO, 2019. *Guidelines for preparing Local Black System Procedures*.

generators to comply with their procedure as quickly as practicable in the event of AEMO advising them to take action to restore the power system following a major supply disruption.[33]

The NER also provides a framework for testing of SRAS and system restart pathways. AEMO is required to set out in its SRAS guideline the factors that it will take into account to determine when it may conduct a system restart test and what information must be reported to AEMO by registered participants that may be required to participate in a restart test.[34] The NER sets out a process to support AEMO in undertaking system restart tests to verify the system restart plan for an electrical sub-network and whether it is likely to be consistent with the achievement of the Standard. This includes clarification of the roles and responsibilities for AEMO, TNSPs and registered participants that are required to participate in system restart tests and a framework for the recovery of associated costs and reporting of related results.[35]

Figure 4.1 provides an overview of the roles and responsibilities of different parties with respect to system restart.

Figure 4.1: Roles and responsibilities for system restart under the current frameworks



Question 1: Appropriateness of the current roles and responsibilities for system restart

- Are stakeholders aware of any issues related to the roles and responsibilities within the current system restart regulatory framework that may impact system restart outcomes over the short to long term? If so, please elaborate.
- What if any, are the potential changes to the current restart frameworks that could improve restart preparedness?

33 NER, clauses 4.8.12(d) and 4.8.14(b).
34 NER clause 3.11.7(3A) and 3.11.7(3B)
35 NER clause 4.3.6

- What if any, are issues or short-comings of the current restart governance arrangements?
- How might SRAS governance arrangements evolve to address risks over the medium and long term?

4.2 Consideration for the restart frameworks in the context of projected changes in the transmission system

As identified in AEMO's 2024 ISP, the transmission system is undergoing significant change, which is expected to continue and intensify over the coming decades. In the context of this review, the Panel is considering potential changes to the governance arrangements for system restart, including the system restart standard, such that they may be fit for purpose during this period of system change.

The Panel recognises the importance of the system restart regulatory frameworks and is mindful that they be fit for purpose for the future power system, to ensure that black start will be physically feasible under all dispatch outcomes considered in the ISP. The Panel notes in particular, the following changes set out in AEMO's 2024 ISP as being relevant to the consideration of the arrangements for restart preparedness in the NEM:

- Projected new transmission network augmentations, including intra-regional network strengthening and expansions and new regional interconnectors.
- The development of renewable energy zones, which are coordinated concentrations of new renewable energy generation and associated network infrastructure intended to streamline and accelerate the development process.

Each of these issues are discussed further below.

4.2.1 The development of renewable energy zones presents challenges and opportunities for system restart

AEMO's 2024 ISP identifies 43 potential renewable energy zones across the NEM regions for the coordinated development of new large scale renewable generation. AEMO projects the need for 83 GW of utility-scale VRE in the NEM out to 2034-35 in the Step Change scenario and even greater uptakeunder the 'green energy export' scenario.[36] It is understood that coordinated development clusters through REZs are central to delivering this new generation capacity.

The Panel notes that the status of the development of these potential REZs varies, with some areas not having progressed from initial resource identification while others are well progressed along the early stages of the development process. At this stage the development of REZs is being lead and coordinated by commitments from jurisdictional governments.

- The Queensland Government is looking at three REZ 'corridors' that span its eight potential zones.[37]
- The New South Wales Government has confirmed that it will develop REZs in five locations:[38]
  - Central-West Orana
  - New England

36 AEMO, 2024. *Integrated System Plan*, 26 June 2024. p.51.

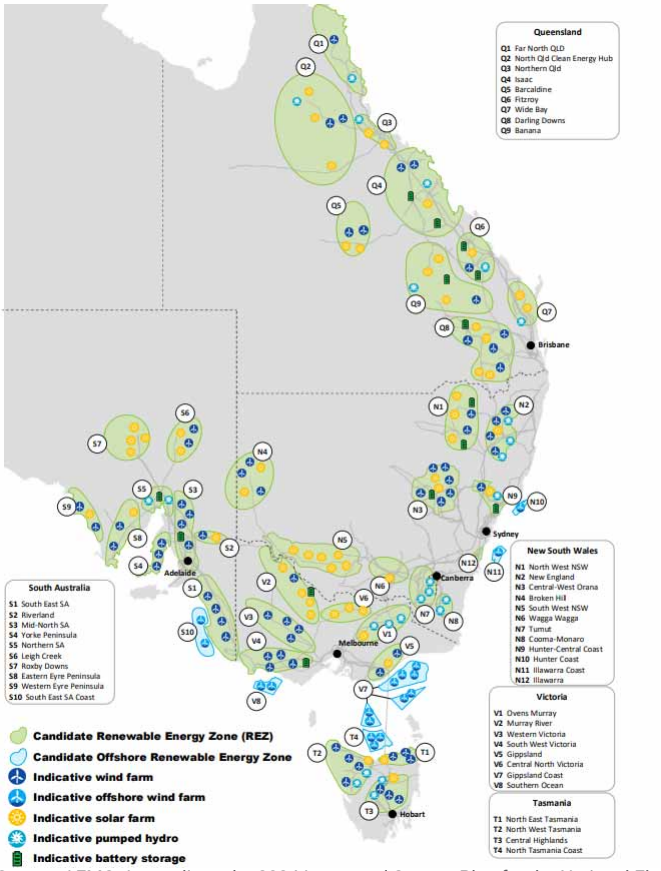
37 Department of Energy and Climate, 2024. *Renewable energy zones*. Date accessed 11 December 2024.

38 EnergyCo, 2024. *Renewable Energy Zone locations*. Date accessed 11 December 2024.

- South-West Region
- Illawarra
- Hunter-Central coast

- The Victorian Government has pledged to fund the development of six REZs across the state:[39]
  - South West Victoria
  - Western Victoria
  - Murray River
  - Central North Victoria
  - Ovens Murray
  - Gippsland
- The Tasmanian Government has also identified the north-western region as a potential REZ.[40]

Figure 4.2: Potential renewable energy zones identified in the 2024 ISP



Source: AEMO, Appendix to the 2024 Integrated System Plan for the National Electricity Market, Appendix 3. Renewable Energy Zones, 26 June 2024

The Panel considers that there may be opportunities for REZ developments to support system restart, given the coordinated nature of these developments. The Panel has requested that AEMO provide advice on the technical feasibility for REZs to be able to remain energised as islanded sub-systems following a broader disturbance and major supply disruption. Such islanded operation

39 VicGrid, 2024. *Renewable energy zones*. Date accessed 11 December 2024.

40 Tasmanian Government, 2024. *Renewable Energy Zones*. Date accessed 11 December 2024.

would potentially provide an energisation source and may also be eligible for SRAS contracts. However, the integration of restart capability in REZ developments would likely be more effective and efficient, if it were identified in advance and included in the generator and network design.

While the Panel is not aware of any limitations arising from the current regulatory frameworks in relation to provision of restart services from REZ's, the Panel is interested in stakeholder input on how the development of REZs intersects with the system restart framework and the system restart standard. In particular the Panel is interested in stakeholders views on how the existing regulatory frameworks support or restrict the contribution of REZs to system restart.

Question 2: System restart capability from Renewable energy zones

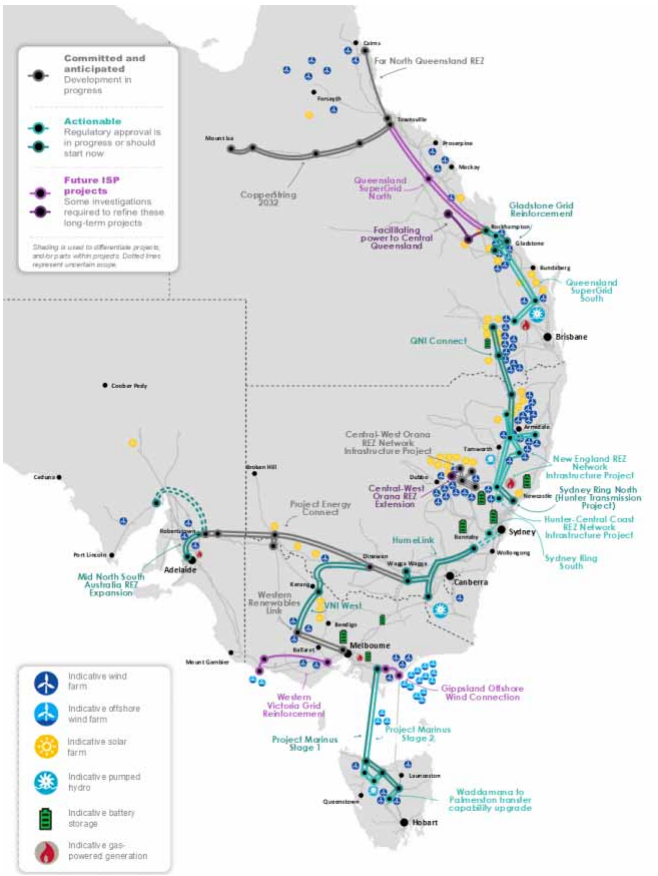
Are there opportunities for the design and development of REZs to support future restart preparedness?

- What opportunities are there for the design and specification of generation and network infrastructure in each REZ help to support future system restart?
- How might the projected REZ developments impact future system restart pathways?
- Do the projected and committed REZ developments require the consideration of any changes or amendments to the system restart frameworks or the system restart standard? If so, please describe any such potential changes.
- How should this information be communicated to the market and/or system planners, and how far in advance would this information be required in order to be actionable?

4.2.2 New transmission augmentations and system restart

AEMO's 2024 ISP also identifies a programme of network augmentation to meet the projected network demand under its optimal development pathway. An overview of the development pipeline for new transmission infrastructure over the ISP outlook through to 2050 is shown in Figure 4.3.

Figure 4.3: Transmission projects in the optimal development path



Source: AEMO, 2024 Integrated System Plan, 26 June 2024, p.58

Of particular relevance to this review is the consideration of the system impacts as a consequence of a number of network augmentations that are anticipated to become operational prior to 2030. These projects are listed in Table 4.1 below for reference.

Table 4.1: Committed and anticipated transmission network projects

Status	Project	Description	Full capacity timing (advised by proponent)
Committed	Far North Queensland REZ	Uplift of an existing 132 kilovolts (kV) circuit into Woree to 275 kV.	June 2024, Powerlink
Committed	Project EnergyConnect	A new 330 kV double-circuit interconnector between South Australia and New South Wales, with a new 220 kV double-circuit line to Victoria.	Stage 1 December 2024and Stage 2 July 2027A,Transgrid, ElectraNet and AusNet Services
Anticipated	Western Renewables	A 500 kV double-circuit network upgrade to provide additional capacity to the	July 2027, AEMO Victoria Planning

Status	Project	Description	Full capacity timing (advised by proponent)
	Link (updated)	Western Victoria REZ, including updated project scope to relocate a terminal station and increase the line capacity.	
Anticipated	Central-West Orana REZ Network Infrastructure Project	A network upgrade consisting of 500 kV and 330 kV circuits to provide additional capacity to the Central West Orana REZ.	August 2028, EnergyCo
Anticipated	CopperString 2032	An 840 km new double-circuit line to connect Queensland's North-West Minerals Province to the NEM near Townsville, as announced by the Queensland Government.	June 2029, Powerlink

Source: AEMO, 2024 Integrated System Plan, 26 June 2024, p.60.

In addition to these committed projects the ISP also identified 12 actionable network projects under the optimal development path (ODP). These actionable projects relate to a need identified by the ISP modelling to optimise the projected benefits for consumers consistent under the ODP.

Table 4.2: Actionable network projects in the 2024 ISP optimal development path

Project	Projected In service timing	Brief description
HumeLink	Northern - July 2026 Southern - December 2026	A 500 kV transmission upgrade connecting Project EnergyConnect and the Snowy Mountains Hydroelectric Scheme to Bannaby.
Hunter-Central Coast REZ Network Infrastructure Project	December 2027	Substation upgrades to supply generation from the Hunter and Central Coast to Sydney, Newcastle and Wollongong load centres.
Sydney Ring South	September 2028	A switching station and modular power flow controllers to reinforce supply to Sydney, Newcastle and Wollongong load centres.
Sydney Ring North(Hunter Transmission Project	December 2028	High capacity 500 kV transmission network to reinforce supply to Sydney, Newcastle and Wollongong load centres.
Gladstone Grid Reinforcement	March 2029	Increase network capacity from Central Queensland into the Gladstone area to support the area's industry once Gladstone Power Station retires, and add capacity between Northern and Southern Queensland.

Project	Projected In service timing	Brief description
Mid North South Australia REZ Expansion	July 2029	New 275 kV and 132 kV transmission lines to connect renewable generation to Adelaide and to supply increasing industrial load.
Waddamana to Palmerston transfer capability upgrade	July 2029	New 220 kV transmission line to connect renewable generation to Hobart, as well as mainland Australia.
Victoria – New South Wales Interconnector West (VNI West)	December 2028	A new high capacity 500 kV double-circuit line to connect Western Renewables Link (from Bulgana) with Project EnergyConnect and HumeLink (at Dinawan) via a new substation near Kerang.
Project Marinus	Stage 1 - June 2030 Stage 2 - June 2032	Two new high voltage direct current (HVDC) cables connecting Victoria and Tasmania, each with 750 MW of transfer capacity and associated alternating current (AC) transmission, to enable more efficient power sharing between these regions. HVAC network assets in Tasmania for REZs under the North West Transmission Developments project.
New England REZ Network Infrastructure project	Part 1 - June 2031 Part 2 - June 2033	Three separate projects to increase the transfer capability between central and northern New South Wales, enable more transfer capacity out of the Queensland New South Wales Interconnector, and expand the New England REZ.
Queensland SuperGrid South	September 2031	Stage 2 of the Queensland SuperGrid, under the Queensland Energy and Jobs Plan, to greatly increase the transfer limit between Central and Southern Queensland and connect to the Borumba Pumped Hydro project.
Queensland – New South Wales Interconnector (QNI Connect)	April 2032	Add capacity between southern Queensland and New England, following development of the New England REZ Network Infrastructure project.

Source: AEMO, 2024 Integrated System Plan, 26 June 2024, p.61-63.

The current electrical sub-networks have been defined by AEMO, largely in alignment with the NEM regions of:[41]

- Queensland
- New South Wales
- Victoria

41 AEMO, 2020. *SRAS Guideline*. 2 November 2020, p.32.

- South Australia
- Tasmania

The boundaries for these electrical sub-networks are defined by AEMO in accordance with NER clause 3.11.8 and the related guidelines in the system restart standard. As required under NER cl.8.8.3(aa)(6), the system restart standard includes the following guidelines for AEMO's determination of electrical sub-network boundaries:[42]

> **7. Guidelines for the determination of electrical sub-networks**
>
> In determining the boundaries for electrical sub-networks, AEMO must consider the technical characteristics that would facilitate the achievement of AEMO's power system security responsibility of procuring adequate system restart ancillary services to enable it to co-ordinate a response to a major supply disruption. These technical characteristics would include, without limitation, the following factors:
>
> - the number and strength of transmission corridors connecting an area to the remainder of the power system;
> - the electrical distance (length of transmission lines) between generation centres;and
> - an electrical sub-network should be capable of being maintained in a satisfactory operating state to the extent practicable during the restoration process, and in a secure operating state from a stage in the restoration when it is practicable to do so, as determined by AEMO.

The definition of electrical sub-networks is an important element of the restart frameworks as this defines the geographic region that is the basis of system restart planning and the procurement of SRAS.

While the electrical sub-networks are defined based on the physical characteristics of the network, the number of electrical sub-networks have a bearing on the number of SRAS procured, the associated cost, and the restoration outcomes following a black system event. The Panel is interested in testing whether the current guidelines for electrical sub-networks are appropriately defined as well as whether the existing sub-network boundaries are likely to be fit for purpose over the 2024 ISP outlook.

It is also relevant to consider the process by which electrical sub-network boundaries may be revised and how this interacts with the process for setting the system restart standard. The current standard specifies the required time, level and aggregate reliability for restoration of each of the electrical sub-networks on an individual basis, as described in chapter 5.[43] This bespoke approach by which the Panel sets the Standard for each electrical sub-network, contributes to some administrative challenges when combined with AEMO's responsibility for defining the boundaries for the electrical sub-networks. The associated challenge is demonstrated by the process surrounding the 2020 Review of the System restart standard, in which one of the primary triggers and objectives was for the standard to be updated to allow for AEMO to combine the "North Queensland" and "South Queensland" electrical sub-networks into one "Queensland" sub-network. The combination of the bespoke approach to setting the standard for each electrical sub-network by the Panel and AEMO's responsibility for determining the electrical sub-networks drives the need for the reliability Panel to be involved in reviewing and setting the standard

42 Reliability Panel, 2021. *System Restart Standard*. 28 January 2021. p.3.

43 This bespoke approach to setting the standard has been applied since the Reliability Panel's 2016 review. Prior to that time, the standard was defined equally for all electrical sub-networks. The history of system restart standard and frameworks is discussed in section 5.3.1.

whenever AEMO has reason to consider substantive changes to the definition of the electrical sub-networks.

Noting the procedural complexity of changing electrical sub-network boundaries and setting the standard, the Panel is interested in considering whether the current process is sufficiently robust and flexible in the context of the projected changes in the power system discussed above. Alternative approaches, that may be more flexible include:

- reverting the Standard to a form that is applied equally across all electrical sub-networks, as was the case prior to 2016.
- considering whether the NER frameworks should be revised to authorise AEMO to be able to define the electrical sub-networks as well as the associated restoration requirements. Under this approach, the form for the Standard could be reviewed with the objective of providing high level guidance for AEMO on the restoration outcomes, while reducing the associated administrative complexity.

The Panel is seeking to gain a better understanding of how the network augmentations projected under the ISP may interact with the system restart framework and the system restart standard. Given the extent of transmission augmentation projected to occur of the coming decade, it is timely to consider how the system restart preparedness may need to adapt and whether the restart frameworks and standard are able to accommodate such change. We encourage stakeholders to share their views on the related opportunities and challenges for system restart.

Question 3: Transmission network changes and system restart

- Given current projected network changes set out in AEMO's ISP planning scenarios, what considerations would need to be given to maintain and strengthen restart capability in the future power system?
- Are the current electrical sub-network boundaries appropriate for the future power system with respect to REZ's and new interconnections? If not, how might they change?
- In the context of the projected changes in the electricity system over the coming decade, are the guidelines in the standard for electrical sub-network boundaries fit for purpose? If not, what adjustment or additions could be made to future proof them?
- What are stakeholders' views on the current process for defining electrical sub-networks and the associated restoration requirements? Do stakeholders consider that any changes could be made to the current frameworks and/or the standard to enable the process of changing electrical sub-network boundaries to be more flexible? Is so, please describe these.

4.3 Consideration for the restart frameworks in the context of the changing distribution system

AEMO has identified a growing risk to system restart due to the impact of distributed PV generation. The capacity of this non-scheduled generation resource in the NEM is currently 21GW and is scheduled to grow to 86 GW under AEMO's latest projections for the ISP step change scenario.[44] As outlined in AEMO's 2024 GPSRR, in the absence of emergency backstop controls, the operation of distributed PV presents risks to system restart.[45]

44 AEMO, 2024. Integrated System Plan. 26 June 2024. p.47.

45 AEMO, 2024. General Power System Risk Review Final report. 25 July 2024. p.125

Another growing risk for system restart is the effects of DPV generation. Sufficient stabilising demand is required for system restart, but higher DPV generation operating conditions are causing load variations and load erosion. The existing DPV management processes may be too cumbersome and/or ineffective to use in restart scenarios. Therefore, it is possible that there may be insufficient stable demand to restart the system until night-time/low DPV operating conditions.

AEMO is working with DNSP's to coordinate its recommended implementation of emergency backstop controls that would provide the ability to curtail all new distributed PV installations to zero active power if required as a last resort to maintain power system security. Such a capability would also support the availability of stable demand/load blocks required to energise the transmission system during a system restart event.[46]

At the same time, the Panel is aware that distributed PV that is coordinated and managed could potentially support improved outcomes for consumers following major supply disruptions, particularly when integrated with batteries and able to operate safely and reliably in an islanded manner. Given the projected levels of distribution connected generation and storage it is conceivable that parts of the distribution network could be set up to support islanded operation in the event that supply is not available from the transmission system.[47] Such a capability would require a dynamic balance between local generation and demand within the power island combined with assets that could provide frequency and voltage control. Such power islands could then be re-synchronised with the broader power system as part the system restoration process.

The potential positive contribution of consumer energy resources (CER) during system restoration, as well as the broader potential for restoration pathways to be initiated from the distribution system, has been identified and investigated by the CIGRE C2.26 Power system operation and control working group in its 2023 technical brochure, *Power system restoration accounting for a rapidly changing power system and generation mix.* The CIGRE working group investigates issues relating to system restart in power system dominated by inverter-based generation and CER.[48]

The working group objectives included investigation of the potential adverse and beneficial impact of CER in relation to system restart noting that "some countries are currently working on developing restart plans originating from the distribution network to complement conventional plans starting with transmission system restoration." This indicates that there may be certain network configurations where distribution-based restoration is viable in the future power system.[49]

The Panel has requested that AEMO's technical advice, include commentary on the potential role of the distribution system during major supply disruptions. This includes the potential to coordinate and manage distribution systems to reduce the impact on consumers during major supply disruptions and the potential for distribution system power islands to contribute to or support system restoration under future operational conditions.

The Panel is interested to work with stakeholders and AEMO to better understand the challenges and opportunities presented by the evolving distribution system for system restart. This includes how the restart process can best accommodate the future operational characteristics of the

46 Ibid.

47 The issue of how DNSP's account for the costs and benefits of micro-grids and stand-alone power systems to improve distribution system resilience is being considered as part of the AEMC's *Including distribution network resilience in the National Electricity Rule*s Rule change.

48 See: https://www.cigre.org/share/article/6005/power-system-restoration-accounting-for-a-rapidly-changing-power-system-and-generation-mix

49 CIGRE - C2 Power system operation and working group, *Power system restoration accounting for a rapidly changing power system and generation mix*, article 8 January 2021, accessed via the link above.

distribution system and whether any changes to the system restart frameworks or system restart standard would be required to help manage or harness the related challenges and opportunities.

Question 4: Managing risks to system restart from changes occurring at the distribution level of the power system

- Do stakeholders consider there likely to be any required changes to the system restart frameworks, including the Standard, as a consequence of changing operational patterns, driven by CER such as roof-top PV and batteries? If so please describe.

Question 5: Opportunities for improved restart preparedness from changes in the distribution system

- Do changes in the distribution level of the power system present any opportunities for improved system restart preparedness over the short, medium and long term?
- Is it conceivable that distribution system power islands could play a role in future power system restoration following major supply disruptions? What are the technical challenges that would need to be overcome to realise such a potential?
- Are stakeholders aware of any impediments to unlocking the benefits of improved resilience in relation to how distribution system respond to major supply disruptions and contribute to system restoration?
- Do stakeholders consider that the current system restart frameworks and standard are helpful, neutral or detrimental to realising the potential of distribution systems for improved system restart outcomes?

5 Restart Capability

Restart capability considers the availability and investment in assets across the power system that provide the required services to initiate and support system restoration and avoid prolonged outages following a major supply disruption or black system event.

This section discusses:

- the challenges identified by AEMO in procuring SRAS to meet the requirements under the current Standard.
- the enhanced SRAS regulatory framework implemented through the System restart services, standards and testing final rule 2020 (*SRAS Rule 2020*).
- the Panel's preliminary understanding of how the Standard may be restricting SRAS procurement options.

5.1 Changes in the generation fleet are impacting the availability of restart capability

AEMO has identified that the reducing availability and participation of existing restart capable units is impacting its ability to procure sufficient SRAS to meet the Standard. AEMO predicts that participation of existing restart capable units will continue to decline, which may continue to inhibit the ability to secure the sufficient system restart capability in the future, and poses a risk to AEMO's ability to restart the system.[50] AEMO has observed the following drivers of this risk in its 2024 GPSRR:

- due to the current reliance on large thermal generation units to provide system restart capability, the limited pool of existing system restoration units is decreasing with generation retirements[51]
- few existing technologies have adequate provisions in place to replace the system restart capability historically and currently provided by retiring thermal generation[52]

These drivers are discussed in more detail in the sub-sections below.

5.1.1 Availability of traditional SRAS sources is reducing as thermal generation retires

Chapter 10 of the NER defines SRAS as:

- black start capability that energises portions of the network following a black system event without needing to draw power from the power system
- restoration support services that may aid in the re-energisation process of parts of the network following a black system event.[53]

SRAS has historically been provided by black start services from large synchronous generating units, including thermal, hydro and gas. These units can output a range of services that support system restart including a consistent supply of active power and inertia to maintain stability. [54]

Large thermal generation units form a significant portion of the current available system restart capability in the NEM. As depicted in Figure 5.1, by 2030, the majority of existing thermal

50 AEMO, 2024. *2024 General Power System Risk Review – Report.* 25 July 2024. p.124.

51 Ibid.

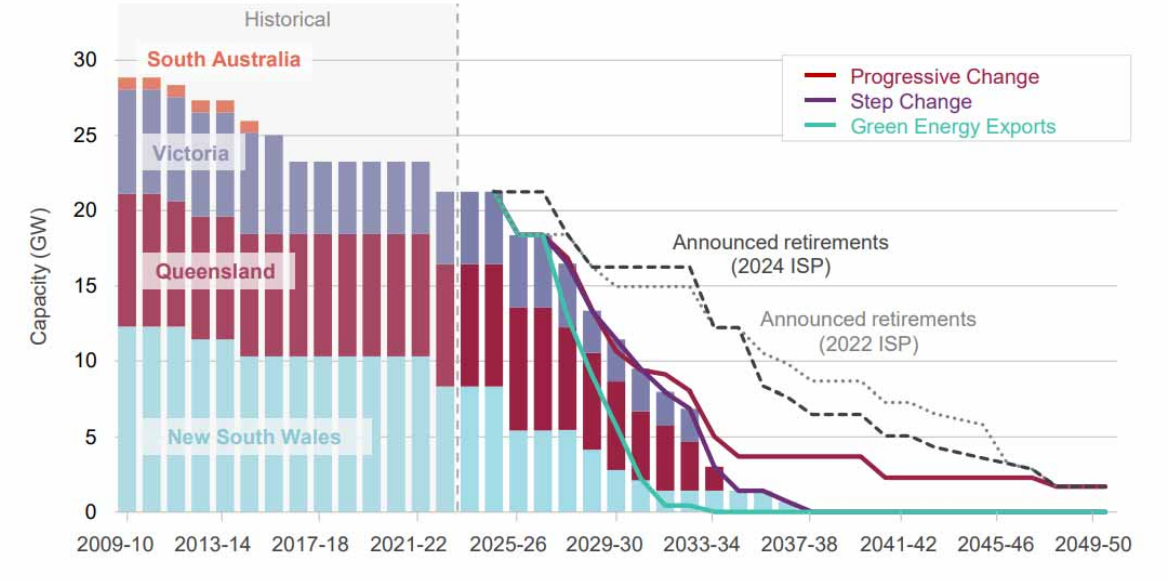
52 Ibid.

53 In the SRAS Guideline AEMO specifies restoration support services to have self-start capability, voltage control capability, frequency control capability, fault current capability or provide stabilising load.

54 AEMO, 2024. *2024 General Power System Risk Review – Report.* 25 July 2024. p.124.

generation will exit the system before 2050. We can therefore likely no longer continue to be dependent on thermal coal to provide system restart services in several NEM electrical sub-networks, including New South Wales, Victoria and Queensland.

Figure 5.1: 2024 ISP projected thermal generation capacity



Source: AEMO, 2024. 2024 Integrated system plan. Figure 1.

AEMO will need to plan for the retirement of thermal generation, including investigating whether the current approach for system restart remains fit for purpose. The Panel understands this is an AEMO priority action under its Engineering Roadmap and outcomes from this action will also be considered as part of this review. We have included discussion on this below.

5.1.2 The process to enable inverter based resources for system restart is uncertain

As we transition, the increasing penetration of IBR and retiring fleet of thermal coal generation, give rise to a future with more asynchronous generation and fewer thermal synchronous SRAS sources.

AEMO highlighted in the 2024 GPSRR that ageing thermal based SRAS sources may not consider investments to upgrade or maintain capability, to meet existing requirements for system restart services on the expectation of the exiting the market.[55] Therefore, we may need to consider ways of enabling other technology sources, such as IBR, to effectively provide the necessary services to commence the process of re-energising the system.

Asynchronous technologies such as IBR have historically not been widely used as system restart capability in the NEM. IBR sources are in many ways not a like-for-like replacement for thermal generation and may require additional restoration support services, such as inertia and frequency control capability, to enable system restart. AEMO considers that restoration support services provides opportunities for new technologies, such as IBR to participate in system restoration even if they are not black start capable.[56] However, to date, AEMO has not contracted any IBR sources to provide SRAS. [57]

55 AEMO, 2024. *2024 General Power System Risk Review – Report.* 25 July 2024. p.124.

56 AEMO, 2024.*2024 Transition Plan for System Security.* 2 December 2024. p.13.

AEMO has highlighted challenges in acquiring IBR based SRAS under the current system restart framework

AEMO noted in its 2024 GPSRR that changes to the physics of the power system as we transition introduces a number of emerging challenges which will make it harder to prepare for major blackouts and to restore the power system if such an event occurs, including:

- new IBR generation and battery connections have not considered system restart requirements in their design
- changes to the system restart path creates uncertainty for IBR to invest in system restart capability

AEMO notes that new transmission-level generator connections are nearly all IBR (either renewables or batteries), and have been designed and installed with no incentive to meet the technical requirements to effectively commence the process of restoring the power system.[58] For example, a lack of system strength during restart also prevents some grid-following battery energy storage systems (BESS) from participating in the early stages of restoration.[59]AEMO has noted in its 2024 transition plan for system security that it has actively worked towards reducing barriers to participation.[60]

AEMO has also raised concerns that the system restart paths across NEM regions are changing as new connections come online and thermal generation exits. This has resulted in restart sources often being a long distance from major load centres.

AEMO will be investigating the requirements for system restart for periods where large synchronous generators are not available

In response to the risks identified, AEMO has outlined some priority actions in its NEM Engineering Roadmap FY2024 and FY2025 priority actions, including:[61]

- As part of its FY24 actions, assessed system restart requirements and capability with increasing aggregate DPV impact. AEMO found in this review that over operational timeframes (18 months to 2 years), SRAS are sufficient and there is no need for additional system restart support services. However, the Panel notes the Standard is not currently met in the Queensland electrical sub-network north of Bundaberg.[62]
- As part of its FY25 action, AEMO will investigate system restart requirements during periods where large synchronous generators are not available to initiate and/or support the restart process, assess options to meet those requirements using new technology and approaches.[63]

AEMO has also identified that the Panel should review the Standard such that it reflects the actual capacity of the power system. (see further discussion on this in section 5.3 below). AEMO has also suggested that possible options to incentivise the construction of restart capable plants and the facilitation of extended network testing should also be investigated. This could include the need for any system restart support services. AEMO has not commented on who it thinks should be responsible for investigating this, however, the Panel is seeking stakeholder feedback on the commercial arrangements and investment signals for SRAS capability.

57 Ibid.
58 AEMO, 2024. *2024 General Power System Risk Review – Report.* 25 July 2024. p.124-125.
59 AEMO, 2024. *2024 General Power System Risk Review – Report.* 25 July 2024. p.125.
60 AEMO, 2024.*2024 Transition Plan for System Security.* 2 December 2024. p.13
61 AEMO, 2024. *Engineering Roadmap FY2025 Priority Actions Report*. 15 August 2024. p.34.
62 AEMO, 2024. *Non Market Ancillary Services report 2023-24*. 4 October 2024. p.8.
63 AEMO, 2024. *Engineering Roadmap – FY2025 priority actions report*. 15 August 2024. p.42, Priority Action FY25-21

5.2 Commercial arrangements need to provide signals and incentives for investment in restart capability

AEMO has flagged in its GPSRR that there are limited investment signals and incentives for the development of new transmission level restart capability in existing and emerging IBR generation sources in the NEM.[64] As the provision of SRAS continues to decline, the appropriate investment signals and incentives need to be provided for:

- existing SRAS generation to continue providing services
- new SRAS generation to make the necessary augmentations to meet the technical requirements to provide SRAS generation.

This requires the procurement approach to provide the appropriate signals to incentivise investment in SRAS and flexibility in the approach to minimise the barriers for new entrants.

5.2.1 Additional signalling may be required to help drive investment in future SRAS capability

The Panel notes that market participants looking to invest in system restart capability may benefit from improved information on:

- what are the technical requirements for system restart resources
- where are the system restart resources required
- when will these services need to be available by.

There are currently a range of reports that discuss system restart planning and sufficiency. This is discussed further in chapter 6.

The technical requirements for system restart resources are prescribed within the SRAS Guideline and considered in the technical modelling AEMO conducts to assess tenders for SRAS. We have provided some general requirements for black start generation based on AEMO's SRAS Guidelines. Under the SRAS Guidelines, black start services need to meet a number of technical requirements including the ability to:[65]

- start without drawing energy from the power system or maintain facilities that safely shutdown generating units within the black start source following a major supply disruption and can maintain a stable state of readiness for subsequent start-ups without external supply of power.
- operate stably with its auxiliary supply without any export load for a specified period of time.
- maintain levels of supply during the restoration process to energise sections of the transmission network while meeting the requirements for voltage and frequency as per the minimum requirements set by AEMO.
- assist in the provision of sufficient fault current for the correct operation of protection systems.

AEMO also notes technical requirements for restoration support services including services for self-start capability, voltage control capability, frequency control capability, provision on stabilising load and fault current capability.[66]

64 AEMO, 2024. *2024 General Power System Risk Review – Report.* 25 July 2024. p.124.
65 AEMO, 2021. *SRAS Guideline*. 8 February 2021. p.11-12.
66 AEMO, 2021. *SRAS Guideline*. 8 February 2021. p.12-13.

The Standard also requires AEMO to provide guidelines for where SRAS is required. The strategic location of services is based on an assessment of how the geographical and electrical location of those services best facilitates power system restoration. The locational value of SRAS relates to its ability to energise the transmission network and assist other generating units in restarting. AEMO notes in the SRAS Guideline that SRAS will be assessed as having a strategic location if it can quickly establish, or support establishment of, a path to the transmission network and other generating units, or facilitate pick up of stabilising of load blocks.[67]

The Panel is unaware of any reporting that is readily available on when SRAS sources are required to be made available, or gaps in future SRAS capability.

5.2.2 The enhanced SRAS regulatory framework supports SRAS procurement and testing

The Panel notes that many of the issues discussed in section 5.1, were considered and addressed through the *System restart services, standards and testing rule 2020 (SRAS Rule 2020)*.

On 2 April 2020 the AEMC made a final rule and final rule determination to enhance the frameworks for system restart and restoration. The *SRAS Rule 2020* responded to rule change requests from AEMO and AER that identified a number of risks related to the provision SRAS and the planning for system restoration following a major supply disruption. The risks identified in the rule change requests were:

- declining availability of SRAS sources due to the declining reliability and availability of synchronous generating plant and increasing penetration of asynchronous, intermittent grid-connected generation that have not been considered for system restart
- a need for stronger incentives to encourage generators, energy storage providers and other types of plant to invest in black start capability.
- a need for expanded restart path testing to validate the effectiveness of system restart pathways
- a need to clarify the roles and responsibilities in relation to system restoration and restart preparedness, including clarification of the role of NSP's in the procurement and verification of SRAS.

The *SRAS Rule 2020* included the following changes to reinforce the NER frameworks and support the procurement and testing of SRAS in the context of the transitioning system:

- expanded the definitions of SRAS and black start capability, to allow AEMO to procure the services needed to effectively and promptly restore supply to consumers
- established a transparent framework for the physical testing of system restart paths
- clarified that AEMO can take overall costs into account when procuring SRAS (including both short-term and long-term costs)

Expanding the definition of SRAS

The final rule amended the definition of SRAS and black start capability under the NER in accordance with rule change requests from AEMO and the AER. Specifically:

- the definition of SRAS was amended to refer to both black start capability and system restoration support services

67 AEMO, 2020. *SRAS Guideline*. 2 November 2020. p.27.

- these system restoration support services would be defined by AEMO in the SRAS Guideline
- the definition of black start capability was amended to allow for this capability to be provided by both generating units and other facilities.

The expanded definitions of SRAS and black start capability under the final rule was intended to provide AEMO with the flexibility to:

- allow emerging technologies, such as batteries with 'grid-forming' inverters, or plant combinations (e.g. an asynchronous generator combined with a battery storage system) to be procured by AEMO to provide black start capability in the future
- increase competition for the provision of black start capability from an expanded range of facilities, reducing the costs of these services for consumers
- allow AEMO to procure system restoration support services, providing for the capability to support the grid during a restart process to be valued under the NER and available when required
- provide AEMO with the flexibility to define the specifics of system restoration support services in the SRAS guideline, allowing AEMO to determine what capability is needed to support system restoration at any given time and within different electrical sub-networks, and to revise these services as required to adapt to changing system conditions.

Establishing a transparent framework for testing

The *SRAS Rule 2020* also established a transparent framework for the physical testing of system restart paths. The final rule:

- established regulatory arrangements to facilitate testing required to verify that the system restart plan is able to meet the requirements of the Standard
- required that affected participants are provided with adequate notice of such tests occurring such that they can adjust their operations as required to minimise the cost and operational impacts of a test
- allowed affected participants to recover their direct costs thereby reducing regulatory uncertainty and investment risk associated with participation in testing.

Clarifying that AEMO can take overall costs into account

The final rule made a minor amendment to the SRAS Procurement Objective to clarify that AEMO can take long term costs into account when procuring SRAS to meet the Standard. The final rule also introduced a requirement for AEMO to provide guidance to Registered Participants on how AEMO will achieve the SRAS Procurement Objective of acquiring SRAS at the lowest long-term cost. The amended SRAS Procurement Objective provides clarity that AEMO has the flexibility to consider entering into long term SRAS contracts or procuring specific combinations of services if this would result in the lowest long term costs for consumers and provides market participants transparency on how this will occur.

Considering generator technical performance standards for system restart

The AEMC also considered AEMO's proposal to amend the technical access standards in the NER to include new minimum and automatic access standards in relation to restoration support services, in particular:

- a minimum access standard to require generating units to have the capability to provide at least one of the restoration support services specified in the SRAS Guideline
- an automatic access standard to apply where the capability of the generating unit extends to all of those restoration support services.

The AEMC did not propose any changes to the existing generator performance standards under the NER as this may impose higher costs on new generators and ultimately lead to higher costs for all consumers.

5.2.3 The Panel is interested in stakeholder views on the incentives for investment in future system restart technologies

In response to the emerging challenges raised by AEMO in the GPSRR (as noted in the section above), and in light of the *SRAS Rule 2020*, the Panel notes:

- AEMO will need to consider contracting IBR for the provision of SRAS to meet the requirement set out in the Standard as the pool of SRAS providers in some NEM regions continues to decline with retiring thermal generation.
- AEMO has the ability under the NER to seek out a range of current and emerging technologies to satisfy the requirements for system restart, including the procurement of support services that AEMO can define within the SRAS Guidelines. The Panel considers:
  - The expanded definition for SRAS provides AEMO with the flexibility to engage with a range of technologies in its procurement of SRAS, thereby potentially expanding the pool of providers considered for the provision of SRAS services.
  - AEMO has the flexibility to engage directly with a range of technology providers and amend the technical requirements in the SRAS Guideline to cater for currently available services.
  - AEMO has flagged that the Standard may need revision to reflect the current capacity of the power system. We have included further discussion on this in the section below.
- To increase the pool of eligible SRAS providers, AEMO has previously proposed in the *SRAS Rule 2020* that generator performance standards should be updated to include provisions for system restart. The AEMC determined not to amend changes to the existing generator performance standards to provide SRAS capability, given the likelihood of increased costs to consumers.
- The Panel understands that the system restart path across NEM regions is changing as a result of a transitioning system and this has implications for system restart testing. The Panel considers the *SRAS Rule 2020* established a transparent framework for the physical testing of system restart paths, provided AEMO with the flexibility to determining the restart testing requirements and compensate providers adequately for participating in testing.
- The Panel also notes that the intent of the *SRAS Rule 2020* was to provide AEMO with greater flexibility to consider both long-term and short-term costs when deciding to engage providers for system restart services. The clarification of the Procurement Objective under the Rule allows AEMO to consider various incentive structures and procurement arrangements to guide its negotiation of SRAS services. However, the Panel also recognises that greater flexibility for AEMO to procure the necessary resources alone may not address the full suite of issues and that while such changes may be outside the scope of the Standard, the Panel is interested in considering whether these issues could be addressed through changes to the Standard and guidelines as well as potential changes to the related rules framework to support the supply of restart sources into the future. The Panel encourages stakeholders to consider this when making their submission to this paper.
- The Panel notes stronger investment signals may be required to help drive investment in future SRAS capability and that limited modelling has been conducted to date of system restart provision once existing units are no longer available or able to provide the service.

There is presently limited forward signalling for the types of new investments and when these investments need to be operational in planning documents such as the ISP or ESOO. Overall, the Panel is interested in understanding from stakeholders how the commercial arrangements could be better enhanced within the current frameworks to provide stronger signals and incentives to the market for investment in SRAS, and whether changes beyond the Standard itself are required as discussed above.

Question 6: Commercial arrangements to provide signals and incentives to for investment in SRAS

- What information would providers seek when deciding to invest and maintain SRAS capability, under the current arrangements? How might this change as the system transitions?
- What commercial arrangements would provide incentives to invest in SRAS capability?
- What is the lead time for investment in SRAS capability if a locational gap was identified?
- Are further commercial incentives needed for plant maintenance and uplift? If any, please elaborate.
- What is the experience of potential providers of new technology-based SRAS, including BESS and grid forming inverters?

5.3 The Panel is interested understanding whether the Standard can be revised to unlock new restart capability

As noted in chapter 2, the Standard specifies some key parameters for system restoration following a major supply disruption. This includes the speed of restoration, how much supply is to be restored and the level of reliability of SRAS. For detail on the quantitative and qualitative parameters in the current Standard, see appendix A.

5.3.1 The Standard has shifted from setting requirements that restore demand to requirements that focus on restoring generation

Over the past decade, there have been a range of rule changes to the framework for system restart and Panel reviews of the Standard. While the current Standard sets a target for the restoration of generation, prior to 2016, the Standard was set based on a goal of restoring demand to a sub-network.

2013 System Restart Standard

On 1 August 2013, the Panel reviewed and set the Standard such that sufficient SRAS was procured for each defined electrical sub-network to:[68]

- re-supply and energise the auxiliaries of power stations within 1.5 hours of a major supply disruption occurring to provide sufficient capacity to meet 40 percent of peak demand in that sub-network
- restore generation and transmission such that 40 per cent of peak demand in that sub-network could be supplied within four hours of a major supply disruption occurring.

SRAS was also defined differently based on their reliability to provide system restart services at the time of need, and included primary and secondary restart services. Primary services for

68 Reliability Panel, 2015. *System Restart Standard, Issues Paper*. 19 November 2015. p.36-38.

system restart were required to be assessed by AEMO to be likely to perform on more than 90% of the occasions the service is called upon, while and secondary services for system restart were required to be called up on more than 60% of the occasions. [69]

The 2016 Standard and subsequent reviews

In 2015, the AEMC introduced new rules to the framework for SRAS, which modified the SRAS governance, procurement and cost recovery frameworks in response to concerns that low competition for SRAS resulted in substantial increases in the price of SRAS.[70]In 2016, this resulted in the Standard evolving to define a more stringent set of requirements for the procurement of SRAS which were tailored to the specific requirements of each electrical sub-network. As noted in the 2016 review of the system restart standard final determination: [71]

- The Standard is to specify that procurement of SRAS for each sub-network takes place under the assumption that supply (other than that provided under a SRAS agreement acquired by AEMO for that electrical sub-network) is not available from any neighbouring electrical sub-network. In effect, this requires AEMO to procure SRAS on the basis of restoring each electrical sub-network independent of neighbouring sub-networks.[72]
- The Standard is to include an aggregate required reliability for SRAS in each sub-network. This allows AEMO to procure multiple SRAS with varying reliability levels to meet a single aggregate reliability requirement in each electrical sub-network.[73]
- The Standard is to specify that SRAS can only be acquired by AEMO for one electrical sub-network at any one time.[74]
- The definitions of primary and secondary restart services were removed from the Rules as was the Panel's requirement to specify their guidelines.

Therefore, the current Standard provides AEMO guidance on how it determines electrical sub-networks which provides for AEMO to provide the Panel with the electrical sub-network boundaries it considers appropriate. The Panel then determines the speed of restoration, how much supply is to be restored and the level of reliability that AEMO needs to meet when procuring SRAS for each electrical sub-network.

The requirements set out in the 2016 Standard have largely remained in place to date, however in 2021, the Panel revised and set the Standard to define requirements for an electrical sub-network in Queensland north of Bundaberg at the request of AEMO. The speed of restoration, how much supply is to be restored and the level of reliability of SRAS in the current Standard is shown in Table 5.1.

Table 5.1: Level of restoration, restoration time and aggregate reliability by electrical sub-network

Electrical sub-network	Level of restoration (MW)	Restoration time (hours)	Required aggregate reliability
Queensland	1650	4.0	90%
New South Wales	1500	2.0	90%

69 Reliability Panel, 2015. *System Restart Standard, Issues Paper*. 19 November 2015. p.36-38.
70 AEMC, 2015. *System Restart Ancillary Services*.
71 Reliability Panel, 2016. *Review of the System Restart Standard, final determination*. 15 December 2016. p.27.
72 NER clause 8.8.3(aa)(2)
73 NER clause 8.8.3(aa)(3)
74 NER clause 8.8.3(aa)(5)

Electrical sub-network	Level of restoration (MW)	Restoration time (hours)	Required aggregate reliability
Victoria	1100	3.0	90%
South Australia	330	2.5	90%
Tasmania	300	2.5	95%

Source: The 2021 system restart standard

In addition, under the current Standard, AEMO will need to satisfy the following requirements:

1. For the New South Wales electrical sub-network, AEMO shall procure SRAS north of Sydney, sufficient to also independently restart, without drawing power from the power system, at least 500 MW of generation capacity north of Sydney within four hours of a major supply disruption with an aggregate reliability of at least 75 per cent.
2. For the Queensland electrical sub-network, AEMO shall procure SRAS north of Bundaberg, sufficient to also independently restart, without drawing power from the power system, at least 825 MW of generation capacity north of Bundaberg within four hours of a major supply disruption with an aggregate reliability of at least 80 per cent.

For each electrical sub-network, AEMO is required to procure SRAS sufficient to restore generation and transmission in that electrical sub-network such that supply in that electrical sub-network is restored to the level of restoration prescribed in Table 5.1. For example, in New South Wales, AEMO needs to procure SRAS to restore 1500 MW of supply within 2 hours of a major supply disruption or black system event. The aggregate reliability is the probability that the generation and transmission in a sub-network is expected to be restored to the specified level within the specified time.

The Standard is a procurement Standard, and is not indicative of how AEMO restores the power system following a major supply disruption. AEMO develops and maintains a system restart plan which guides AEMO to coordinate the restoration of power. It is not necessarily the case that the power system will be restored using SRAS following a major supply disruption. Following the 2016 South Australia black system event, AEMO commenced the process of restoring generation from Victoria via the Heywood AC interconnector due to issues commencing the restoration from SRAS. [75]

5.3.2 The Standard has historically been informed by analysis of restoration time frames and costs

For the 2016 and 2020 reviews, the parameters in the Standard were set by performing an economic analysis that identifies the optimal level of SRAS to be procured for each electrical sub-network, based on the range of available SRAS technology options available within the electrical sub-network at the time of setting the Standard.

In setting the Standard AEMO provides technical advice to the Panel on a range of SRAS procurement options, based on previous procurement rounds and supporting power system modelling which involves:

- determining a set of optimal transmission links (restart paths) that need to be energised following a black system event
- identifying procurement options that support the energisation of restart pathways

The selection of technologies in determining the Standard were used to determine the economically efficient restoration time and cost, which in turn set the parameters in the Standard.

75 AEMO, 2016. *Black system South Australia Final Report*. 28 September 2024. p.70-71.

As a result of this process the levels set in the Standard are reflective of restart pathways and capabilities of black-start capable generators at the time of setting the Standard.

The parameters for speed of restoration, quantity of supply and level of reliability in the present Standard are based on available and confidential cost and technical information from AEMO's procurement of SRAS prior to 2016. AEMO provided the Panel with more recent technical advice which included confidential procurement information prior to 2020 tendering round when the Standard was updated in 2020 to include requirements for the region north of Bundaberg Queensland.

The Panel is unable to disclose specific detail on the generation technologies considered, however it can generally note that the technology options considered in the setting of the current Standard were largely from synchronous based generation and may not be reflective of the range of SRAS technologies that is presently available or will be available in the future.

At the time of the 2020 review, the Panel did not consider it possible to identify economically efficient Standard settings that account for new technologies in the absence of experience in their procurement and information on their cost. In the Panel's final determination for the 2020 Review, it acknowledged that further work would be required to address future emerging technology considerations, noting that:

- it necessary to wait until information on the actual costs, location, availability and characteristics of restoration support services and non-traditional providers of black start capability is available.
- the impact of non-generation black start SRAS and restoration support services should be considered in the next fulsome review of the Standard following AEMO's next procurement round.

5.3.3 The Standard may be too stringent in how it prescribes the requirements for SRAS and this may limit its flexibility in achieving a compliant outcome

In response to updates to the system restart framework from the *SRAS Rule 2020*, for contracts commencing 2024 to 2027, AEMO updated its SRAS Guideline. This included changes to the design of the procurement process to reflect changes to the system restart framework to allow for the consideration of lowest long term cost. The procurement process commenced relatively early to allow for the market to respond and aimed to encourage new technology and existing technologies to make necessary augmentation to their plant.

AEMO received tenders for 16 SRAS services and two expressions of interest for restart support services. Following contract negotiations, six new contracts and one contract extension (for 12 SRAS services in total) were executed. Despite this, AEMO is not able to meet the requirements set out in the Standard for the Queensland electrical sub-network north of Bundaberg, from 1 July 2024. As noted in Table 5.1, the Standard requires AEMO to procure 825MW of SRAS to restore generation within 4 hours in this electrical sub-network. However, for periods outside of business hours, AEMO was only able to procure generation and transmission capability that can restart 705MW of supply in 4 hours, 120MW short of the Standard requirements for this electrical sub-network.[76]

AEMO's difficulty in meeting the Standard in Queensland outside of business hours demonstrates that, under the levels and times set in the Standard, small changes in the availability of SRAS and the associated restart pathway can drive a non-compliant outcome. The Panel is interested in

76 AEMO, 2024. *Non Market Ancillary Services report 2023-24*. 4 October 2024. p.8.

considering alternative ways to set the Standard to support effective and timely system restoration, while providing flexibility to adapt to changes in system restart capability associated with the expected system changes over the coming decade.

5.3.4 The Panel is interested in stakeholder views on the current Standard

The Panel understands that AEMO has identified a review of the Standard should consider how the Standard can reflect the current capacity of the power system. The Panel notes:

- would like to better understand how the Standard may create a barrier to AEMO's procurement of SRAS, in light of the risks it highlights in the 2024 GPSRR. The Panel understands that the Standard is set based on the known understanding of the power system at the time it is set and that the current Standard may not be reflective of the current system. However, the Panel is unclear how the Standard inhibits the ability to secure sufficient SRAS capability in the future as the NEM continues to transition, and we are interested in stakeholder views on this.
- recognises that in selecting the operational approach to restarting the system following a major supply disruption, AEMO may seek to commence generation restoration from neighbouring regions via interconnectors. The Rules place an assumption when setting the Standard, that supply (other than that provided under a SRAS agreement acquired by AEMO for that electrical sub-network) is not available from any neighbouring electrical sub-network. This assumption however, may not preclude SRAS from being procured from a neighbouring region, for use in that electrical sub-network, via an interconnector. The Panel will seek to clarify this through this review process.
- it is also interested in stakeholder views on whether the way the Standard is expressed remains appropriate when considering ways to incentivise technologies that have not previously provided system restart services in the NEM.
- that the Standard is set such that a relatively small changes in available restoration capacity could drive a non-compliant outcomes. The Panel is interested in alternative ways to set the Standard that would support effective and timely system restoration, while providing flexibility to adapt to changes in system restart capability associated with the expected system changes over the coming decade.
- a review of the Standard may not address the range of issues outlined above as the system transitions. Therefore, this review has been designed for the Panel to seek stakeholder views beyond the Standard and also on the current SRAS framework to better understand whether it promotes the right incentives for both investing in new restart technology, as well as undertaking operational and maintenance activities to maintain restart capability.
- will seek technical advice from AEMO on what resources could provide SRAS when coal has exited the system and under the full range of dispatch patterns in the ISP, which the Panel will use to assess the suitability of the Standard in the future and whether current system restart framework remain fit-for-purpose.
- stakeholder views will help inform the Panel's:
  - view on whether the form of the Standard requires change and how this might impact the methodology used to determine the Standard's settings
  - technical advice it will request from AEMO to support an understanding of the costs and characteristics of both synchronous and asynchronous technologies based on the agreed form of the Standard and methodology used to determine the Standard settings. [77]

77 The Panel will seek stakeholder views on the methodology to inform the Standard in its draft determination.

Question 7: Understanding how the Standard could evolve to support a transitioning system

- Do the current requirements set out in the NER for setting the Standard remain appropriate when considering the issues for system restart? If not, please elaborate. Note the current NER requirements for setting the Standard are outlined in section 3.2.
- How does the Standard inhibit the ability to secure sufficient SRAS capability in the future as the NEM continues to transition?
- What are some considerations for providing SRAS across interconnectors?
- What would be the elements for a Standard that is appropriate for an inverter based resources dominated power system?

6 Transparency and reporting

Transparency and reporting of SRAS sufficiency and emerging system restart risks could provide insights to revise restart planning and signal for new investment.

This chapter investigates the current transparency and reporting arrangements for system restart arrangements and seeks stakeholder views on enhancements that could be made to increase transparency and signal investment needs for new SRAS capability.

6.1 AEMO reports on the system restart sufficiency through a range of publications

AEMO is currently required to report on system restart preparation and sufficiency through:

- Non-market ancillary services (NMAS) report

While not obligated to do so under the NER, AEMO reports on risks to system restart and actions it may be taking through the following reports:

- General power system risk review (GPSRR)
- Engineering roadmap
- Electricity Statement of Opportunities (ESOO)
- Transition plan for system security

The below sub-sections set out the current arrangements and content for each report.

6.1.1 The NMAS reports annually on historical performance of SRAS

AEMO is required under the NER to report annually through its non-market ancillary services report on:[78]

- The processes followed by AEMO to acquire SRAS for each electrical sub-network
- The total cost of procuring SRAS in each sub-network and region
- Whether AEMO has been unable to procure sufficient SRAS to meet the Standard and the reasons for this.

Currently, this is the only reporting requirement prescribed in the NER for SRAS. This report is designed to be an account of the actions taken over the previous financial year in securing the required SRAS, but this is not a forward looking report. In the most recent report, published in October 2024, AEMO noted:[79]

- Changes to the possible restart pathway in Queensland meant the Queensland region, north of Bundaberg outlined in section 5 of the Standard is not met for periods outside of business hours. Outside of business hours, the Standard requires 825MW of generation to restore supply within 4 hours. However, outside of business hours only up to 705MW of generation and transmission capability can be restarted in 4 hours.
- The estimated cost of SRAS services for financial year 2024-25 is $44.6m. This is an $8.9m increase over the 2023-24 spend for SRAS services. This increase is driven based on new contracts effective from 1 July 2024 and a substantial increase in the estimated availability charge from providers. AEMO notes this increase can be attributed to increased cost of maintaining and providing SRAS from Queensland plant.

78 NER, clause 3.11.10

79 AEMO, 2024. *NMAS annual summary 2023-24*. 4 October 2024. p.8.

- Several system restart tests were conducted successfully in financial year 2023-24. The tests were conducted for SRAS units in the South Australia region in November 2023, New South Wales region in April 2024 and Victorian region in May 2024.

6.1.2 The 2024 GPSRR highlighted upcoming challenges for system restart

AEMO reports on priority power system risks and actions through its annual generalised power system risk review (GPSRR) process.

The purpose of the GPSRR is to review a prioritised set of power system risks, comprising events or conditions that, alone or in combination, would likely lead to cascading outages or major supply disruptions. For each priority risk, the GPSRR assesses the adequacy of current risk management arrangements and (where appropriate) options for future management. [80]

The GPSRR explores the risks and consequences of non-credible contingencies as well as other system events and conditions that could lead to cascading outages or major supply disruptions, evaluated over a five-year planning horizon.[81]

Whilst there are no explicit NER requirements for reporting of SRAS , AEMO's 2024 GPSRR highlighted risks related to the future provision of SRAS which have been discussed in detail in chapter 2 and chapter 5.

6.1.3 The Engineering Roadmap highlights actions AEMO is taking to address risks identified in system restart

The Engineering Roadmap presents AEMO's view of the technical, engineering, and operational actions required to remove the barriers to high renewables contribution across both the NEM and the South West Interconnected System (SWIS). The Engineering Roadmap's are ongoing bodies of work which identify and prioritise the critical engineering actions required to advance operational capability of Australia's power system to operate at times of high renewables contribution.[82]

The Engineering Roadmap's include:[83]

- Engineering Roadmap to 100% Renewables, published by AEMO in December 2022, presents AEMO's view of the technical, engineering, and operational actions required to prepare the NEM to securely and reliably operate at times of high renewables contribution.
- FY2024 - Priority Actions Report and FY2025 - Priority Actions Report have catalogued the specific actions taken forward in each financial year, and provide a summary of progress toward high renewables contribution.
- In 2024, AEMO also undertook a parallel process to prepare a SWIS Engineering Roadmap, capturing learning from the NEM Engineering Roadmap and applying them to the specific needs of the SWIS.

In its 2025 Priority Actions Report, AEMO under action FY25_21 committed to evaluate system restart capability and options during periods where large synchronous generation is offline.[84]

80 AEMO, 2024. *GPSRR - Approach Paper*. 22 August 2023. p.5.
81 AEMC, 2021. *Implementing a general power system risk review*.
82 AEMO, 2024. *Engineering Roadmaps*.
83 AEMO, 2024. *Engineering Roadmaps*. p.42.
84 Ibid.

6.1.4 The ESOO highlights opportunities for investment in system restart services

The ESOO highlights the opportunities for market participants, investors, governments and other jurisdictional bodies to invest in new assets and systems to maintain a reliable supply of electricity in the NEM. It provides technical and market data, providing a 10 year outlook. The most recent ESOO, published in 2024 provides this outlook for the period from 2024-25 to 2033-34.

While there are no requirements for the reporting of system restart, the 2024 ESOO notes:[85]

- Over the coming decade the rapid energy transition will result in a significant need for new assets and providers of essential system services including system restart.
- Continued retirement of existing service providers will require careful case-by-case monitoring and may open opportunities for new service providers
- The timing and magnitude of new system restart requirements are influenced by retiring thermal generation, increases in IBR development, major network augmentations and levels of investment in CER.

6.1.5 The transition plan for system security supports industry understanding of the system security needs through the transition

The AEMC's improving security frameworks for the energy transition rule change introduced a new annual reporting requirement on AEMO, known as the 'transition plan for system security' (or transition plan), in which AEMO will report annually on the steps it will take to manage security through the transition.[86]

On 2 December 2024, AEMO published its first *Transition plan for system security (Transition plan)*. This plan will be updated annually to set out how AEMO plans to maintain system security through the system transition. The purpose of the *Transition plan* is to support industry understanding of:

- how AEMO is planning to maintain power system security through the transition
- AEMO's current technical understanding of how to achieve security in a low- or zero-emissions power system, and its work to improve this understanding.

AEMO considers three horizons for the key activities and initiatives it has identified in the transition plan:

- Horizon one: Looks at planning for specific operational transition points over the 0 to 2 year time horizon, working within the constrains of today's system and available technology
- Horizon two: Preparation for 2 to 5 years ahead and considers planning that needs to be done before they arise in operations.
- Horizon three: Preparation for 5+ years ahead and considers transition points in the planning horizon.

The rule does not require AEMO to comment on system restart and its requirements through the transition ,however, outcomes from this planning function may be relevant to restart planning. AEMO notes in its plan that it is undertaking future-focused analysis as part of the Engineering Roadmap on options for a system restart to prepare for both the upcoming 2026-29 SRAS procurement round and longer-term procurement from 2030 onwards. The outcomes of the analysis will be published as a paper to inform this Review with forward-looking commentary on areas which will require action to prepare the NEM to procure sufficient and resilient system restart capability into the future.

85 AEMO, 2024. *2024 Electricity Statement of Opportunities.*

86 AEMC, 2024. *Improving security frameworks for the energy transition*.

6.2 Issues for consideration

Given the challenges identified by AEMO in relation to the provision of SRAS in the future system, we propose to investigate the potential benefit of revised or additional reporting arrangements to provide sufficient transparency to support investment in new SRAS capability. Transparency and reporting of SRAS market arrangements enable:

- market participants to be aware of current gaps in the market for the provision of SRAS services
- provide a signal for new investment to address gaps in the future

Such changes to transparency and reporting are likely to sit outside the standard itself. However, as noted earlier, we are interested in exploring whether there are any broader changes required to the framework itself through rule changes.

The Panel understands there is a trade-off that exists between improved transparency of system restart planning and SRAS sufficiency, and the requirement for certain information to be kept confidential, such as the System restart plan prepared by AEMO[87] The Panel understands:

- At present there is reporting of SRAS sufficiency through AEMO's annual NMAS report. This is a historical view of the sufficiency of SRAS capability and reports on gaps within the current provision of system restart services. However, this report does not provide an analysis of upcoming risks and challenges and how these issues may be addressed.
- AEMO considers risks to system restart planning and its impact on SRAS sufficiency through the GPSRR over a five-year planning horizon. The Engineering Roadmap is an important document to consider alongside the GPSRR as it seeks to prioritise actions to guide further engineering planning for the risks identified in system restart.
- AEMO reports on system needs through the ESOO, and while it considers needs for investment in system restart resources, it does not provide details on current or future gaps in system restart planning to better guide investment.
- There are provisions for AEMO to seek information from market participants to better understand risks for system restart, however there is currently no established framework for market participants, either contracted to provide SRAS or otherwise to report on system restart risks within the system to AEMO.
- We will also need to consider the trade-off between improved transparency and the requirement for certain information to be kept confidential, such as the System restart plan prepared by AEMO under NER cl4.8.12(a).

The Panel is interested in stakeholder views on the current arrangements for transparency and reporting, and whether stakeholders require further information to inform changes to planning provisions within the current framework and investment decisions for new investment in SRAS.

Question 8: Evolving the arrangements for transparency and reporting

- How can existing reporting arrangements be improved for market participants and stakeholders to understand the gaps in restart planning and opportunities for investment in SRAS provision? What additional information would stakeholders find useful to inform decisions on whether to invest in new SRAS capability?

87 Clause 4.8.12(a) NER.

- How should system restart related information be made available to stakeholders?
- Would there be benefits in AEMO identifying potential system restart challenges and opportunities through the Transition Plan for System Security?

A Setting the parameters in the Current Standard

The current Standard has a set of quantative and qualitative parameters designed to guide AEMO's procurement of SRAS. The Standard is determined and reviewed by the Panel in accordance with the SRAS procurement objective. This section details the:

- quantitative parameters of the standard
- qualitative parameters of the standard

A.1 Quantitative elements of the Standard

The NER sets out requirements for the Standard, including the elements that the Panel must include when determining the Standard. The elements of the Standard can be divided into qualitative guidance and quantitative settings. The quantitative and qualitative elements of the current standard are noted below and on the following slide as context for the issues to be considered by the Panel in this review.

The quantitative Standard settings represent targets for AEMO's procurement of SRAS in each sub-region of the NEM. These include the following:

- **Level of restoration** - The level of restoration represents the minimum level (MW) of generation that must be restored for the continued stable restoration of the power system.
- **Restoration time** - The Panel is required to specify the maximum amount of time within which procured SRAS is required to restore supply to a sub-network to a specific level. The Panel considers the costs and benefits of requiring a particular speed of restoration such that Standard settings are economically efficient.
- **Required aggregate reliability** - Aggregate reliability is the probability that the generation and transmission in a sub-network is restored to the specified restoration level within the specified restoration time. The aggregate reliability of the procured SRAS in each electrical sub-network is determined considering the combination of the individual reliability of the SRAS procured in that electrical sub-network, together with an assessment of the impact of the points of failure.

The current SRAS requirements are specified in Table A.1 below.

Table A.1: Level of restoration, restoration time and aggregate reliability by electrical sub-network

Electrical sub-network	Level of restoration (MW)	Restoration time (hours)	Required aggregate reliability
Queensland	1650	4.0	90%
New South Wales	1500	2.0	90%
Victoria	1100	3.0	90%
South Australia	330	2.5	90%
Tasmania	300	2.5	95%

Source: The 2020 system restart standard

In addition, under the current Standard, AEMO will need to satisfy the following requirements:

- For the New South Wales electrical sub-network, AEMO shall procure SRAS north of Sydney, sufficient to also independently restart, without drawing power from the power system, at least

500 MW of generation capacity north of Sydney within four hours of a major supply disruption with an aggregate reliability of at least 75 per cent.

- For the Queensland electrical sub-network, AEMO shall procure SRAS north of Bundaberg, sufficient to also independently restart, without drawing power from the power system, at least 825 MW of generation capacity north of Bundaberg within four hours of a major supply disruption with an aggregate reliability of at least 80 per cent.

A.2 Setting the quantitative elements in the Standard

The methodology to determine the quantitative settings in the current Standard remain unchanged since the 2016 review of the Standard. These settings were determined based on an economic assessment of the costs and benefits of SRAS by Deloitte Access Economics. The approach used to identify the efficient level of SRAS is set out in Table A.2. For readers interested in specifics of this methodology, refer to the Deloitte Access Economics Economic assessment of System Restart Ancillary Services in the NEM report.

Table A.2: Summary of steps to identify efficient levels of SRAS

Stage	Assessment description	Summary of methodology
1	Determining unserved energy for different SRAS procurement options available	Unserved energy is assessed from the supply restoration curves associated with each SRAS procurement option assessed.
2	Valuing the benefit of different options for SRAS procurement	The economic benefit of avoided unserved energy for each candidate SRAS procurement option is valued using Value of Customer Reliability (VCR).
3	Calculating the annualised benefit of procuring SRAS given the probability of a black system event in the relevant sub-network	The economic benefit of each candidate SRAS procurement option is then annualised using an estimate of the probability of a black system event occurring in each sub-network.
4	Efficient levels of SRAS are identified	Efficient levels of SRAS are identified by comparing the annualised benefit of procuring an additional SRAS with the cost of procurement.
5	Quantifying uncertainty	Uncertainty associated with a set of key variables is accounted for through a sensitivity analysis.

Source: AEMC, 2020. System restart standard review 2020 consultation paper, Table 5.1

A.3 The qualitative elements in the Standard

In addition to the quantitative settings for restoration level, time and aggregate reliability, the Standard also provides qualitative guidance on the interpretation of the quantitative settings, including:

- **Guidelines for the determination of electrical sub-networks:** In determining the boundaries for electrical sub-networks, AEMO must consider the technical characteristics that would facilitate the achievement of AEMO's power system security responsibility of procuring adequate system restart ancillary services to enable it to co-ordinate a response to a major

supply disruption. These technical characteristics would include, without limitation, consideration of the number and strength of transmission corridors, electrical distance between generation centres, and the extent to which the sub-network can be kept in a satisfactory (stable) state during restoration.

- **Guidelines for assessing the diversity of services:** In determining the aggregate reliability of SRAS in an electrical sub-network, AEMO shall incorporate an assessment of the impact of diversity of the services by taking into account electrical, geographical, and energy source diversity.
- **Guidelines for the strategic location of services** - AEMO shall determine the strategic location of SRAS based on an assessment of how the geographical and electrical location of those services best facilitates the power system restoration. The locational value of SRAS relates to its ability to energise the transmission network and assist other generating units to restart.

B Elements of the system restart framework

SRAS Guideline

AEMO publishes the 'SRAS Guideline' under clause 3.11.7 of the National Electricity Rules (NER). The SRAS Guideline describes principles and processes designed to ensure AEMO procures SRAS that meet the Standard (set by the Panel) at the lowest long-term cost.[88] The SRAS Guideline includes technical, modelling, assessment and testing requirements for SRAS, a process for assessing individual and aggregate reliability of SRAS, and applicable procurement processes. The SRAS Guideline includes requirements applicable to SRAS providers, network service providers, and registered participants who need to participate in a system restart test. AEMO updated the SRAS Guideline on 8 February 2021, to align with updates to the Standard.

System restart plan

AEMO also develops and maintains the system restart plan for the purpose of managing and coordinating system restoration activities following any major supply disruption or black system event. The system restart plan contains all relevant procedures that would be expected to be followed by generators, including those contracted to provide SRAS, network service providers, and JSSCs in restoring an electrical sub-network following a major supply disruption, including a black system event. The system restart plan considers the requirements of the Standard, as well as different potential failure modes and possible system restart pathways. AEMO works closely with NSPs in development of the system restart plan.

While the System Restart Plan is confidential, AEMO may provide elements or details of the plan to the following parties to support preparations for system restoration activities:[89]

- Jurisdictional System Security Coordinator;
- a Network Service Provider;
- a Generator or Integrated Resource Provider contracted to provide SRAS;
- any other Registered Participant whose assistance AEMO considers is necessary for the implementation of the system restart plan,

Local black system procedure

Under clause 4.8.12 (d) of the NER, each generator and network service provider must develop local black system procedures (LBSP). AEMO develops and maintains the LBSP Guidelines in accordance with clause 4.8.12(e) of the NER. The LBSPs of Generators and NSPs are the main source of information for AEMO to understand the likely condition and the capabilities of generation and network plant, following supply disruptions resulting in an absence of voltage on part of the power system, causing disconnection of power station/s or the loss of supply to load.

88 AEMO, 2021. *SRAS guideline*.

89 NER cl.4.8.12(a2)

Glossary

Available capacity	The total MW capacity available for dispatch by a scheduled generating unit or scheduled load (i.e. maximum plant availability) or, in relation to a specified price band, the MW capacity within that price band available for dispatch (i.e. availability at each price band).
Black system	When the absense of voltage from a major supply disruption extends to a significant part of the transmission system addecting a significant number of customers, this is referred to as a black system.
Busbar	A busbar is an electrical conductor in the transmission system that is maintained at a specific voltage. It is capable of carrying a high current and is normally used to make a common connection between several circuits within the transmission system. The rules define busbar as 'a common connection point in a power station switchyard or a transmission network substation'.
Cascading outage	The occurrence of a succession of outages, each of which is initiated by conditions (e.g. instability or overloading) arising or made worse as a result of the event preceding it.
Contingency events	These are events that affect the power system's operation, such as the failure or removal from operational service of a generating unit or transmission element. There are several categories of contingency event, as described below: • credible contingency event is a contingency event whose occurrence is considered "reasonably possible" in the circumstances. For example: the unexpected disconnection or unplanned reduction in capacity of one operating generating unit; or the unexpected disconnection of one major item of transmission plant • non-credible contingency event is a contingency event whose occurrence is not considered "reasonably possible" in the circumstances. Typically a non-credible contingency event involves simultaneous multiple disruptions, such as the failure of several generating units at the same time.
Distribution network	The apparatus, equipment, plant and buildings (including the connection assets) used to convey and control the conveyance of electricity to

	consumers from the network and which is not a transmission network.
Distribution network service provider (DNSP)	A person who engages in the activity of owning, controlling, or operating a distribution network.
Frequency control ancillary services (FCAS)	Those ancillary services concerned with balancing, over short intervals, the power supplied by generators with the power consumed by loads (throughout the power system). Imbalances cause the frequency to deviate from 50 Hz.
Interconnector	A transmission line or group of transmission lines that connect the transmission networks in adjacent regions.
Jurisdictional planning body	The transmission network service provider responsible for planning a NEM jurisdiction's transmission network.
Lack of reserve	This is when reserves are below specified reporting levels.
Load	A connection point (or defined set of connection points) at which electrical power is delivered, or the amount of electrical power delivered at a defined instant at a connection point (or aggregated over a defined set of connection points).
Load event	In the context of frequency control ancillary services, a load event: involves a disconnection or a sudden reduction in the amount of power consumed at a connection point and results in an overall excess of supply.
Load shedding	Reducing or disconnecting load from the power system either by automatic control systems or under instructions from AEMO. Load shedding will cause interruptions to some energy consumers' supplies.
Low reserve condition (LRC)	This is when reserves are below the minimum reserve level.
Major supply disruption	The unplanned absence of voltage on a part of the transmission system affecting one or more power stations and which leads to the loss of supply to one or more loads.
Medium term projected assessment of system (MT PASA) (also see ST PASA)	A comprehensive programme of information collection, analysis and disclosure of medium-term power system reliability prospects. This assessment covers a period of 24 months and enables market participants to make decisions concerning supply, demand and outages. It must be issued weekly by AEMO.
Minimum reserve level (MRL)	The minimum reserve margin calculated by AEMO to meet the reliability standard.

National Electricity Code	The National Electricity Code was replaced by the National Electricity Rules on 1 July 2005.
National electricity market (NEM)	The NEM is a wholesale exchange for the supply of electricity to retailers and consumers. It commenced on 13 December 1998, and now includes Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia, and Tasmania.
National Electricity Law (NEL)	The NEL is contained in a schedule to the National Electricity (South Australia) Act 1996. The NEL is applied as law in each participating jurisdiction of the NEM by the application statutes.
National Electricity Rules (NER or the Rules)	The NER came into effect on 1 July 2005, replacing the National Electricity Code.
Network	The apparatus, equipment and buildings used to convey and control the conveyance of electricity. This applies to both transmission and distribution networks.
Network capability	The capability of a network or part of a network to transfer electricity from one location to another.
Network control ancillary services (NCAS)	Ancillary services concerned with maintaining and extending the operational efficiency and capability of the network within secure operating limits.
Network event	In the context of frequency control ancillary services, the tripping of a network resulting in a generation event or load event.
Network service providers	An entity that operates as either a transmission network service provider (TNSP) or a distribution network service provider (DNSP).
Network services	The services (provided by a TNSP or DNSP) associated with conveying electricity and which also include entry, exit, and use-of-system services.
Operating state	The operating state of the power system is defined as satisfactory, secure or reliable, as described below. The power system is in a **satisfactory** operating state when: • it is operating within its technical limits (i.e. frequency, voltage, current etc are within the relevant standards and ratings) • the severity of any potential fault is within the capability of circuit breakers to disconnect the faulted circuit or equipment. The power system is in a **secure** operating state when: • it is in a satisfactory operating state

	• it will return to a satisfactory operating state following a single credible contingency event. The power system is in a **reliable** operating state when: • AEMO has not disconnected, and does not expect to disconnect, any points of load connection under NER clause 4.8.9 • no load shedding is occurring or expected to occur anywhere on the power system under NER clause 4.8.9 • in AEMO's reasonable opinion the levels of short term and medium term capacity reserves available to the power system are at least equal to the required levels determined in accordance with the power system security and reliability standards.
Participant	An entity that participates in the national electricity market.
Plant capability	The maximum MW output which an item of electrical equipment is capable of achieving for a given period.
Power system reliability	The measure of the power system's ability to supply adequate power to satisfy demand, allowing for unplanned losses of generation capacity.
Power system security	The safe scheduling, operation and control of the power system on a continuous basis.
Probability of exceedance (POE)	POE relates to the weather/temperature dependence of the maximum demand in a region. A detailed description is given in the AEMO ESOO.
Reliable operating state	Refer to operating state.
Reliability of supply	The likelihood of having sufficient capacity (generation or demand-side response) to meet demand (the consumer load).
Reliability standard	The Reliability Panel's current standard for reliability is that there should be sufficient generation and bulk transmission capacity so that the maximum expected unserved energy is 0.002 per cent.
Reserve	The amount of supply (including available generation capability, demand side participation and interconnector capability) in excess of the demand forecast for a particular period.
Reserve margin	The difference between reserve and the projected demand for electricity, where: Reserve margin = (generation capability + interconnection reserve sharing) – peak demand + demand-side participation.

Satisfactory operating state	Refer to operating state.
Scheduled load	A market load which has been classified by AEMO as a scheduled load at the market customer's request. A market customer may submit dispatch bids in relation to scheduled loads.
Secure operating state	Refer to operating state.
Separation event	In the context of frequency control ancillary services, this describes the electrical separation of one or more NEM regions from the others, thereby preventing frequency control ancillary services being transferred from one region to another.
Short term projected assessment of system adequacy (ST PASA) (also see MT PASA)	The PASA in respect of the period from two days after the current trading day to the end of the seventh day after the current trading day inclusive in respect of each trading interval in that period.
Spot market	Wholesale trading in electricity is conducted as a spot market. The spot market allows instantaneous matching of supply against demand. The spot market trades from an electricity pool, and is effectively a set of rules and procedures (not a physical location) managed by AEMO (in conjunction with market participants and regulatory agencies) that are set out in the NER.
Supply-demand balance	A calculation of the reserve margin for a given set of demand conditions, which is used to minimise reserve deficits by making use of available interconnector capabilities.
System restart ancillary service (SRAS)	A service provided by facilities with black start capability which allows energy to be supplied and a connection to be established, sufficient to restart large generating units following a major supply disruption.
System restart standard (Standard)	The Standard as determined by the Reliability Panel in accordance with clause 8.8.3(aa), for the aquisition of system restart ancillary services.
Technical envelope	The power system's technical boundary limits for achieving and maintaining a secure operating state for a given demand and power system scenario.
Transmission network	The high-voltage transmission assets that transport electricity between generators and distribution networks. Transmission networks do not include connection assets, which form part of a transmission system.
Transmission network service provider (TNSP)	An entity that owns operates and/or controls a transmission network.
Unserved energy (USE)	The amount of energy that is required (or demanded)

by consumers but which is not supplied due to a shortage of generation or interconnection capacity. Unserved energy does not include interruptions to consumer supply that are caused by outages of local transmission or distribution elements that do not significantly impact the ability to transfer power into a region.

Abbreviations

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AC	Alternating current
BESS	Batter energy storage system
Commission	See AEMC
CER	Consumer energy resources
DC	Direct current
Distributed PV	Distributed photovoltaic
ESOO	Electricity statement of opportunities
GPSRR	General power system risk review
HVDC	High voltage direct current
IBR	Inverter based resources
ISP	Integrated System Plan
LSBP	Local black start procedure
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NEO	National electricity objective
NERL	National Energy Retail Law
NERO	National energy retail objective
NGL	National Gas Law
NGO	National gas objective
NMAS	Non market ancillary service
ODP	Optimal development path
SRAS	System restart ancillary service
SRAS Rule 2020	2020 System restart ancillary services standard and testing Rule
Standard	System restart standard
SWIS	South west interconnected system
REZ	Renewable energy zone
VRE	Variable renewable energy