RELIABILITY PANEL AEMC

REVIEW

Reliability Panel AEMC

DETERMINATION

SYSTEM RESTART STANDARD REVIEW 2020

29 OCTOBER 2020

INQUIRIES

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ABOUT THE RELIABILITY PANEL

The Panel is a specialist body established by the Australian Energy Market Commission (AEMC) in accordance with section 38 of the National Electricity Law and the National Electricity Rules. The Panel 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.

RELIABILITY PANEL MEMBERS

Charles Popple (Chairman), Chairman and AEMC Commissioner
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SUMMARY

1 This report presents the Reliability Panel's (Panel):

- final determination on amendments to the System Restart Standard (Standard) to incorporate changes to SRAS frameworks in the National Electricity Rules (NER) made by the Commission's final rule for the System restart services, standards and testing rule change (SRAS rule), which was published on 2 April 2020
- draft determination on quantitative Standard settings for a Queensland sub-network following AEMO's final determination to combine the two existing Queensland sub-networks into a single sub-network published on 16 October 2020.

The System Restart Standard (Standard) provides qualitative guidance and prescribes quantitative settings to guide the Australian Energy Market Operator's (AEMO) procurement of System Restart Ancillary Services (SRAS) for re-energising the power system following a major supply disruption or black system event. Quantitative settings set out in the Standard include the level of restoration, restoration time and required aggregate reliability for each sub-network in the NEM. Qualitative guidelines in the Standard provide guidance to AEMO on interpreting the quantitative settings, determining electrical sub-network boundaries and assessing diversity and strategic location of SRAS. The Panel is responsible for determining, modifying and publishing the Standard. The NER requires AEMO to meet the requirements set by the Panel in the Standard when procuring SRAS.

2 The scope of the Panel's review on this occasion is limited by the need to conclude the review prior to AEMO commencing its next round of SRAS procurement in late 2020/early 2021. As such, the terms of reference for the review recommend the Panel limit the scope of the review to amending the qualitative guidance in the Standard to account for changes made to the SRAS frameworks in the SRAS rule, and amending relevant quantitative settings in the Standard to account for any decision by AEMO to combine two existing Queensland electrical sub-networks into a single sub-network for SRAS procurement purposes.

Final determination on changes to the qualitative guidance in the Standard to incorporate the SRAS rule

3 This report presents the Panel's final determination on amendments to the Standard's qualitative guidance to account for changes made in the SRAS rule, which was published by the AEMC on 2 April 2020. The SRAS rule made a number of changes to the frameworks for power system restoration in the NER to make them better suited to the changing generation mix. These included:

- expanding the definition of SRAS to include black start services provided by facilities other than generating units and
- introducing system restoration support services as a new type of SRAS that are needed to support the stable re-energisation of the grid following a major supply disruption or black system event.

4 In making its final determination, the Panel has considered the changes necessary to address language in the standard that is unnecessarily limiting and/or could act as a barrier to

AEMO's procurement of restoration support services and SRAS from non-traditional providers. The Panel has not determined to include additional detailed guidance on the procurement of these new services on this occasion. The Panel considers it prudent to wait until more information is available following AEMO's experience with its next procurement round in 2021. This additional information will allow the Panel to add guidance that is accurate, relevant, and appropriately targeted to AEMO's procurement of SRAS of different types from different technologies.

5 The Panel's final determination is to amend guidance in the following sections of the Standard in the manner set out in Box 1:

- Section 4 - Aggregate reliability of SRAS
- Section 8 - Guidelines for assessing the diversity of services, and
- Section 9 - Strategic location of services

BOX 1: FINAL DETERMINATION ON CHANGES TO QUALITATIVE GUIDANCE TO INCORPORATE THE SRAS RULE

The Panel's final determination is to amend the Standard's qualitative guidance in the following areas:

- Section 4 - aggregate reliability of SRAS will be amended to:
  - qualify the requirement for AEMO to consider 'start up performance' when assessing individual reliability as only applying where relevant. This qualification removes the potential for this guidance to preclude AEMO's procurement of non-generation black start SRAS or restoration support services.
  - generalise reference to the network by removing references to 'transmission' in the factors AEMO must consider when assessing individual reliability of SRAS. This change provides for AEMO to assess individual reliability for distribution connected restoration support services.
  - provide additional flexibility to AEMO in the factors it can consider when assessing individual reliability by qualifying the existing list of factors as a non-exhaustive list. This change will allow AEMO to consider a wider range of relevant factors to the reliability of non-generation SRAS and restoration support services such as the reliability of communications and IT systems.
  - replace reference to the first transmission substation with reference to the first location on a shared network from which the SRAS can energise, or support the energisation of, other generation. This change will provide additional flexibility for AEMO to consider alternate delivery points for restoration support services and additional transmission elements beyond the first transmission sub-station where the first transmission sub-station doesn't connect to multiple transmission paths.
- Section 8 - guidelines for assessing the diversity of services will be amended to quantify the requirement for AEMO to consider energy source or fuel diversity as only applying

'where applicable'. This change accounts for circumstances where there is no specific energy or fuel source for some non-generation SRAS and restoration support services.

- Section 9 - Strategic location of services will be amended to quantify references to SRAS energisation of the power system and extend the guidance on strategic location of services to 'sustaining stable restoration of the power system'. This change provides for restoration support services that support restoration stability rather than directly energising the power system.

Draft determination on changes to quantitative Standard settings for a combined Queensland sub-network

6 This review also sets out the Commission's draft determination on quantitative standard settings for a combined Queensland sub-network. The Panel will consult on these settings prior to publishing its final determination in January 2021. Submissions on this element are due on 26 November 2020.

7 The NEM is divided into electrical sub-networks for SRAS procurement purposes. NER frameworks provide AEMO with the authority to determine the boundaries of these sub-networks based on guidance in the Standard, and in consultation with stakeholders. On 16 October 2020 AEMO published a final determination to combine the two existing electrical subnetworks, being North Queensland and South Queensland, into a single subnetwork in the Queensland region of the NEM.

8 The current Standard specifies separate quantitative settings for restoration level, restoration time frame, and aggregate reliability for each of the North Queensland and South Queensland sub-networks. Amendments to the quantitative settings for Queensland in the Standard are therefore required to ensure that the Standard is able to guide AEMO's procurement of SRAS for a single Queensland sub-network in its next procurement round, which is likely to commence in early 2021.

9 The Panel is required to determine the Standard in accordance with the SRAS Objective,[1] that minimises the expected costs of a major supply disruption, to the extent appropriate having regard to the national electricity objective. The Panel conducted an economic assessment using inputs from AEMO to identify efficient levels of SRAS for procurement in a combined Queensland sub-network for this purpose. Outcomes from the Panel's economic assessment, combined with technical advice from AEMO, were then used to identify the standard settings contained in Panel's draft determination.

10 In addition to the draft standard settings for restoration level, restoration time frame, and aggregate reliability, the Panel's draft determination includes an additional locational requirement for AEMO to procure SRAS north of Bundaberg. The Panel has identified such a requirement to be consistent with a Standard set to minimise the expected costs AEMO's procurement of SRAS and considers characteristics of the Queensland network to justify an

1 Clause 8.8.3(aa)(1) of the NER.

explicit requirement for SRAS to be procured north of Bundaberg. AEMO provided advice to the Panel on the characteristics of this requirement.

11 The Panel's draft determination on quantitative Standard settings for a combined Queensland sub-network are summarised in Box 2. The Panel has determined these settings using an approach consistent with the method used in its 2016 review of the Standard. The information and inputs used in the modelling has of course been updated since 2016. This updated information incorporated learning from the South Australian black system event and revised information from updated generator local black start procedures.[2] In particular, these learnings demonstrated that actual network switching times (this refers to the time AEMO takes to progressively re- energise each network element in a restart pathway) would be longer than anticipated in 2016. As a consequence, AEMO used longer network switching times in its modelling than were used in 2016. This has impacted draft Standard settings such that while the level of SRAS being procured in a combined Queensland sub-network is similar to existing levels for North and South Queensland, and the restoration performance is similar to that which would previously have been achieved, the identified timeframes for restoration are now longer than those identified in 2016.

BOX 2: DRAFT DETERMINATION ON QUANTITATIVE STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

The Panel has made a draft determination for the following restoration level (MW), restoration time frame (hours), and aggregate reliability to apply to AEMO's procurement of SRAS in a combined Queensland sub-network.

Table 1: Draft quantitative Standard settings for Queensland

RESTORATION LEVEL (MW)	RESTORATION TIME FRAME (HOURS)	AGGREGATE RELIABILITY
1650	4	90%

Source: AEMC

- The Panel has also made a draft determination to require AEMO to procure SRAS north of Bundaberg capable of restoring 825 MW of generation, within 4 hours, with an aggregate reliability of at least 80%.

Next steps

12 The Panel invites written submissions on the draft determination on quantitative setting for a combined Queensland sub-network (set out in Chapter 5) from interested parties by no later than 26 November 2020.

2 AEMO, advice to the reliability Panel, 8 October 2020, p. 3.

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FIGURES

1 INTRODUCTION

The System Restart Standard (Standard) provides guidance and sets targets for the Australian Energy Market Operator's (AEMO) procurement of System Restart Ancillary Services (SRAS) to re-energise the power system following a major supply disruption or black system event. The Standard is determined by the Reliability Panel which has been requested by the Australian Energy Market Commission (AEMC) to review the Standard in accordance with its responsibilities under the National Electricity Rules (NER or Rules).[3]

The Standard is a key element of the NER's framework for power system restoration in the event of a major supply disruption or black system event. While major supply disruptions and black system events are rare, AEMO's power system security responsibilities also include a requirement to procure sufficient SRAS to re-energise the power system should one occur.[4]SRAS are special services which can commence generation without drawing power from the network, and/or support the stable re-energisation of the network, in order to begin the process of restoring the power system. The Standard provides guidance to AEMO on its procurement of SRAS and sets out key parameters for power system restoration in the event of a major supply disruption, including the restoration time and level of available supply from the restored generation and transmission network.[5] AEMO is required to procure SRAS in accordance with the Standard's requirements and develop its system restart plan to be consistent with the Standard.[6]

In line with the review's terms of reference, this report presents the review's:

- final determination on changes to the qualitative guidance in the Standard to account for the changes made in the Commission's SRAS rule, and
- draft determination on quantitative standard settings for a combined Queensland sub-network.

This chapter introduces the review and its elements including:

- Scope of the review
- Review process and timeline
- submission process, and
- structure of the consultation paper.

1.1 Scope of the review

On 24 June 2020, the Commission provided terms of reference to the Panel to initiate a review of the Standard.[7] This section summarises the scope of the review and role of this determination in satisfying the review's terms of reference.

3 Clause 8.8.3(b) of the NER.

4 Clause 4.2.6(e) of the NER.

5 Clause 8.8.3(aa) of the NER.

6 Clauses 3.11.7(a1) and 4.8.12(c) of the NER.

7 Clause 8.8.3(c) of the NER requires the Commission to issue terms of reference to the Panel prior to it commencing a review of the System Restart Standard.

The Commission requested the Panel undertake a limited review of the Standard on this occasion. The scope of the review is limited on this occasion by the need to conclude the review prior to AEMO commencing its next round of SRAS procurement in late 2020/early 2021. This timeline is not conducive to the Panel conducting a fulsome review of all aspects of the Standard, including the quantitative settings relating to restoration levels, timeframes and aggregate reliability of SRAS sources for each electrical sub-network in the national electricity market (NEM). As a result, the scope of the review is limited to the changes required to facilitate AEMO's next SRAS procurement round.

Given that the review needs to occur as soon as practicable,[8] the Commission's terms of reference requested that the Panel limit the scope of the review to the following issues:

- To provide guidance to AEMO in its procurement of SRAS for all electrical sub-networks, the Commission recommends the Panel publish an interim Standard by 2 November 2020 updating relevant qualitative elements of the Standard to reflect changes made in the SRAS rule to include system restoration support services in the definition of SRAS under the NER as a consequence of the recent SRAS rule.
- The Commission recommended the Panel consider amending relevant quantitative Standard settings to account for any decision by AEMO to combine the two existing Queensland electrical sub-networks into a single sub-network. In particular, if the two existing Queensland sub-networks are combined into a single sub-network, the Panel should determine and publish restoration levels, timeframes, and aggregate reliability requirements for a single Queensland sub-network in a final Standard, which would likely be published in early 2021.

Details are provided on the changes made in the SRAS rule, and AEMO's final determination that combines the North and South Queensland subnetworks into a single Queensland wide sub-network are provided in the following sections.

1.1.1 SRAS Rule

The Commission's SRAS rule made a number of changes to the SRAS frameworks in the NER so that the framework adapts and evolves as the power system changes. These included changes to the definitions of SRAS and black start capability, implementing a framework for physical testing of system restart paths, and providing for greater transparency and certainty about participant roles and responsibilities in system restoration. This section introduces the changes made in the SRAS rule that require amendment to the Standard.[9]

Of these changes, the Commission's terms of reference for this Review specifically identifies the changes to the definition of SRAS as being materially relevant to the Standard.[10] The amended definition of SRAS:[11]

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8 The final SRAS rule included transitional arrangements that require the Panel to review the Standard as soon as practicable following 2 April 2020 to take into account the changes made in the amending rule.

9 For further information on the SRAS rule see: https://www.aemc.gov.au/rule-changes/system-restart-services-standards-and-testing

10 Black start services are provided by generating units or other types of plant which are able to restart without drawing supply from the network. Further explanation of black start is provided in Chapter 2.

11 Chapter 10 (Glossary) of the NER.

- allows for black start capability to be provided by plant other than generating units. This may include new technologies such as batteries combined with grid forming inverters which may be capable of providing this service.
- allows AEMO to procure system restoration support services. These are a new type of SRAS that support the stable re-energisation of the grid, in support of black start services. These services will be specified by AEMO in the SRAS Guideline and procured under the SRAS procurement framework.

The Standard provides guidance to AEMO on the procurement of SRAS. This guidance reflects the former definition of SRAS and may be inappropriate or impose barriers to AEMO's procurement of non-traditional black start service providers and/or system restoration support services. The Panel has therefore determined to update the Standard to allow AEMO's procurement of SRAS from these new sources.

1.1.2 AEMO's determination to combine the Queensland sub-networks

The NEM is divided into electrical sub-networks for the purposes of AEMO's preparations for system restoration and procurement of SRAS.[12] The Standard specifies quantitative requirements for AEMO's procurement of SRAS in each sub-network, including restoration timeframes, levels and aggregate reliability requirements. Under the NER, AEMO has the responsibility to determine the boundaries of the sub-networks following consultation with stakeholders.[13]

On 16 October 2020, AEMO published a final determination to combine the two existing Queensland sub-networks into a single sub-network incorporating the entire state.[14]

In making its final determination, AEMO considered combining the sub-networks will reduce any inefficiency created by the need to allocate SRAS exclusively to a single North or South Queensland sub-network. A single Queensland subnetwork was identified to allow increased restoration path flexibility and better access to stabilising loads.[15]

As the rules require AEMO to procure SRAS in accordance with the quantitative targets set out in the Standard, and the Standard currently specifies settings for two separate Queensland sub-networks, the quantitative settings in the Standard need to be amended to allow AEMO to procure SRAS for a combined Queensland sub-network in its next procurement round. Following AEMO's determination to combine the Queensland sub-networks, the Panel has made a draft determination on quantitative settings for a combined Queensland sub-network.

1.2 Review process and timeline

The Panel is conducting the review via the following two stage process, consistent with the terms of reference from the AEMC as described in section 1.1:

12 Clause 3.11.8(a) of the NER.
13 Clause 3.11.8(b) of the NER.
14 Queensland is currently divided into North and South Queensland sub-networks. Further information is provided in Chapter 5.
15 AEMO, SRAS Guideline consultation - final determination, 16 October 2020.

- **Stage 1** - publication of a final determination and interim Standard, which will update relevant qualitative elements of the Standard to reflect changes made in the SRAS rule. Stage one also includes publication of a draft determination on quantitative Standard settings for a combined Queensland sub-network.
- **Stage 2** - a final Standard in January 2021, which will update quantitative Standard settings for a combined Queensland sub-network.

Stage 1 - Updating relevant qualitative elements of the Standard to reflect changes made in the SRAS rule

The Panel has prioritised amendments to the Standard to reflect changes made in the SRAS rule. The SRAS rule require the Panel to review the Standard as soon as practicable to incorporate the changes made in the rule. The SRAS rule further requires AEMO to make changes to the SRAS Guideline to, amongst other things, describe the capabilities of system restoration support services by 2 November 2020.[16]

This report therefore sets out a final determination on changes to qualitative guidance in the Standard incorporating stakeholder feedback provided in response to the review's consultation paper. The Panel considers that a single stage of consultation was sufficient to obtain feedback on the changes to the Standard needed to account for the expansion of the definition of SRAS, and is consistent with its obligations under the NER and the terms of reference issued by the AEMC.

Stage 2 - Settings for a combined Queensland sub-network

On 16 October 2020 AEMO published a final determination to consolidate the two existing Queensland sub-networks into a single statewide sub-network. The Panel has therefore made a draft determination on quantitative Standard settings for a combined Queensland sub-network. The Panel will consult on these quantitative settings for restoration level, time, and aggregate reliability prior to publishing a final determination in January 2021 prior to AEMO's next round of procurement for Queensland.

The Panel considers that the complexity associated with determining quantitative Standard settings for a combined Queensland sub-network requires an additional round of consultation following publication of a draft determination. This additional consultation will provide stakeholders with the opportunity to provide input into the final Standard settings for the Queensland sub-network.

Review timeline

In carrying out this Review, the Panel is required to follow the consultation process set out in clause 8.8.3 of the Rules along with the specific requirements set out in the Terms of Reference. The AEMC's terms of reference require the Panel to carry out the review to develop the Standard in accordance with the process set out in Table 1.1.

16 Clause 11.123.2 of the NER.

Table 1.1: **Review timetable**

MILESTONES	DETAILS	KEY DATES
Consultation paper publication	A consultation paper was published giving notice to all registered participants of commencement of this review and invited submissions on key issues and questions for a period of at least four weeks.	20 August 2020
Publish an interim Standard and final determination on changes to qualitative elements of the standard.	An interim Standard and final determination are published updating relevant qualitative elements of the Standard to reflect the inclusion of system restoration support services in the definition of SRAS.	29 October 2020
Publish a draft determination on changes to quantitative Standard settings for a combined Queensland sub-network.	Publish a draft report setting out proposed restoration timeframes, levels of restoration and aggregate reliability requirements for a combined Queensland sub-network. This draft determination will be published at the same time as the interim Standard.	29 October 2020
Submissions close	Submissions close on the draft determination on quantitative Standard settings for a combined Queensland sub-network.	26 November 2020
Publish a final standard and final report on changes to quantitative Standard settings for a combined Queensland sub-network.	If AEMO determines to combine the two existing Queensland sub-networks into a single sub-network, publish a final report and final Standard setting out proposed restoration timeframes, levels of restoration and aggregate reliability requirements for a combined Queensland sub-	January 2021

MILESTONES	DETAILS	KEY DATES
	network.	

1.3 Submissions on the Panel's draft determination

The Panel invites written submissions on the draft determination on quantitative Standard settings for a combined Queensland sub-network set out in Chapter 5. Electronic submissions must be lodged online through the AEMC's website using the link entitled "lodge a submission" and reference code "REL0077".

Submissions are requested from interested parties by no later than **26 November 2020**. All submissions received will be published on the AEMC's website (www.aemc.gov.au), subject to any claims for confidentiality.

Any questions regarding the consultation process should be directed to Graham Mills, graham.mills@aemc.gov.au

1.4 Structure of this determination

The remainder of this draft determination is structured as follows:

- Chapter 2 - Background
- Chapter 3 - Assessment framework
- Chapter 4 - Final determination on changes to the changes to the qualitative guidance in the Standard
- Chapter 5 - Draft determination on quantitative Standard settings for a combined Queensland sub-network.

2 BACKGROUND

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

- SRAS and the process of responding to a major supply disruption and the role of SRAS in this process
- Governance arrangements relating to SRAS and the role of the Standard in this framework
- the different elements comprising the Standard.

2.1 Introduction to SRAS and the process of responding to a major supply disruption

The NEM has historically delivered a safe, secure and reliable supply of electricity to consumers. The requirements for system security, generally set out in Chapter 4 of the NER, impose obligations on AEMO to maintain the power system in a secure state without load-shedding for any contingency event which is considered credible.[17] The NER also requires AEMO to maintain emergency control schemes to prevent a major supply disruption or black system event due to a severe non-credible event affecting the power system.[18] These are generally considered to be events that are rare in occurrence, such as the combination of a number of credible contingency events occurring at the same time.

Despite these arrangements, major supply disruptions and black system events can occur,[19] which require generation in an affected part of the power system to be restarted and customer load re-connected. To manage the consequences of such an event if it did occur, AEMO's power system security responsibilities also include a requirement to procure sufficient SRAS in accordance with the Standard to allow for the restarting of generating units and subsequent restoration of load following a major supply disruption.[20]

A major supply disruption or black system event is a rare but serious event involving shut down entire sections of the power system with significant economic and social costs due to the loss of supply to affected customers. The most recent black system event was in South Australia in September 2016. Prior to that event, two more occurred in; northern Queensland in 2009; and New South Wales in 1964.[21] As an example of the severity of the economic and social costs of black system events, the economic costs of the South Australian black system event have been estimated at 376 million dollars.[22]

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17 A secure operating state is defined in clause 4.2.4 of the NER.

18 Clause 4.2.6(c) of the NER.

19 A major supply disruption occurs when voltage is lost on part of the transmission network affecting one or more generators leading to the loss of supply to customers. The NER defines a black system as the absence of voltage on all or a significant part of the transmission system or within a region during a major supply disruption affecting a significant number of customers. It should be noted that not all major supply disruptions involve black system conditions, and therefore require SRAS to restore affected customers.

20 Clause 4.2.6(e) of the NER.

21 Reliability Panel, Fact Sheet - Black system events. https://www.aemc.gov.au/sites/default/files/content/b705e0e4-afd3-47ef-bc41-32ea3393629c/Fact-Sheet-Black-system-events.pdf

22 Business South Australia - https://www.business-sa.com/Commercial-Content/Media-Centre/Latest-Media-Releases/September-

The section introduces the process of responding to a major supply disruption or black system event and the role of SRAS and the Standard in that process.

2.1.1 What are SRAS

SRAS are resources that AEMO procures to re-energise parts of the power system affected by a major supply disruption or black system event. AEMO procures SRAS to minimise the impact of a rare but possible disruption to the power system.

Traditionally, SRAS are services provided by generating units with "black start" capability which allows them to start, or remain in service, without electricity being provided from the network. In the event of a major supply disruption or black system event SRAS are the first resources to restart and commence the re-energisation process.[23]

SRAS providers commence the re-energisation process by supplying power to auxiliary loads at non-SRAS generating systems. Generating units require some machinery to operate, such as conveyor belts, compressors, fans, pumps and coal pulverisers, which are known as auxiliaries. Non-SRAS generating systems are unable to start without an external source of supply for their auxiliary loads. SRAS generators provide this initial supply, which allows non-SRAS generating systems to re-start and contribute to power system re-energisation.

A number of different technologies have traditionally provided SRAS in the NEM. These include:

- generating units that can restart without being connected to the grid, such as hydro or various gas turbine generating units
- 'Trip To House Load' (TTHL) schemes, which include large generating units that can disconnect from the grid in the event of a major supply disruption and continue to supply their own auxiliaries, and
- combination system restart sources, which are large generating units that can be started from a nearby small power station, such as a thermal power station with a gas turbine generating unit that is capable of starting without grid supply.

In addition to traditional SRAS providers, a number of non-traditional providers of "black start" capability are emerging. These include technologies such as batteries combined with grid forming inverters. SRAS may also be provided by facilities which have the capability to assist the re-energisation process. The Commission's SRAS rule included changes to allow for restoration support services and non-traditional technologies capable of providing black start services to be captured by the SRAS frameworks. More detail on these changes is provided in Chapter 4.

2.1.2 Process of responding to a black system event

Frameworks in the NER set out a process for restoring the power system following a major supply disruption or black system event. This process has several stages and involves AEMO,

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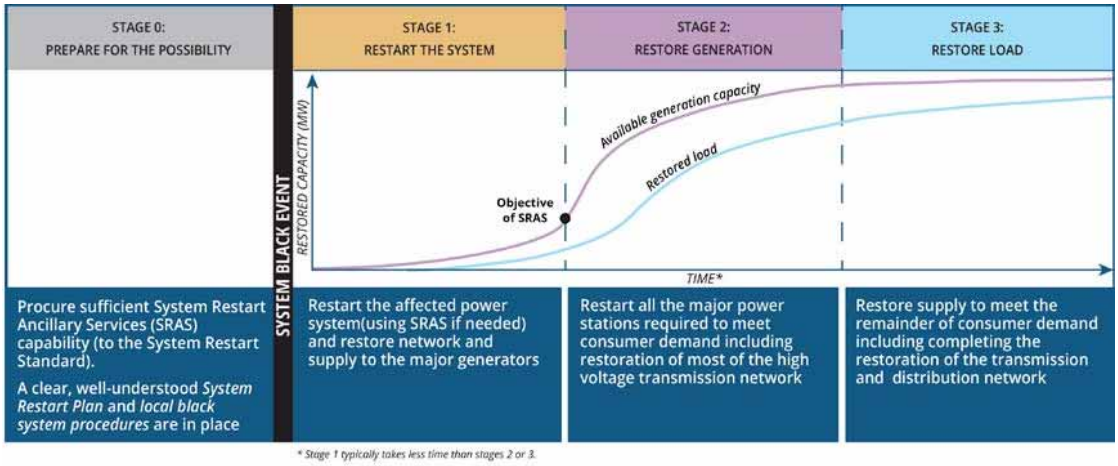
Blackout-Cost-State-$367-Million

23 Re-energisation can also occur from neighbouring regions.

transmission and distribution network service providers and generators each coordinating in their respective roles. An overview of the stages involved in preparing for and responding to a black system event is illustrated in Figure 2.1.

Figure 2.1: Stages in the process of responding to a black system event



Source: AEMC

Stage zero - Prepare for the possibility: AEMO procures SRAS for each electrical sub-network during stage zero in preparation for a possible major supply disruption or black system event. During this period AEMO enters into contracts with SRAS providers and develops a system restart plan for each of the electrical sub-networks to guide restoration of the system. The Standard is primarily relevant to stage zero as it provides qualitative guidance and quantitative settings to guide AEMO's procurement of SRAS.

AEMO develops system restart plans for each sub-network for the purpose of planning for a black system event or major supply disruption that must be consistent with the requirements of the Standard.[24] System restart plans cover the first two stages of the restoration process following a black system condition, that is, the re-energising of the transmission network and restoration of supply from major power stations and identify restoration pathways and options for re-energisation. The actual contracted restart services form part of the system restart plan, which is confidential information in accordance with clause 4.8.12 (b) of the Rules.

Stage one - Restart the system: immediately following the occurrence of a major supply disruption or black system event AEMO will consider its options for restoring the power system. These may include calling upon SRAS procured during stage zero and, if available, requesting the provision of energy from unaffected parts of the power system. The objective of stage 1 is to re-start a critical number of major power stations necessary to stably restore remaining generation and load.

24 Clause 4.8.12(c) of the NER.

The quantitative Standard settings for restoration level and time frame define the level of supply energisation achieved in a sub-network at the end of Stage one of the restoration process.

Stages two and three - Restore generation and load: Remaining generation will be restarted with supply to consumers restored progressively during stages two and three. The Rules set out requirements relating to the restoration of sensitive loads which AEMO must meet.

The speed of customer restoration during these stages is dependent on a range of factors, including network conditions. In accordance with their local black system procedures and instructions from AEMO, it is the responsibility of network operators to restore power to individual consumers. Restoration of supply to consumers may not occur until a number of hours after the restoration of capability for generators as contemplated in the Standard. The Standard doesn't specify requirements for power system restoration during stages two and three.

2.2 Governance arrangements and the role of the Standard

The Panel, AEMO, networks, and generators all have obligations under the frameworks for system restoration in the NEM. The Standard is a central element in this overall framework. This section introduces the role of the Standard in the context of governance arrangements and roles and responsibilities applying to the different parties responsible for system restoration in the NEM.

The Reliability Panel - The Standard is set by the Panel[25] in accordance with the SRAS Objective and the requirements for the Standard set out in the NER.[26] The NER requires the Standard to include quantitative settings relating to system restoration and provide qualitative guidance for AEMO to follow in its procurement of SRAS. The specific elements of the standard are introduced in section 2.3.

The Standard is used to set requirements for AEMO's procurement of SRAS, help inform AEMO's system restart plan, and guide AEMO's determinations of sub-networks. The Standard is therefore an overarching element of the governance arrangements for system restoration in the NEM.

AEMO - AEMO has overall authority for procuring SRAS and coordinating power system restoration following a major supply disruption or black system event.[27] Other parties being network service providers, generators, and jurisdictional system security coordinators (JSSCs) are obliged to provide relevant information and assist AEMO with the restoration process. AEMO publishes three key coordinating documents being the SRAS Guideline, system restart plan, and guidelines for preparing local black system procedures for this purpose.

25 The Reliability Panel, which forms part of the AEMC's institutional arrangements, reviews and reports on the safety, security and reliability of the national electricity system. The Panel is comprised of members who represent a range of participants in the national electricity market, including consumer groups, generators, network businesses, retailers and AEMO.

26 Clause 8.8.3(aa) of the NER.

27 Clauses 3.11.7(a1) and 4.3.1(p) of the NER.

The SRAS Guideline sets out details of AEMO's technical requirements for SRAS, modelling and testing requirements for SRAS providers, and details of its SRAS procurement processes. It is therefore a significant document in stage zero of the restart process, which is to prepare for the possibility of a major supply disruption or black system event. The Rules require AEMO to publish its SRAS Guidelines in accordance with the relevant guidance provided in the Standard.[28]

The NEM is sub-divided into electrical sub-networks both for acquiring SRAS and developing operational plans to manage major supply disruptions. AEMO is responsible for determining the boundaries of the electrical sub-networks,[29] using criteria specified in the Standard by the Panel.[30] AEMO has determined that there are five electrical sub-networks aligned to the boundaries of the NEM regions being Queensland, New South Wales, Victoria, South Australia and Tasmania. Prior to 16 October 2020, Queensland was divided into two electrical subnetworks being North Queensland and South Queensland. On 16 October 2020 AEMO determined to combine these sub-network boundaries into a single Queensland subnetwork.

AEMO also develops a 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.[31] The system restart plan is required to be consistent with the Standard.[32]

AEMO also develops guidelines for use by networks and generators to develop their local black system procedures, which are discussed further below.[33]

Networks and generators - The networks are responsible for providing AEMO with any information which AEMO reasonably requires in order for AEMO to assess the capability of an SRAS provider to meet the Standard. They are also required to participate in, or facilitate, testing of SRAS to be provided by a prospective SRAS Provider.[34]

Generators with the relevant specialised equipment are able to offer to provide SRAS. Generators that receive payment for the provision of SRAS are required to maintain their restart capacity and undertake regular testing as set out in the SRAS guidelines.

Networks and generators are both required to develop local black system procedures conforming with AEMO's guideline and setting out the technical characteristics of their plant under black system conditions. These procedures are approved by AEMO.

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28 Clause 3.11.7(c) of the NER.

29 Clause 3.11.8(b) of the NER.

30 Clause 8.8.3(aa)(6) of the NER.

31 A JSSC is a person appointed by the Minister of a participating jurisdiction who must prepare, maintain, and if necessary, update guidelines in relation to the shedding, and restoration, of loads

32 Clause 4.8.12(c) of the NER.

33 Clause 4.8.12(e) of the NER.

34 Clause 3.11.9(i) of the NER.

2.3 The Standard

The NER sets out requirements for the Standard including the elements that the Panel must include when determining the Standard.[35] The elements of the Standard can be divided into qualitative guidance and quantitative settings. This section introduces the quantitative and qualitative elements of the Standard as context for the issues being considered by the Panel in this review.

Quantitative standard settings

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 by the end of stage one of the restoration process.
- **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 the defined restoration level. This restoration time defines the end of stage one of the restoration process.
- **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 reliabilities of the SRAS procured in that electrical sub-network, together with an assessment of the impact of the points of failure.

The quantitative elements of the Standard provide settings for AEMO's procurement of SRAS. While AEMO would aim to restore the power system to the requirements of the Standard following a major supply disruption, the Standard does not set operational targets to be achieved during an actual restoration event. AEMO is taken to have complied with the quantitative settings in the Standard in respect of the modelled outcomes from its procurement of SRAS rather than operational outcomes during an actual restoration event.

It should also be noted that the Standard's quantitative settings do not specify the level of load that needs to be restored. This is because it is network service providers who are responsible for reconnecting consumers, the level of which can be dependent on a range of issues (such as network damage) that are beyond AEMO's ability to control.

The existing quantitative Standard settings for each sub-network in the NEM are set out in Table 2.1 below. In addition to the settings for restoration level, restoration time frame, and aggregate reliability the Standard also contains a specific locational requirement for AEMO to procure SRAS north of Sydney.[36]

35 Clauses 8.8.3(a)(5) and (aa) of the NER.

36 The Standard requires 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.

Table 2.1: **Existing Quantitative Standard settings**

ELECTRICAL SUB-NETWORK	LEVEL OF RESTORATION (MW)	RESTORATION TIME (HOURS)	REQUIRED AGGREGATE RELIABILITY
North Queensland	825	3.5	90%
South Queensland	825	3.0	90%
New South Wales	1500	2.0	90%
Victoria	1100	3.0	90%
South Australia	330	2.5	90%
Tasmania	300	2.5	95%

Qualitative guidance and guidelines

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

- **Guidance on the interpretation of the quantitative Standard requirements** - The Standard includes qualitative guidance to assist AEMO interpret the quantitative Standard requirements including restoration timeframe, aggregate reliability of SRAS, use of SRAS in neighbouring sub-networks.
- **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.

Specific additional requirements applying to certain sub-networks

The existing Standard sets out quantitative requirements that apply uniformly across a sub-network. The selection of locations for SRAS within a sub-networks is left to AEMO's discretion, which is guided by the qualitative guidance on assessing diversity of services and strategic location of services.

The existing Standard determines an additional requirement applying to the NSW sub-network. This requirement is for AEMO to procure SRAS north of Sydney, sufficient to also independently restart, without drawing power from the power system, at least 500 MW of generation capacity within four hours of a major supply disruption with an aggregate reliability of at least 75 per cent.

This additional requirement reflects the importance of an SRAS resource being located north of Sydney for the restoration of generation in the Hunter Valley. This requirement avoids the potential time delays in restarting Hunter valley generation from SRAS located in the south of the state.

3 ASSESSMENT FRAMEWORK

This chapter sets out the assessment framework proposed by the Panel. This framework includes consideration of:

- the National Electricity Objective and the SRAS Objective
- the requirements for the Standard set out in the NER and the terms of reference issued by the Commission, and
- additional factors relevant to the Panel's assessment of the Standard.

3.1 SRAS Objective and National Electricity Objective

The Panel is required to have regard to the National Electricity Objective (NEO) when considering the SRAS Objective 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."*

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 NER also requires the Panel to determine the Standard in accordance with the SRAS Objective set out below:[37]

> *"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. This expected cost reflects the cost of providing SRAS plus the costs to society of a prolonged disruption to electricity supply. The SRAS Objective therefore 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.

3.2 Requirements of the NER and terms of reference

The NER requires the Panel to determine a Standard that meets the following requirements.[38]

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

37 Clause 8.8.3(aa)(1) of the NER.

38 Clauses 8.8.3(aa)(2) to (7) of the NER

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.

In this review, the Panel will determine a Standard addressing the necessary elements of the above requirements, having regard to the review's scope as set out in the terms of reference issued by the Commission. Given that the review needs to be completed as soon as practicable, the Commission's terms of reference request that the Panel limit the scope of this review as set out in Chapter 1.

3.3 Factors relevant to the Panel's assessment of the Standard

When determining the Standard, the Panel also intends to considers a number of other factors relevant to addressing the scope of the review. These other factors include:

- in relation to the consideration of any revised Queensland networks, the physical underpinnings of the power system in Queensland, including minimum load levels needed to restore stability on the main transmission flow paths as well as the physical limitations of the system that may be relevant to the minimum technically feasible timeframe for system restoration
- critical timeframes for re-energisation of non-SRAS generating systems
- more generally:
  - the outcomes of consultation with jurisdictional governments to identify any specific issues or matters relevant to the speed of restoration and the cost of restart services to deliver that speed of restoration in specific jurisdictions
  - feedback received from stakeholders though written submissions and discussions.

3.4 Stakeholder submissions on the Panel's assessment framework

The review's consultation paper sought stakeholder views on whether they agreed with the Panel's assessment framework and/or were aware of other relevant factors the Panel should consider when undertaking the review.[39]

The only specific comment received on the Panel's assessment framework was from Delta Electricity which considered it to be appropriate.[40] While Delta Electricity considered the Panel's assessment framework to be appropriate, it identified a range of additional considerations including:[41]

- the potential for extended delays to occur due to thermal mismatch between power station elements if re-energisation is not sufficiently rapid.
- assessing the risk to a successful restoration from AEMO's reliance on uncompensated non-SRAS key power system elements, such as restart of the first dispatchable generating unit on a restoration path.

Panel response to stakeholder submissions

The Panel agrees with Delta Electricity that it is important to include the potential for extended delays to occur if the re-energisation of certain thermal power stations is not sufficiently rapid. The Panel has therefore added this issue to the list the factors relevant to the Panel's assessment of the Standard in section 3.3. The inclusion of such constraints in the modelling used by the Panel will be further discussed in Chapter 5.

The Panel acknowledges Delta Electricity's concerns regarding the risk to a successful restoration arising from AEMO's reliance on key non-SRAS power system elements, such as restart of the first dispatchable generating unit on a restoration pathway. The Panel however notes that compensation arrangements are not currently within the Panel's remit and a Rule change will be required to address Delta's concerns regarding the compensation of such non-SRAS power system elements.

39 AEMC Reliability Panel, system restart standard review - 2020, consultation paper, p. 17.
40 Delta electricity, submission to the consultation paper, p. 3.
41 Delta Electricity, submission to the consultation paper, p. 3-5.

4 FINAL DETERMINATION ON CHANGES TO THE QUALITATIVE GUIDANCE

On 2 April 2020, the Commission made the System restart services, standards, and testing rule (SRAS rule). The SRAS rule made a range of changes to frameworks governing the definition, procurement, testing and deployment of SRAS. This rule was made to address challenges from fewer traditional sources of SRAS being available in some NEM regions, with those remaining potentially less capable of restoring the power system.[42]

The review's terms of reference require the Panel to publish an interim Standard by 2 November 2020 updating relevant qualitative elements of the Standard to reflect changes made in the SRAS rule to include system restoration support services in the definition of SRAS under the NER. The SRAS rule further required the Panel to review the Standard as soon as practicable to incorporate the changes made in the rule.[43]

This chapter presents the Panel's final determination on changes to the qualitative guidance in the Standard to account for the changes made in the SRAS rule. This chapter presents:

- the Panel's approach to amending to the Standard to reflect changes made in the SRAS rule
- stakeholder submissions on the Panel's approach to amending qualitative guidance proposed in the review's consultation paper
- The Panel's final determination for changes to the qualitative guidance on:
  - Aggregate reliability of SRAS
  - Guidelines for assessing diversity of services
  - Guidelines for strategic locations

BOX 3: SUMMARY OF THE PANEL'S FINAL DETERMINATION ON CHANGES TO THE QUALITATIVE GUIDANCE

The Panel's final determination is to amend the Standard's qualitative guidance in the following areas:

- Section 4 - aggregate reliability of SRAS will be amended to:
  - qualify the requirement for AEMO to consider 'start up performance' when assessing individual reliability as only applying where relevant. This qualification removes the potential for this guidance to preclude AEMO's procurement of non-generation black start SRAS or restoration support services.
  - generalise reference to the network by removing references to 'transmission' in the factors AEMO must consider when assessing individual reliability of SRAS. This

42 AEMC, System restart services, standards and testing rule - final determination, p. ii

43 Clause 11.123.2 of the NER.

change provides for AEMO to assess individual reliability for distribution connected restoration support services.

- provide additional flexibility to AEMO in the factors it can consider when assessing individual reliability by qualifying the existing list of factors as a non-exhaustive list. This change will allow AEMO to consider a wider range of relevant factors to the reliability of non-generation SRAS and restoration support services such as the reliability of communications and IT systems.
- replace reference to the first transmission substation with reference to the first location on a shared network from which the SRAS can energise, or support the energisation of, other generation. This change will provide additional flexibility for AEMO to consider alternate delivery points for restoration support services and additional transmission elements beyond the first transmission sub-station where the first transmission sub-station doesn't connect to multiple transmission paths.

- Section 8 - guidelines for assessing the diversity of services will be amended to qualify the requirement for AEMO to consider energy source or fuel diversity as only applying 'where applicable'. This change accounts for circumstances where there is no specific energy or fuel source for some non-generation SRAS and restoration support services.
- Section 9 - Strategic location of services will be amended to quanlify references to SRAS energisation of the power system and extend the guidance on strategic location of services to 'sustaining stable restoration of the power system'. This change provides for restoration support services that support restoration stability rather than directly energising the power system.

4.1 The Panel's approach to amending to the Standard to reflect changes made in the SRAS rule

This section presents details on the changes made in the Commission's SRAS rule and the Panel's approach to amending the qualitative guidance in the Standard to account for these changes.

4.1.1 Relevant changes made in the SRAS rule

The SRAS rule included changes to the definitions of SRAS and black start capability, implemented a framework for physical testing of system restart paths, and provided for greater transparency and certainty about participant roles and responsibilities in system restoration.[44] Of these changes, the Commission's terms of reference specifically identified changes to the definition of SRAS as materially relevant to the Standard.[45]

44 AEMC, System restart services, standard and testing rule - final determination, p. ii-iii.

45 In the review's consultation paper, the Panel considered changes to implement a framework for physical testing of system restart paths and provide greater transparency and certainty on participant roles and responsibilities are important for wider SRAS frameworks, but are not material to the settings and guidance provided by the Standard for AEMO's procurement of SRAS. The focus of amendments to the Standard are therefore on changes to qualitative guidance to account for the revised definitions of SRAS and black start capability.

The existing definition of SRAS is limited to facilities with black start capability, with the definition of black start capability being framed as applying specifically to generating units.[46] The Commission's SRAS rule, upon its commencement on 2 November 2020, will update both the definition of black start capability, to provide for the provision of this capability by providers other than generating units, and the definition of SRAS, to include a new category of restoration support services.

The definitions of these terms, as amended by the SRAS rule, are as follows:

- black start capability is defined as a capability that allows a generating unit, facility or a combination of facilities following disconnection from the power system, to be able to deliver electricity to either:(a) a connection point; or (b) a suitable point in the network from which supply can be made available to other generating units, without taking supply from any part of the power system following disconnection.
- SRAS is defined as a service provided by plant or facilities with: (a) black start capability; or (b) the capabilities described in the SRAS Guideline to supply one or more services to sustain the stable energisation of generation and transmission, sufficient to facilitate the restoration and maintenance of power system security and the restart of generating units following a major supply disruption.[47]

The Commission considered that this revised definition will increase competition for the provision of black start capability from an expanded range of facilities:[48]

- provide for emerging technologies, such as batteries with 'grid forming' inverters, or other combinations of plant to be procured by AEMO to provide black start capability, and
- allow AEMO to procure system restoration support services as SRAS, thereby making sure that the capability to support the grid during a restart process is valued and available when required.

4.1.2 Panel's approach to amending the Standard to account for the SRAS rule

As the Standard is currently written to accord with the existing definition of SRAS, the Panel identifies a risk that the qualitative and quantitative elements of the Standard do not fully encompass the expanded technological and service scope of SRAS given the new definition.

Existing language in the Standard may therefore create barriers to and/or provide insufficient guidance for AEMO's procurement of SRAS of all types from all eligible sources. In making its final determination, the Panel has considered the changes necessary to address language in the standard that is inappropriate and/or could act as a barrier to AEMO's procurement of restoration support services and SRAS from non-traditional providers.

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46 Until the SRAS rule comes into effect on 2 November 2020, Black start capability is defined in full in Chapter 10 of the NER as: A capability that allows a generating unit, following its disconnection from the power system, to be able to deliver electricity to either: (a) its connection point; or (b) a suitable point in the network from which supply can be made available to other generating units, without taking supply from any part of the power system following disconnection.

47 AEMO published a final determination on the capabilities and technical characteristics for restoration support services in its Final SRAS Guideline published on 16 October 2020 and available at: https://aemo.com.au/en/consultations/current-and-closed-consultations/sras-guideline-2020

48 AEMC, System restart services, standards and testing rule - final determination, p. 19

The Panel has focused on amending existing qualitative guidance rather than providing additional guidance, over and above that currently in the standard, specific to AEMO's procurement of black start capability provided by non-traditional providers and restoration support services. The Panel considers it prudent to augment the Standard with detailed additional guidance on procuring SRAS from non-traditional providers and restoration support services once more information is available following AEMO's next procurement round in 2021. This additional information will allow the Panel to add guidance that is accurate, relevant, and appropriately targeted to AEMO's procurement of SRAS of different types from different technologies. The Panel considers the next review of the Standard should be a fulsome review of the qualitative guidance to specify additional qualitative guidance following AEMO's next procurement round.

This approach is consistent with the Panel's treatment of changes to quantitative settings in response to the amended SRAS rule. Chapter 5 sets out the Panel approach to quantitative Standard settings which is also to wait until additional information is available before including SRAS from non-traditional providers and restoration support services in the assessment identifying efficient levels of SRAS to be procured in a particular sub-network.[49]

4.2 Stakeholder submissions on the Panel's approach to amending the Standard's qualitative guidance

The review's consultation paper sought Stakeholder feedback on whether they agreed with the Panel's proposed approach to amending the Standard's qualitative guidance and whether stakeholders were aware of any specific elements of the Standard that require amendment and/or had views on how the changes made in the SRAS rule affect the review.

The Panel received six submissions to its consultation paper.[50] None of these submissions objected to the Panel's approach to amending the Standard's qualitative guidance proposed in the consultation paper. Submissions supporting the Panel's approach included:

- Tesla supported the Reliability Panel's approach to amending the Standard to account for the recent SRAS rule change, and to incorporate the revised definition of SRAS.[51]
- Origin supported the Reliability Panel's proposed approach of waiting until more information is available before amending the standard to account for the changes to the broader definition of SRAS.[52]
- Delta considered the amendment to the Standard's qualitative guidance to be urgently required.[53]

Delta Electricity's submission raises the issue of the Standard including qualitative guidance on co-ordination of SRAS and non-SRAS generating units that may be essential to AEMO

49 Information on the actual costs, location, availability and characteristics of restoration support services and non-traditional providers of black start capability will not be available until after AEMO's next SRAS procurement round in 2021.

50 Submissions were received from: PIAC; Snowy Hydro; Delta Electricity; AER; Tesla. Submissions are available on the review's project page: https://www.aemc.gov.au/market-reviews-advice/review-system-restart-standard-2020

51 Tesla, submission to the consultation paper, p. 4

52 Origin, submission to the consultation paper, p. 1.

53 Delta Energy, submission to the consultation paper, p. 6.

meeting the Standard. Delta identifies a lack of co-ordination and compensation for generators that are critical for successful restart, in particular the first non-SRAS generator on a restart path, as a potential weak link in current arrangements.[54]

Panel's response to stakeholder views

The Panel notes stakeholder agreement with its proposed approach. The Panel has therefore utilised the approach put forward in the consultation paper in making the final determination on changes to the Standard's qualitative guidance.

The Panel considers including additional guidance in the Standard on the co-ordination of SRAS and non-SRAS generating units to be beyond the scope of this review. Additional qualitative guidance in this area may be considered in the next fulsome review of the Standard. As noted in Chapter 3, the Panel considers a rule change to be required the issue raised by Delta on the compensation of critical non-SRAS power system elements.

4.3 Final determination on changes to the qualitative guidance in the Standard

This section sets out the Panel's final determination on changes to the qualitative guidance in the Standard to account for the amended definition of SRAS. Consistent with the approach set out in section 4.1, the Panel has assessed whether changes are required to the guidance in each section of the standard to address language which is inappropriate or may represents a barrier to AEMO's procurement of non-generation black start SRAS or restoration support services.

The Panel's final determination is to amend the following elements of the Standard:

- Section 4 - Aggregate reliability of SRAS
- Section 8 - Guidelines for assessing the diversity of services, and
- Section 9 - Strategic location of services

The Panel's amendments are set out in the following sections.

The Panel does not consider the language used in the other sections of the Standard to represent a barrier to AEMO's procurement of restoration support services and/or black start SRAS from non-generation providers. The Panel's final determination in this review is therefore to make no changes to the guidance provided in elements of the Standard other than those listed above.[55]

4.3.1 Section 4 - Aggregate reliability of SRAS

Section 4 of the Standard specifies aggregate reliability to be the probability that the generation and transmission in a sub-network is expected to be restored to the specified restoration level (MW) in the restoration timeframe (hours).

54 Delta Electricity, submission to the consultation paper, p. 6.

55 The Panel has determined to make no change in each of the following parts of the Standard: Section 1 - Introduction, Section 3 - Restoration timeframes, Section 5 - Applicability of the standard in electrical sub-networks, Section 6 - Use of SRAS in neighbouring electrical sub-networks, Section 7 - Guidelines for the determination of electrical sub-networks.

The existing Standard requires AEMO to consider the combination of the individual reliabilities of the SRAS procured in each sub-network when determining the aggregate reliability of the sub-network. The Standard requires AEMO to incorporate the following when assessing the reliability of an individual SRAS:

- availability of that service
- expected start up performance, and
- the reliability of the transmission components between the SRAS source and the first transmission substation to which it is connected.

Existing guidance on aggregate reliability is presented in Box 4.

BOX 4: EXISTING STANDARD - AGGREGATE RELIABILITY OF SRAS

The Standard specifies aggregate reliability to be the probability that the generation and transmission in a sub-network is expected to be restored to the specified restoration level (MW) in the restoration timeframe (hours).

The reliability of any individual SRAS will incorporate the availability of that service, the expected start-up performance and the reliability of the transmission components between the SRAS source and the first transmission substation to which it is connected.

The aggregate reliability of the procured SRAS in each electrical sub-network shall be determined by AEMO, considering the combination of the individual reliabilities of the SRAS procured in that electrical sub-network, together with an assessment of the impact of the points of failure set out in the guidelines for diversity in section 8 of the standard.

AEMO will determine the manner in which reliability will be assessed in accordance with the requirements in the Rules.

The Panel identifies the factors to be considered by AEMO when assessing individual reliability of SRAS to potentially create barriers to AEMO's procurement of non-traditional black start SRAS and restoration support services:

- The reference to 'start up performance' may not encompass all technologies providing non-generation black start SRAS or restoration support services.
- Consideration is limited to the reliability of transmission elements thereby precluding consideration of distribution network reliability for distribution connected SRAS and restoration support services.
- The list of factors for AEMO to consider when assessing individual reliability is prescriptive and doesn't explicitly provide AEMO with flexibility to consider a range of new factors relevant to non-generation black start SRAS and/or restoration support services.

Each of these issues is considered further below along with the Panel's proposed amendments to the guidance in Section 4 of the Standard.

Consideration of 'start up performance' - Not all SRAS are expected to have a 'start up performance' under the new definition. 'Start up performance' is specific to synchronous

black start generation systems and may not encompass SRAS or restoration support services provided by non-mechanical inverter connected black start or restoration support services. Batteries, reactive support devices providing restoration support services, and stabilising load fall into this category.

The Panel therefore has determined to qualify the requirement for AEMO to consider 'start up performance' when assessing individual reliability as only where relevant. This qualification removes the potential for this guidance to preclude AEMO's procurement of non-generation black start SRAS or restoration support services.

Providing for distribution connected resources - References to transmission network may preclude consideration of network reliability for services connected to the distribution network. While past practice has not utilised SRAS in the distribution network, AEMO's SRAS Guideline, published on 16 October 2020, provided examples that contemplated procuring distribution connected 'stabilising load' as a distribution connected restoration support service.[56]

AEMO's guideline considered stabilising load could be provided by aggregators or virtual power plants in areas where distribution feeders may be in reverse flow or provide limited or fluctuating levels of load. It identifies the scope of such a 'stabilising load' restoration support service to include an aggregator who is able to reduce/turn off sufficient rooftop PV or control batteries to increase the amount of available stabilising load.[57]

The Panel has therefore determined to generalise reference to the network by removing references to 'transmission' in the factors AEMO must consider when assessing individual reliability of SRAS.

Flexibility in the factors that can be considered when assessing individual reliability - The list of factors AEMO is required to consider when assessing individual reliability is prescriptive and doesn't explicitly provide AEMO with flexibility to consider a range of new factors relevant to non-generation black start SRAS and restoration support services. The Panel identifies that a prescriptive list may not provide sufficient flexibility to AEMO to consider the full range of factors relevant to the individual reliability of such services.

The Panel considers a wide range of factors are likely relevant to the individual reliability of restoration support services. These factors include the reliability of communication related signalling systems, the characteristics of the specific technology providing the service, the nature of the service, and whether the services is from an aggregated distribution connected resource. As an example, communication and control system reliability may be important indicator for the reliability of services in the distribution network that are delivered by aggregators or VPPs.

56 AEMO, SRAS Guideline consultation - final determination, 16 October 2020.

57 Ibid.

The Panel has therefore determined to provide additional flexibility to AEMO in the factors it can consider when assessing individual reliability by qualifying the existing list as representing a non-exhaustive list of items.

Scope of the network requiring assessment - The existing standard considers the reliability of the transmission components between the SRAS source and the first transmission substation to which it is connected when assessing the individual reliability of an SRAS. The Panel has sought language that would cover both black start and restoration support services, and the range of points where different types of service need to be 'delivered' in order to provide value in a restoration.

The Panel notes circumstances where the first substation may not connect to multiple paths. It therefore makes sense for individual reliability to be assessed from the source up to the point from which multiple paths are connected. The service provided by restoration support services may also need to be defined at locations other than the first transmission sub-station. For example, this might be at individual connection points on a transmission network or within a distribution feeder (e.g. in the case of aggregators providing stabilising load).

For these reasons, the Panel has determined to generalise the reference to the first transmission substation to instead refer to the first location on a shared network from which the SRAS can energise, or support the energisation of, other generation.

BOX 5: FINAL DETERMINATION - AGGREGATE RELIABILITY OF SRAS

The Standard specifies aggregate reliability to be the probability that the generation and transmission in a sub-network is expected to be restored to the specified restoration level (MW) in the restoration timeframe (hours).

~~The reliability of any individual SRAS will incorporate the availability of that service, the expected start-up performance and the reliability of the transmission components between the SRAS source and the first transmission substation to which it is connected.~~

"Without limitation, AEMO's assessment of the reliability of any individual SRAS will incorporate:

- (1) the availability of that service,
- (2) where applicable, the expected start up performance,
- (3) the reliability of the network components between the SRAS source and the first location on a shared network from which the SRAS can energise, or support the energisation of, other generation."

The aggregate reliability of the procured SRAS in each electrical sub-network shall be determined by AEMO, considering the combination of the individual reliabilities of the SRAS procured in that electrical sub-network, together with an assessment of the impact of the points of failure set out in the guidelines for diversity in section 8 of the standard.

AEMO will determine the manner in which reliability will be assessed in accordance with the

requirements in the Rules.

4.3.2 Section 8 - Guidelines for assessing the diversity of services

The Rules require the Standard to include guidelines for diversity in AEMO's procurement of SRAS as part of AEMO's determination of aggregate reliability.[58] These guidelines are set out in Section 8 of the Standard. Diversity requirements provide for independence between different SRAS sources. AEMO's procurement of a more independent set of SRAS may lessen the probability that any specific circumstance could lead to a situation where the system could not be restored due to the unavailability of SRAS services.

Existing Standard guidance on the types of diversity AEMO must consider when procuring SRAS in a sub-network is set out in Box 6.

BOX 6: EXISTING STANDARD - 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 the following guidelines:

- Electrical - diversity in the electrical characteristics shall be considered particularly to account for any single points of electrical or physical failure across the procured SRAS sources for each electrical sub-network;
- Geographical - diversity in geography shall be considered particularly to account for any single points of failure related to the potential impact of geographical events such as natural disasters; and
- Energy Source - diversity in the energy source or fuel utilised by services shall be considered particularly to account for any single points of failure across the procured SRAS sources for each electrical sub-network.

In accounting for the electrical diversity AEMO needs to consider the failure of any single significant transmission element, such as a single line or corridor that is downstream of the first transmission substation in the restoration path.

The Panel identifies that the requirement for diversity in energy source or fuel utilised may not apply to restoration support services or some non-traditional black start SRAS providers. Restoration support services can include services including the provision of stabilising load and voltage control which do not have a specific energy source or fuel. Some non-traditional black start providers such as batteries may also not have a specific identifiable energy source or fuel associated with them. This requirement is therefore not relevant to these services.

58 Clause 8.8.3(aa)(7) of the NER.

The Panel has therefore determined that the requirement for energy source or fuel diversity should be qualified as only applying 'where applicable'. The Panel's final determination on changes to the guidelines for assessing the diversity of services is as set out in Box 7:

BOX 7: FINAL DETERMINATION - 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 the following guidelines:

- Electrical - diversity in the electrical characteristics shall be considered particularly to account for any single points of electrical or physical failure across the procured SRAS sources for each electrical sub-network;
- Geographical - diversity in geography shall be considered particularly to account for any single points of failure related to the potential impact of geographical events such as natural disasters; and
- Energy Source - diversity in the energy source or fuel utilised by services shall be considered where applicable, particularly to account for any single points of failure across the procured SRAS sources for each electrical sub-network.

In accounting for the electrical diversity AEMO needs to consider the failure of any single significant transmission element, such as a single line or corridor that is downstream of the first transmission substation in the restoration path.

4.3.3 Section 9 - Strategic location of services

Section 9 of the Standard sets out guidance requiring AEMO to 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. This guidance relates to the locational value of AEMO procuring certain SRAS resources given their electrical or physical location close to critical loads. As an example, a strategic location for SRAS is one that increases the probability that the specific area of the system would be restored sooner, allowing AEMO to supply energy to the specific load faster than otherwise would be the case.

Existing Standard guidance on the strategic location of services is as set out in Box 8.

BOX 8: EXISTING STANDARD - 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. A strategic location for an SRAS may be either within or outside the electrical sub-network for which the service is procured.

The Panel identifies that the locational value of SRAS is currently specified in terms of its ability to energise the transmission network. Energisation is a concept specific to black start SRAS and does not apply to restoration support services which are procured to enhance the stability of restoration rather than provide initial energisation. As a result, the existing guidance in Section 9 of the Standard does not encompass restoration support services as these services may not 'energise' the transmission network.

The Panel's final determination is therefore to extend the guidance on strategic location of services to 'sustaining stable restoration of the power system' in addition to energising the transmission network.

The Panel's final determination in respect of Section 9 of the Standard is set out in Box 9.

BOX 9: FINAL DETERMINATION - 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/or sustain stable restoration of the power system assisting other generating units to restart. A strategic location for an SRAS may be either within or outside the electrical sub-network for which the service is procured.

5 DRAFT DETERMINATION ON STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

Quantitative Standard settings for restoration level, restoration timeframe, and aggregate reliability provide targets for AEMO's procurement of sufficient SRAS and define restoration expectations in each electrical sub-network.

Existing Standard settings for Queensland define separate restoration level, restoration timeframe, and aggregate reliability targets for north and south Queensland. This reflects the sub-network boundaries in the NEM prior to AEMO's final determination to combine the two Queensland sub-networks on 16 October 2020.[59]

The review's terms of reference recommended that the Panel determine relevant Standard settings should AEMO determine to combine the existing Queensland sub-networks. As AEMO has decided to combine the sub-networks, the Panel has made a draft determination on quantitative Standard settings for a combined Queensland sub-network. This Chapter:

- introduces the method used by the Panel to determine draft standard settings for a Queensland sub-network
- presents stakeholder views on the Panel's approach as set out in the review's consultation paper, and
- presents draft Standard settings along with outcomes from the panel's economic analysis.

Box 10 summarises the Panel's draft determination on restoration level, restoration timeframe, and aggregate reliability settings for a single Queensland sub-network.

The Panel has determined these settings using an approach consistent with the method used in its 2016 review of the Standard. The information and inputs used in the modelling has of course been updated since 2016. This updated information incorporated learning from the South Australian black system event and revised information from updated generator local black start procedures.[60] In particular, these learnings demonstrated that actual network switching times (this refers to the time AEMO takes to progressively re- energise each network element in a restart pathway) would be longer than anticipated in 2016. As a consequence, AEMO used longer network switching times in its modelling than were used in 2016. This has impacted draft Standard settings such that while the level of SRAS being procured in a combined Queensland sub-network is similar to existing levels for North and South Queensland, and the restoration performance is similar to that which would previously have been achieved, the identified timeframes for restoration are now longer than those identified in 2016.

59 AEMO, SRAS Guideline - final determination, 16 October 2020, p. 12

60 AEMO, advice to the Reliability Panel, 8 October 2020, p. 3.

BOX 10: DRAFT STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

The Panel has made a draft determination for the following restoration level (MW), restoration timeframe (hours), and aggregate reliability to apply to AEMO's procurement of SRAS in a combined Queensland sub-network.

- Restoration level - 1650 MW
- Restoration timeframe - 4 hours
- Aggregate reliability - 90%

The Panel has also made a draft determination to require AEMO to procure SRAS north of Bundaberg capable of restoring 825 MW of generation, within 4 hours, with an aggregate reliability of at least 80%.

5.1 Panel's approach to determining Standard settings for a combined Queensland sub-network

This section presents the Panel's approach to determining draft Standard settings for a combined Queensland sub-network. It summarises the methods used by the Panel for:

- identifying efficient levels of SRAS, and
- determining Standard settings for a combined Queensland sub-network

The information sources and key assumptions used to determine draft Standard settings are then introduced.

5.1.1 Economic assessment to identify efficient levels of SRAS

The Panel is required to determine the Standard in accordance with the SRAS Objective,[61] which is to minimise the expected costs of a major supply disruption to the extent appropriate having regard to the national electricity objective.[62]

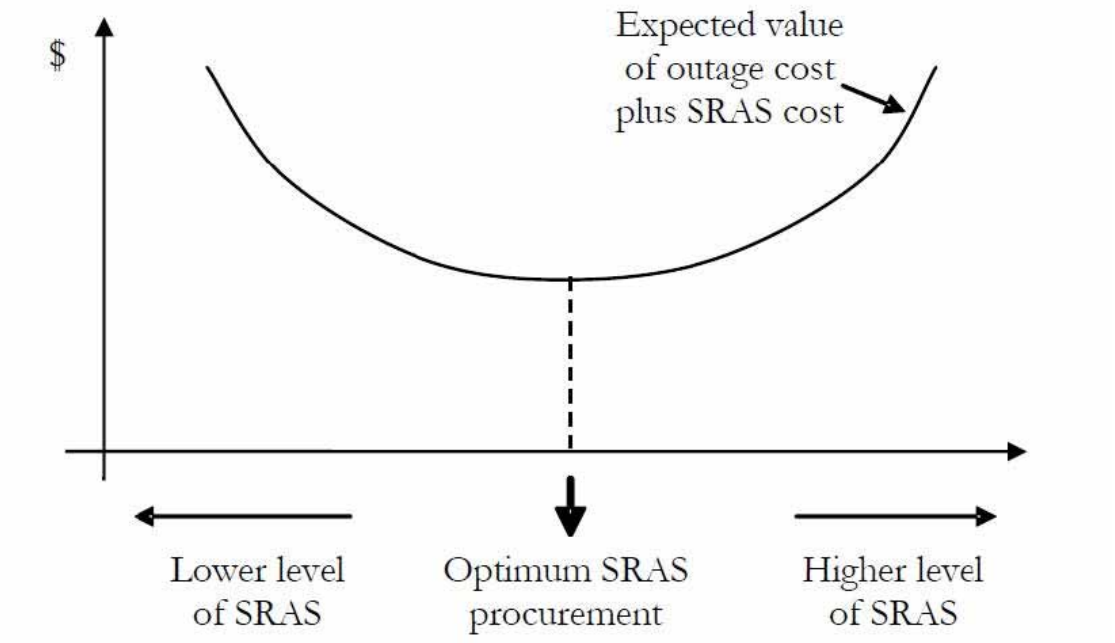
This section summarises the method used by the Panel to identify efficient levels of SRAS in a Queensland sub-network. The efficient level of SRAS, once identified, is then used to inform the draft Standard settings presented in section 5.4. It should be noted that the efficient level is used to set the restoration timeframe, MW restoration level, and aggregate reliability settings and does not represent a binding requirement for AEMO to procure a specific number or set of units to meet those settings.

The efficient level is conceptually illustrated in Figure 5.1 as the level that minimises the total combined cost to consumers of SRAS procurement and the economic and social costs due to a major supply disruption.

61 Clause 8.8.3(aa)(1) of the NER.

62 Chapter 10 (Glossary) of the NER.

Figure 5.1: Identifying the efficient level of SRAS



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The economic assessment performed by the Panel identifies the optimum level of SRAS procurement for Queensland by considering the trade-off between the cost of procuring SRAS and the economic benefits arising from a reduction in unserved energy due to the procured SRAS.

This trade off was assessed by considering the marginal costs and marginal benefits of various levels of SRAS in a Queensland sub-network. The optimum level, which minimises the total cost to consumers, is identified as the level where the marginal benefit achieved from the procurement of an additional unit of SRAS is the same as the cost to procure that unit.

This approach was used by the Panel, and its consultants Deloitte Access Economics (Deloitte), in its 2016 review of the Standard. Further information is available in the report provided to the Panel by Deloitte.[63]This assessment involves the following elements:

1. **Estimate unserved energy for each of the different SRAS procurement options** - Unserved energy is assessed from the supply restoration curves associated with each SRAS procurement option assessed.
2. **Value and reliability weight the unserved energy for each SRAS procurement option -** The unserved energy avoided by each SRAS procurement option is valued using

63 Deloitte Access Economics, Economic assessment of System Restart Ancillary Services in the NEM, 30 November 2016. Available at: https://www.aemc.gov.au/markets-reviews-advice/review-of-the-system-restart-standard

Value of Customer Reliability (VCR) and weighted to account for the individual reliability of the SRAS to be procured.

3. **Annualise the benefit of each procurement option given the probability of a black system event** - The reliability adjusted economic benefit of each SRAS procurement option is then annualised using an estimate of the probability of a black system event in a combined Queensland sub-network.
4. **Identify efficient level of SRAS** - The efficient number of SRAS is identified as the number of units where the marginal reliability weighted benefit is less than the additional cost of procurement.
5. **Quantify uncertainty** - Uncertainty is accounted for by assessing the sensitivity of the results to changes in key variables.

Each of these steps is explained further below.

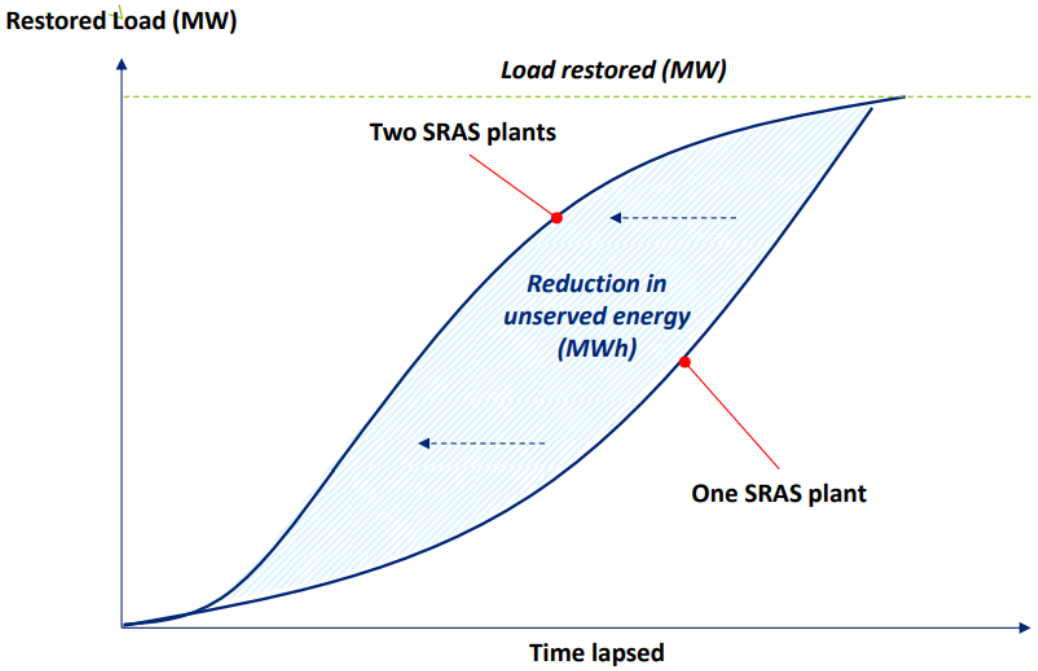
Estimate unserved energy for each of the different SRAS procurement options

AEMO procures SRAS capable of energising the network in preparation for a potential black system event. Additional restart services can increase the speed of restoration and make the process more reliable thereby minimising the expected level of unserved energy from a major supply disruption to black system event.

The level of unserved energy associated an SRAS procurement option is assessed from the supply restoration curves for that option modelled by AEMO for the review (for more information see section 5.1.3). Supply restoration curves describe the process of re-energising the network from one or more SRAS included in the procurement option. Unserved energy can be identified as the area to the left-hand side of the supply restoration curve.

In general, procuring additional SRAS reduces the level of unserved energy by allowing for a faster and more reliable restoration of supply thereby minimising the expected level of disruption and economic losses from the event. Figure 5.2 illustrates by conceptually depicting the unserved energy avoided from the procurement of two SRAS capable generating units relative to one unit. This reduction in unserved energy represents the marginal benefit of procuring the additional unit of SRAS.

Figure 5.2: Marginal benefit achieved by procuring two units of SRAS relative to one



Source: Deloitte Access Economics

Deloitte Access Economics

Value and reliability weight the unserved energy for each SRAS procurement option

The reduction in unserved energy, identified for each SRAS procurement option, is reliability weighted prior to being valued.

Reliability weighting accounts for the potential failure of one or more of the SRAS procured as part of the procurement option. Procuring more than one unit of SRAS within the electrical sub-network not only improves the speed of the restoration process but also provides backup should one unit not operate successfully, thus increasing the probability of successful restart relative to the case with only one unit.

If a hypothetical SRAS procurement option is for the procurement of two units, there is a chance that both units successfully operate, one of the units operates, or neither operate. The reliability weighted outcome is the expected outcome given the individual probabilities of the units in the procurement option.

The reliability weighted unserved energy avoided under each SRAS procurement option is then valued using the estimates of VCR for Queensland published by the AER.[64]

Annualise the reliability weighted value of each procurement option given the probability of a black system event

The benefit of procuring SRAS will be realised infrequently when there is a black system event, or major supply disruption in Queensland. The reliability weighted value of procured SRAS is therefore annualised for comparison with the annual cost of procuring SRAS in the assessed portfolio. The Panel estimated the probability that a black system event will occur in Queensland in a particular year for this purpose.

Consistent with the approach used by the Panel's consultants Deloitte Access Economics in 2016, the Panel estimated the probability of a black system event in a Queensland using a power law relationship to extrapolate from data on historic lost load events in the sub-network. Following the Deloitte methodology, we set a 400 MW threshold for this analysis.

It is challenging to estimate the likelihood of high risk, low probability events such as a black system events and the Panel had limited data for this purpose. As a result, the Panel accounted for uncertainty in the probability of a black system event by including it as a variable in the sensitivity analysis described below.

Identify efficient level of SRAS

The Panel determined efficient level of SRAS in a combined Queensland sub-network as the number of units of SRAS to be procured such that the annualised probability weighted value of procuring an additional SRAS unit is less than the annual cost of procuring that resource. This approach minimises the total cost to consumers consistent with the Panel's obligation to set the Standard consistent with the SRAS Objective.

Quantify uncertainty

There is significant uncertainty associated with several of the parameters used in the Panel's economic assessment. The Panel used a sensitivity analysis to account for uncertainty associated with the variables listed below. This sensitivity analysis involved estimating upper and lower bounds for each of these parameters. Uncertainty was assessed for each of the following:

- VCR ($/MWh) (for each sub-network)
- Probability of a black system event occurring

5.1.2 Method for determining Standard settings for a combined Queensland sub-network

The Panel determined the following Standard settings, as required by the NER and the review's terms of reference, for a combined Queensland sub-network using inputs from AEMO and results from the Panel's economic assessment:

64 Note that the AER now has responsibility for publishing estimates of VCR in the NEM. On 18 December 2019, the AER published its first set of VCR values. https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability

- restoration level (MW) - a level of generation and transmission capacity to be available at the end of stage 1 of the restoration process
- restoration timeframe (hours) - a maximum time to achieve the MW restoration level of generation and transmission capacity, and
- aggregate reliability - an aggregate reliability, or probability, for achieving this level within the required restoration timeframe.

The Panel's approach to its draft determination on each of these Standard parameters are described below. The Panel has applied its 2016 approach to determining each of these parameters. Further information on the Panel's 2016 assessment is available at: https://www.aemc.gov.au/markets-reviews-advice/review-of-the-system-restart-standard

The Panel has utilised its approach from 2016 to be consistent with the process used to determine existing settings for the other sub-networks in the NEM. The Panel has however used the most up to date information and modelling available. In particular, learning from the South Australian black system event and information from updated generator local black start procedures have been incorporated into AEMO's modelling of restoration progress and processes.[65] The Panel notes that the next fulsome review of the Standard will likely revisit this approach and update it to account for a more diverse set of SRAS services and service providers.

Restoration level and time

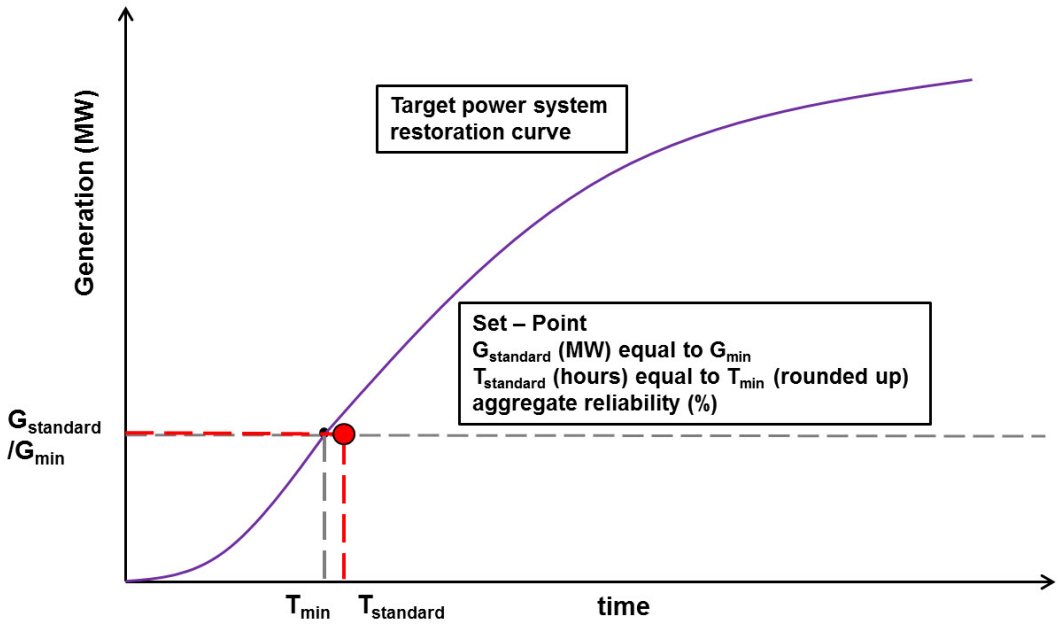
The restoration level, in MW, represents the minimum online generation capacity required to support ongoing restoration. This level is represented in Figure 5.3 as G_{min} and is a measure of the minimum threshold for generation restoration, beyond which the auxiliary loads of all major power stations can be energised and the ongoing restoration of the power system can proceed without the need for SRAS. G_{min} was provided by AEMO in its advice to the Panel and determined from modelling of the restoration process.

The restoration time, in hours, represents the technically feasible time, T_{min} to restore the power system to G_{min}, plus a margin to account for uncertainty. Consistent with the approach utilised in its 2016 review, The Panel has determined a restoration time for a combined Queensland sub-network of T_{min} plus a margin beyond T_{min} equal to 15 minutes, rounded up to the nearest half hour. The Panel included this 15 minute margin because of the inherent uncertainty of the assumptions used to determine the Standard, particularly the assumed VCR and the probability of a black system event.

Figure 5.3 illustrates the Panel's approach to setting restoration level and time settings relative to G_{min} and T_{min}.

65 AEMO, advice to the Reliability Panel, 8 October 2020, p. 3.

Figure 5.3: Panel approach to determining restoration time and level settings



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Aggregate reliability

The aggregate required reliability of SRAS represents the probability that the combined SRAS procured for a given electrical sub-network is able to restore supply to the minimum capacity required to support ongoing restoration (i.e. G_{min}) within the restoration time. The existing standard specifies an aggregate reliability of 90% for both North and South Queensland sub-networks.

The Panel was guided by the economic assessment in setting the aggregate reliability requirement for a combined Queensland sub-network. In particular, the level of the aggregate reliability depends on the number of restart services that the economic assessment suggests will minimise the expected costs of a major supply disruption, and the individual reliabilities of the SRAS available for AEMO to procure.

Additional locational requirements

In determining to combine the Queensland sub-networks, AEMO's draft determination considered the procurement of at least one SRAS resource in central Queensland may preserve some of the benefit of retaining two sub-networks while also allowing the benefits of combining the sub-networks to be realised. AEMO specifically suggested that the Standard could expressly require sources to be procured in both south and central Queensland (e.g. "north of Bundaberg").[66]

66 AEMO, SRAS guideline consultation - final determination, 16 October 2020, p. 13.

The Panel notes that a "hybrid" approach already applies to the New South Wales sub-network. In 2016, the Panel determined to include an additional requirement for AEMO to procure SRAS in New South Wales sufficient to independently restart 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. This requirement was imposed to address concerns about the speed of restoration in the region should the New South Wales sub-network be restarted entirely from the fast response hydro-power resources in the south of the state.

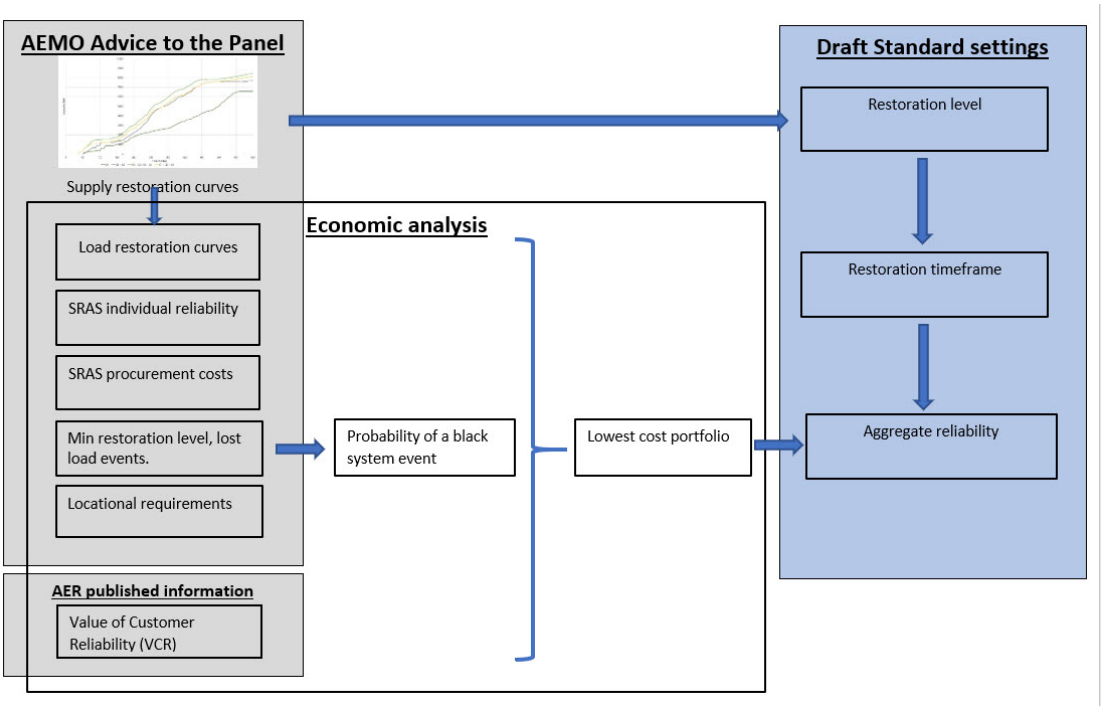
The Panel's assessment framework includes, in relation to the consideration of any revised Queensland networks, the physical underpinnings of the power system in Queensland, including minimum load levels needed to restore stability on the main transmission flow paths as well as the physical limitations of the system that may be relevant to the minimum technically feasible timeframe for system restoration.

The Panel has considered these factors in determining a locational requirement for SRAS north of Bundaberg. AEMO provided advice to the Panel on a specific locational requirement. Further details are provided in section 5.3.3.

5.1.3 Information sources and key assumptions

The key sources of information used to identify draft Standard settings for a combined Queensland sub-network are presented in Figure 5.4. These sources of information are organised to depict the relationship between the advice supplied to the review by AEMO, the economic analysis performed by the Panel, and the determination of the draft Standard settings.

Figure 5.4: Key sources of information used by the review



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Each of the key pieces of information used by the Panel in determining draft Standard settings are introduced below.

AEMO advice

AEMO provided the Panel with advice on the following:

- supply restoration curves for potential Queensland SRAS procurement options including the supply restoration curves associated with the combination of units within each procurement option.
- the average cost of procuring an SRAS source in Queensland obtained from previous SRAS procurement rounds
- estimated start up reliability for each SRAS unit available for procurement in Queensland
- minimum levels of restoration (MW) necessary for ongoing restoration in stages two and three of the restoration process, and
- advice on lost load events during the period 1999 to 2019 which were used to estimate the probability of a major supply disruption in Queensland.

Details of AEMO's advice to the Panel are provided in AEMO's advice report available on the review's project page:https://www.aemc.gov.au/market-reviews-advice/review-system-restart-standard-2020.

AEMO's key contribution was the provision of modelled supply restoration curves for different combinations of units potentially available in Queensland for procurement as SRAS. The supply restoration curves were developed by AEMO for each SRAS procurement option using detailed modelling of the restoration pathways used to re-energise a combined Queensland sub-network. Details of the method used by AEMO to develop the supply restoration curves used by the Panel is available in AEMO's advice to the Panel.

The Panel notes AEMO's use of the latest available information in its modelling to produce supply restoration curves. In particular, the Panel notes AEMO's use of the latest generator and network Local Black System Procedures (LBSPs), and learnings from operational experience when restoring the South Australian power system after the 2016 black system event. In particular, AEMO used a longer network switching time (this refers to the time AEMO takes to progressively re-energise each network element in a restart pathway) in its modelling than the value that was used in 2016. Approximately 10 minutes was allowed to energise one transmission line (branch) during restoration instead of 5 minutes as was used in 2016.[67]

This has impacts on the outcomes of the modelling, resulting in a slower overall restoration and longer restoration timeframe. However, the longer restoration time frame does not result in a lower level of SRAS being procured in a combined Queensland sub-network relative to existing levels for North and South Queensland. Further information on this point is available in section 5.3.

Discussion on use of existing system to develop Standard settings

The Panel has considered the role of the Standard to guide AEMO's efficient procurement of SRAS in the short term, next procurement round, and also incentivise longer term investment in SRAS capabilities. In this regard, the Panel notes a tension that exists between the Standard acting to drive investment in new SRAS capability and Standard settings reflecting existing power system capabilities.

Consistent with the approach used in 2016, the Panel has determined draft Standard settings from system restoration curves produced by modelling restoration using existing SRAS capable generation options. The Panel's draft determination on quantitative Standard settings for a combined Queensland sub-network therefore reflects existing system capabilities appropriate to guide AEMO's next procurement round in 2021. The Panel considers that this is the most appropriate approach to make sure that the system restart capabilities are fit for purpose, but does recognize that this necessitates future changes to the output of the modelling and so the Standard.

The Panel however has identified a need for the Standard to more effectively reflect future system needs in a manner appropriate to guide investment in new SRAS capability. This will be particularly important as existing SRAS capable units retire or otherwise become unavailable. As a result, the approach used to determine quantitative Standard settings will require consideration in the Panel's next fulsome review of the Standard settings in all NEM sub-networks.

67 AEMO, advice to the Reliability Panel, 8 October 2020, p. 3.

The Panel notes the next fulsome review of the Standard will incorporate changes made in the Commission's SRAS rule 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 provided AEMO with scope to enter into longer term contracts for SRAS as a means of incentivising investment in new SRAS capabilities.[68]

Other input assumptions used in the analysis

The Panel made a set of key input assumptions in its analysis. The Panel has utilised assumptions that are consistent with those made in its 2016 review to the extent possible and that reflect NER requirements where relevant. These are:

- The economic assessment is based on a complete blackout of an electrical sub-network. This is the most severe condition that can affect the supply to an individual electrical sub-network. This is also consistent with the requirements of the Rules. [69]
- the restoration of generation and load in the sub-network, is performed assuming that supply from neighbouring sub-networks is not available. This is a requirement set out in the NER.[70]
- there is sufficient redundancy in the transmission network such that there is no impact of transmission network damage on the restart or restoration processes.
- consumer load is assumed to be restored following the restoration of generation within an electrical sub-network with a 90-minute time lag.
- delays or failures of the generation and load restoration process after the end of stage one of the restoration process are ignored.
- each restart service has been assumed to have an availability of 95 per cent; and
- it is assumed that when all restart services in an assessed SRAS portfolio initially fail to operate the power system in an electrical sub-network will be restarted to a minimum level of generation and transmission according to a defined 'default blackout'. T_{max} describes the length of time in which the system must be restarted to avoid a very prolonged restoration process.[71]Consistent with its 2016 review, the Panel has assumed T_{max} to be 10 hours.

68 AEMC, system restart services, standards and testing rule - final determination, p. 57. Changes to the definition of SRAS and to the SRAS Procurement Objective under the final rule provide AEMO with the ability to offer longer term contracts to potential SRAS providers, which increases incentives for new generators to be capable of offering this service.

69 Clause 8.8.3(aa)(2) of the NER.

70 Clause 8.8.3(aa)(2) of the NER.

71 A prolonged restoration is likely to occur as the control and protection systems at the transmission substations rely on emergency supplies (batteries and sometimes backup diesel generator) that only operate for a number of hours without supply from the transmission network

5.2 Stakeholder views on Panel's approach to determining Standard settings for a combined Queensland sub-network

The Panel sought stakeholder views on its approach to determining Standard settings for a combined Queensland sub-network in the review's consultation paper published on 20 August 2020. In particular the Panel sought stakeholder views on the following:

- the method of determining quantitative parameters for a combined Queensland sub-network, in particular, the Panel's proposal to apply the approach used in its 2016 review.
- the approach to applying AER's WALDO VCR estimates to establish quantitative settings for a combined Queensland sub-network.
- inclusion of explicit locational requirements for the procurement of SRAS in a Queensland sub-network.

The Panel received seven submission in response to the review's consultation paper.[72] Stakeholder views relevant to the questions in the Panel's consultation paper are summarised below.

Method of determining quantitative parameters for a combined Queensland sub-network

Stakeholders supported the Panel using its 2016 method to determine draft Standard settings in a combined Queensland sub-network. Specific comments on the method used by the Panel included:

- Origin considered that the Reliability Panel should set Standard requirements for Queensland by combining the quantities currently specified for North and South Queensland. Origin considered that a combined Queensland sub-network should not lead to a reduction in SRAS procured. Origin considered such an approach will maintain consistency with the approach specified for the other sub-networks under the 2016 methodology.[73]
- Delta Electricity considered it may be a more effective SRAS strategy to procure more than what is economically considered necessary to cater for contingent failures possible if fewer sources are procured. Delta energy considered the Standard should ensure the standard can be met even catering for the failure of any party involved in the restart. Delta considered decisions that minimise SRAS costs in preparation for an event will be proven impotent if they result in insufficient or ineffective SRAS delivery or the laws of probability conspire to make a single or dual source ineffective despite compliant testing regimes.[74]
- Delta Electricity emphasised the reliability and timeliness of restoration given power station characteristics that may lead to extended delays if restart sources are delayed in re-energising the power station. Delta identified certain thermal power station

72 Submissions were received from: Origin Energy, Delta Electricity, Snowy Hydro, PIAC, Tesla, AER, and CS Energy.

73 Origin Energy, submission to the consultation paper, p. 1.

74 Delta Electricity, submission to the consultation paper, p. 4.

performance characteristics that may lead to extended delays of days is restart sources are delayed in re-energising the power station.[75]

The Panel notes Origin's proposal to determine Standard settings for a combined Queensland sub-network by combining the existing settings currently specified for North and South Queensland. The Panel is however required to determine the Standard in accordance with the SRAS Objective which is to minimise the expected costs of a major supply disruption to the extent appropriate having regard to the national electricity objective. The Panel is therefore required to perform an economic assessment that considers the specific restart characteristics associated with Queensland as a whole rather than as two separate sub-networks. The Panel has utilised the same approach used in its 2016 review in determining the draft Standard settings presented in this chapter.

The Panel notes Delta Electricity's proposal to require the procurement of more than what is economically considered necessary to cater for the potential failure of restart sources. The Panel considers the reliability of each individual SRAS, and the potential for failures of SRAS in restart when identifying the economically efficient level of SRAS for AEMO to procure. The Panel further determines an aggregate reliability requirement to provide an appropriate minimum level of restart reliability which assumes no restoration from neighbouring sub-networks.

The Panel notes Delta's concern regarding timeliness of restoration given power station characteristics that may lead to extended delays if restart sources are delayed in re-energising the power station. The modelling AEMO undertook to develop the supply restoration curves used by the Panel included individual generator restart time constraints. As a result, these factors have been internalised into the Panel's assessment.

Approach to applying AER's Wide Area Long Duration Outage (WALDO) VCR

The Panel's consultation paper sought stakeholder views on the use of the AER's draft model for estimating the economic costs of Widespread and Long Duration Outages (WALDOs).[76] The Panel's consultation paper requested stakeholder views on how to best apply the WALDO model to establish quantitative Standard settings for a combined Queensland sub-network.

In its submission to the review's consultation paper, the AER announced that it was no longer pursuing development of a WALDO VCR at this time. The AER encouraged the Reliability Panel to use the relevant load weighted averages of the standard VCRs from its 2019 VCR review when valuing unserved energy, similar to the approach used by the Reliability Panel in its System restart standard review 2016.[77]

The Panel will no longer consider WALDO in this review for valuing unserved energy. As recommended, the Panel has used the standard VCRs from the AER's 2019 VCR review in its economic analysis.

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75 Ibid.

76 These are outages of longer duration and/or greater geographical coverage than those considered in the set of VCRs for standard outages. For more information see: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability/updates

77 AER, submission to the consultation paper, p. 1.

Locational requirements

The Panel's consultation paper sought stakeholder views on whether it is necessary to include a locational requirement related to the procurement of SRAS in a combined Queensland sub-network. Views were sought on the proposal put forward by AEMO in its draft SRAS Guideline determination to require the procurement of SRAS 'north of Bundaberg'. Origin Energy and provided the following views:

- Origin Energy supported use of a 'hybrid' approach to determining SRAS settings for a combined Queensland sub-network, similar to the approach currently used in New South Wales. Origin considered that the procurement requirements should specify that enough black start capacity is available for un-supported system restart on both sides of the South Pine - Palmwoods and Halys - Calvale transmission lines natural break point.[78]
- CS Energy identified what it considered to be risks to restarting a single Queensland sub-network from SRAS in the south of the State.[79]

The Panel agrees with Origin Energy and CS Energy that the Queensland power system has characteristics which require consideration of locational SRAS requirements. The Panel notes the breakpoints in the Queensland network on the South Pine - Palmwoods and Halys - Calvale transmission lines and the potential for there to be single points of failure that requires SRAS to be procured outside south Queensland.

The Panel has made a draft determination that includes a specific locational requirement. This requirement incorporates advice provided by AEMO on the scope of that requirement. More details are provided in section 5.3.3.

Scope of technologies considered in Panel assessment

Stakeholders raised a number of other issues relevant to the scope of SRAS sources included in the Panel's economic assessment. These issues include:

- The Public Interest Advocacy Centre (PIAC) recommended the Panel consider interconnectors as a possible SRAS sources when identifying efficient levels of SRAS for AEMO to procure in a sub-network. While PIAC acknowledged that changes to the existing framework would be required for AEMO to procure interconnectors as SRAS sources, they recommended the review examine the issue further to identify how the current framework may be reformed to allow it where appropriate.[80]
- Snowy Hydro suggested that the Panel should in the first instance revise the Standard to include the full range of restart services and then understand if generation participants can respond to the expanded range of services in a reliable and cost-efficient manner.[81]
- Tesla's submission identified its battery systems as capable of providing all services considered by the revised definition of SRAS. It however identified nuances in the definition of black-start, system restart support, restoration services should be considered

78 Origin Energy, submission to the consultation paper, p. 1.
79 CS Energy, submission to the consultation paper, p. 3
80 PIAC, submission to the consultation paper, p. 1.
81 Snowy Hydro, submission to the consultation paper, p. 1.

to ensure AEMO can procure necessary services efficiently, with adequate testing procedures undertaken with potential SRAS providers.[82]

The Panel acknowledges stakeholder views that the wider 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. The Panel however does not consider it possible to identify economically efficient Standard settings that account for these technologies in the absence of experience in their procurement and information on their cost. The Panel therefore considers 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 Panel considers 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.

While the Panel appreciates PIAC's submission regarding the procurement of interconnectors as SRAS sources, the Panel notes that such a change would require a rule change to clause 8.8.3(aa)(2) of the Standard. It also considers PIAC's suggestion to investigate this issue, with a view to informing a future change to the framework, to be best considered in the next review of the Standard. The broad scope of the next review lends itself to consideration of issues that may inform a future rule changes. The limited scope and time available does not provide the opportunity to consider this issue as part of the review.

The Panel notes that a rule change may be required to address Tesla's concerns regarding definition of black-start, system restart support, restoration services. This issue is therefore beyond the scope of this review of the Standard.

5.3 Draft determination on Standard settings in a combined Queensland sub-network

This section presents the Panel's draft determination on Standard settings for a combined Queensland sub-network. The draft determination is set out in the following sections:

- economic analysis of SRAS in a combined Queensland sub-network
- Standard settings for:
  - restoration time and level
  - aggregate reliability, and
  - locational requirements.

5.3.1 Economic analysis of SRAS in a combined Queensland sub-network

This section presents results from the Panel's economic analysis of SRAS in a combined Queensland sub-network. The Panel's analysis identified an efficient portfolio of SRAS units from a set of candidate SRAS in Queensland. Information on this efficient portfolio was used to identify the optimal number of SRAS capable units to procure in a combined Queensland sub-network and Standard settings for restoration timeframe and aggregate reliability. This

82 Tesla, submission to the consultation paper, p. 1.

analysis was performed using the key sources of information identified in section 5.1.3 and according to the method presented in section 5.1.1.

Results are presented for each of the stages of analysis being:

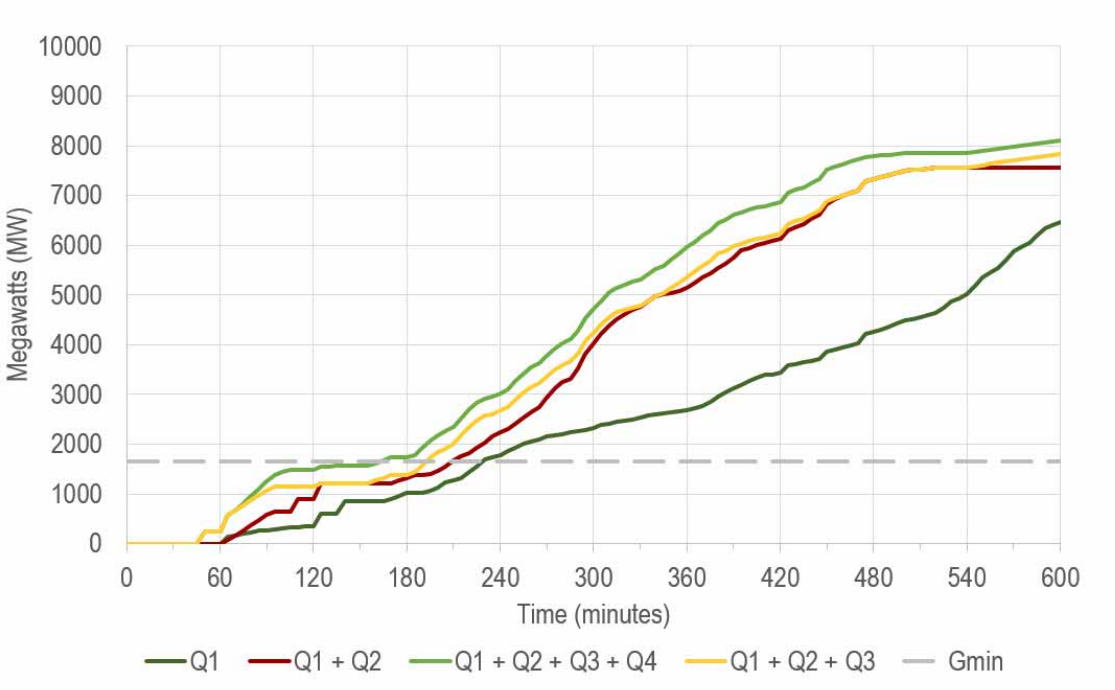
1. Estimate un-served energy for each assessed SRAS procurement option
2. Reliability weight the un-served energy for each SRAS procurement option
3. Value and annualise the un-served energy each procurement option, and
4. Identify efficient level of SRAS in a Queensland sub-network.

Estimate un-served energy for each assessed SRAS procurement option

AEMO provided supply restoration curves for SRAS procurement portfolios made up of generating units from four SRAS capable generating systems in Queensland that were considered to be realistic options for procurement.[83] As information on the cost, location, and performance of the generating units assessed by the Panel is confidential, the units included in these procurement portfolios will be referred to as Q1, Q2, Q3, and Q4.

To illustrate, the supply restoration curves corresponding to the single unit, two unit, three unit, and four unit portfolios with the lowest levels unserved energy are shown in Figure 5.5.

Figure 5.5: Example portfolio supply restoration curves



Reliability Panel from information provided by AEMO

83 AEMO excluded several SRAS capable generators in Queensland on technical or network factors made them impractical for procurement to meet the Standard.

Table 5.1 presents the un-weighted total and marginal levels of unserved energy for each assessed portfolio. These figures assume 100% generator reliability. The 'default blackout' accounts for the case where each of the procured SRAS fail to operate. Section 5.1.3 describes the parameters used to define the default black out.

Table 5.1: Un-weighted unserved energy for each assessed portfolio

SRAS PORTFOLIO	USE (MWH)	MARGINAL USE (MWH)
Default blackout	80,238	
Q1	47,208	33,029
Q1 + Q2	36,081	11,126
Q1 + Q2 + Q3	34,494	1,587
Q1 + Q2 + Q3 + Q4	32,409	2,084

Source: Panel analysis using AEMO information
Note: These figures assume 100% reliability of the SRAS in the assessed portfolio.
Note: The default blackout is identified as the unserved energy arising from the slowest technically feasable SRAS option delayed such that Gmin is reached after 10 hours.

Reliability weight the un-served energy for each SRAS procurement option

The marginal unserved energy listed in Table 5.2 assumes 100% SRAS reliability. The SRAS capable generating units available for procurement in Queensland are not 100% reliable with composite reliabilities of the potential SRAS in Queensland which range from 84.6% to 60.8%.[84]

Results are reliability weighted for each portfolio to account for the probability that SRAS units will fail to deliver as contracted.[85] The un-served energy for each SRAS combination is estimated for each possible combination of available units and multiplied by the probability of that combination occurring during restart. AEMO provided individual supply restoration curves for each combination of available units for this purpose.

Reliability weighted total and marginal unserved energy is presented for the four example portfolios in Table 5.3.

84 Composite reliability is the product of individual reliability and availability. Availability is assumed to be 95%.

85 We have accounted for the reliability of the different SRAS units by assuming the reliability of every unit is independent.

Table 5.2: **Reliability weighted total and marginal un-served energy**

SRAS PORTFOLIO	RELIABILITY WEIGHTED USE (MWH)	RELIABILITY WEIGHTED MARGINAL USE (MWH)
Q1	53,566	26,671
Q1 + Q2	42,158	11,408
Q1 + Q2 + Q3	39,537	2,621
Q1 + Q2 + Q3 + Q4	35,723	3,814

Source: Panel analysis using AEMO information

Value and annualise the un-served energy each procurement option

The reliability weighted unserved energy is valued by multiplying with the VCR for Queensland, and then is annualised using an estimate probability of a black system event in a combined Queensland sub-network. The Panel's base case estimate of the probability of a black system event was calculated as the probability of lost load in excess of the average historical operational demand for Queensland for the period covering financial years 2009-10 to 2019-20.[86] This probability was identified to be 2.24% or around once every 45 years.

The assessed probability of a black system event is sensitive to thresholds used in the analysis.[87] To account for uncertainty in the outcome created through the selection of these thresholds, the Panel conducted a sensitivity analysis by defining upper and lower bounds for the probability of a black system event. The low black system event probability case was set at 50% of the base case for a probability of 1.12% (once every 89 years). The high system black probability case was set at 150% of the base case for a probability of 3.36% (once every 30 years).

The VCR for Queensland is used to value the unserved energy for each SRAS portfolio combination. To be consistent with its approach in 2016, and in the absence of the AER's WALDO model, the Panel has conducted a sensitivity analysis on VCR by defining a range of possible VCR estimates with upper and lower bounds that are +/- 30% different to the central estimate.

86 Average historic demand for Queensland over this period is 6,195 MW.

87 For further information on the thresholds used in the analysis see section 5.1.3. The Panel used the same threshold as Deloitte Access Economics 2016 analysis.

Table 5.3: **Black system event probability and VCR ranges**

	LOW ESTIMATE	CENTRAL ESTIMATE	HIGH ESTIMATE
Annual probability of a black system event	1.12% (1 in 89 years)	2.24% (1 in 45 years)	3.36% (1 in 30 years)
Estimated VCR for Queensland	28,021 ($/MWh)	40,030 ($/MWh)	42,039 ($/MWh)

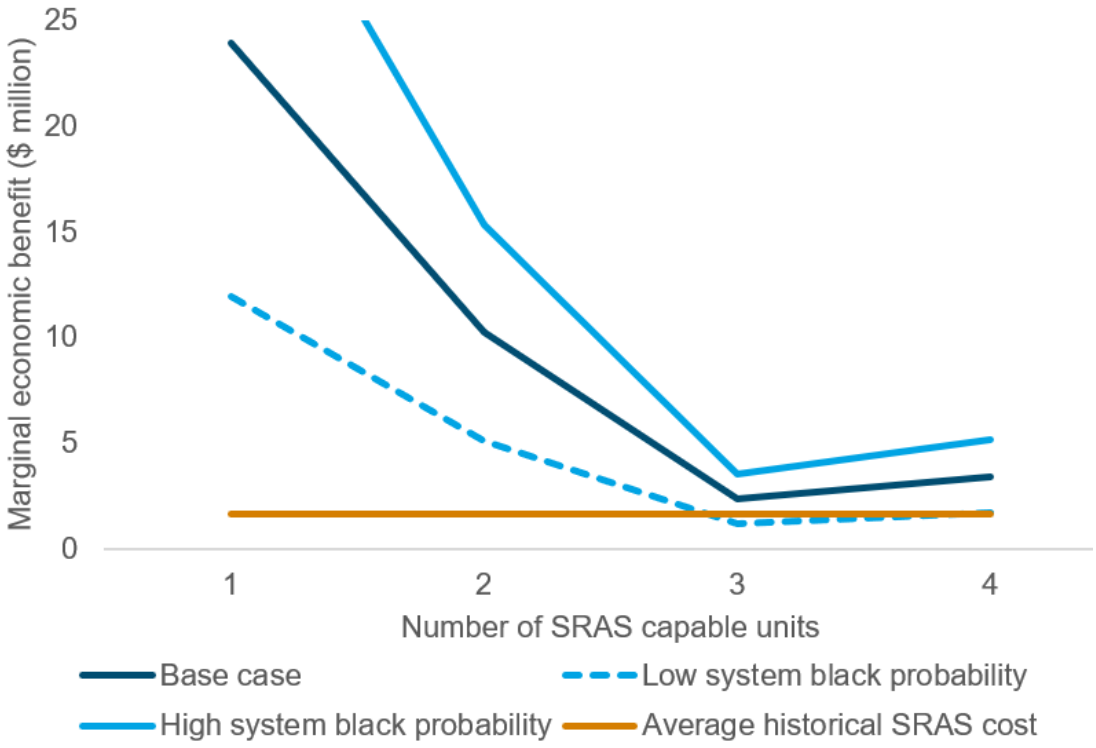
Source: Reliability Panel analysis of AEMO data, AER data

Identify efficient level of SRAS in a Queensland sub-network

The Panel utilised the black system event probability and VCR ranges to obtain the reliability weighted range of value associated with the different portfolio sizes. These results are then compared with the average cost of procuring SRAS in Queensland to identify the efficient level of SRAS in a combined Queensland sub-network.

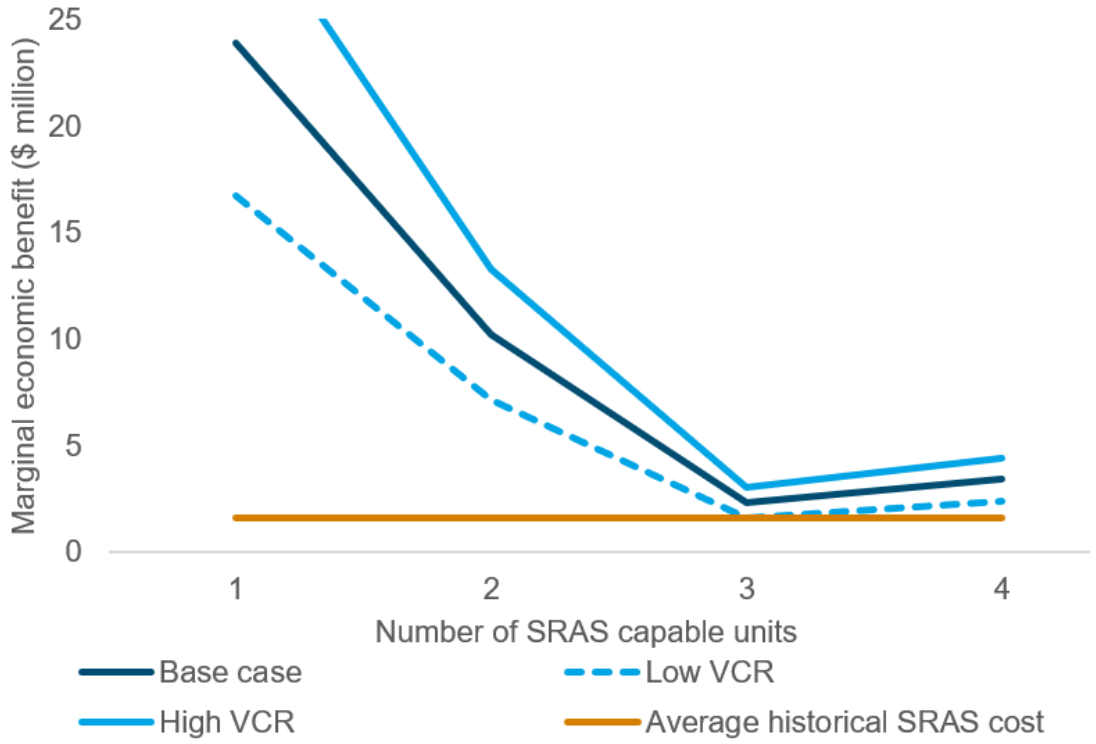
Figure 5.6 compares the range of costs and benefits, from which the efficient number of SRAS units can be identified accounting for uncertainty in the probability of a black system event. Figure 5.7 compares the same range of costs and benefits, accounting for uncertainty in the VCR.

Figure 5.6: Marginal benefit of procuring different levels of SRAS in Queensland given uncertainty in the probability of a black system event



Source: Reliability Panel analysis

Figure 5.7: Marginal benefit of procuring different levels of SRAS in Queensland given uncertainty in the VCR accounting for social costs



Source: Reliability Panel analysis

As more units of SRAS are added, the marginal economic benefit decreases, and in most cases, the uncertainty narrows. This is mainly due to the reduced weight of the "default" blackout cost as more SRAS are added to the mix. The minimum marginal benefit is observed for the procurement of three SRAS units with an increase then observed for the procurement of a fourth unit.

The marginal benefit for the central case investigated by the Panel exceeds the average cost for AEMO to procure a unit of SRAS in Queensland regardless of the number of units procured. The only exception is the low system black probability case which is observed to be slightly less than the average SRAS cost for the three unit case. Due to data limitations and the combinatorial nature of the exercise we have been unable to assess the benefits and costs of a fifth SRAS unit.

From the results presented in Figure 5.6, the optimal portfolio for a combined Queensland subnetwork, from which Standard settings are derived, comprise four units from at least three separate power stations.

It should be noted that the Standard does not require AEMO to procure the number of units identified in this assessment. This assessment is made by the Panel for use in determining

restoration timeframe, MW restoration level, and aggregate reliability settings rather than the outcome of AEMO's procurement process. AEMO is required to procure SRAS in accordance with the SRAS procurement objective sufficient to achieve the Standard settings identified in section 5.3.2. The actual number and location of the SRAS procured by AEMO will depend on contractual negotiations between AEMO and potential SRAS providers the details of which are not available to the Panel for this assessment.

5.3.2 Draft determination of Standard settings for a combined Queensland sub-network

This section presents the Panel's draft determination on quantitative Standard settings for a combined Queensland sub-network. In accordance with its obligations under the NER, the Panel has set the Standard to minimise the expected costs of a major supply disruption to the extent appropriate having regard to the national electricity objective. The Panel has utilised results from its economic assessment, and the resulting supply restoration curves, to determine these settings.

The draft determination includes Standard settings for:

- Restoration level and timeframe,
- aggregate reliability, and
- locational requirements.

Restoration level

The Panel's approach is to set the restoration level for a combined Queensland sub-network at G_{min} (MW) which is the threshold for generation restoration, beyond which the auxiliary loads of all major power stations can be energised and the ongoing restoration of the power system can proceed without the need for SRAS.

G_{min} is determined by AEMO from modelling of the restoration process. AEMO's advice to the Panel was for G_{min} of 1650MW in a combined Queensland sub-network. AEMO identify this nominated value of 1650 MW to be the combination of the existing restoration levels for Queensland North and Queensland South electrical sub-networks. In providing its advice to the Panel AEMO considered it important to set a G_{min} that will provide confidence for the market that there will be no degradation in service levels arising from the combination of the sub-networks relative to existing Standard requirements.

Consistent with the approach utilised in its 2016 review, the Panel's draft determination is to set the restoration level to G_{min} as advised by AEMO.

> BOX 11: PANEL'S DRAFT DETERMINATION ON RESTORATION LEVEL
>
> The Panel's draft determination is to set the restoration level for a combined Queensland sub-network to 1650 MW.

Restoration timeframe

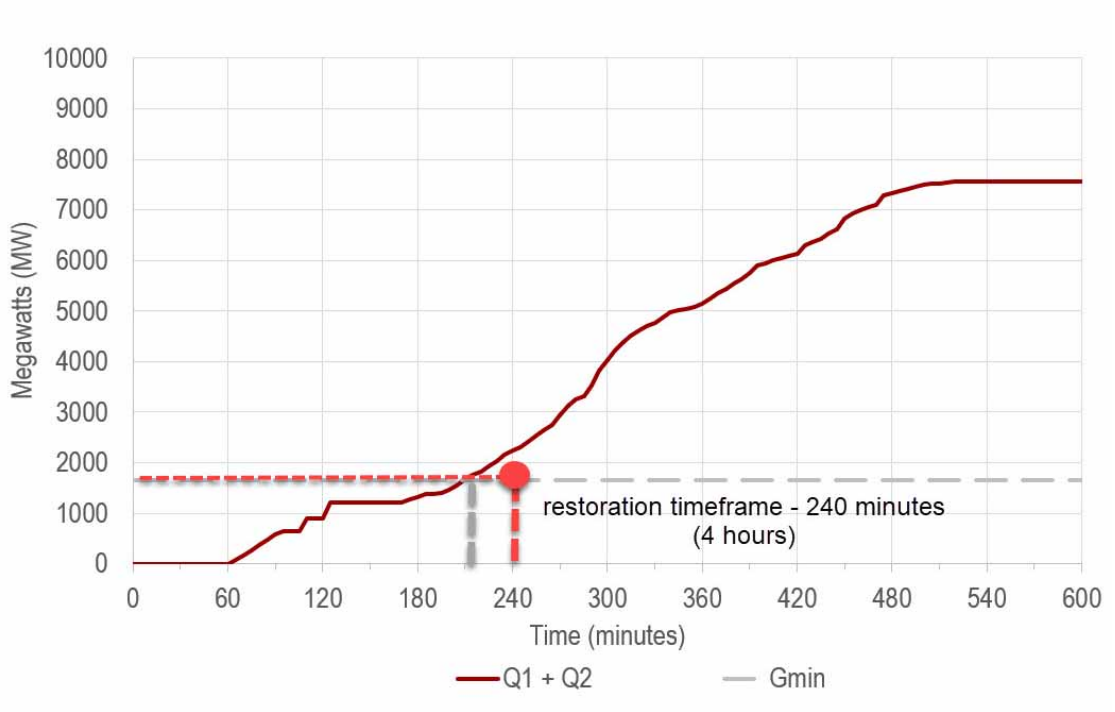
The restoration timeframe, in hours, represents the technically feasible time, T_{min}, to restore the power system to the level where available generation capacity exceeds G_{min}, plus a margin to account for uncertainty. Consistent with the approach taken in its 2016 review, and described in section 5.1, the Panel has set the restoration time as the time taken by the slowest technically feasible combination of SRAS in the optimal portfolio to re-energise the power system to G_{min} plus a buffer of 15 minutes, rounded up to the nearest half hour.

The slowest feasible combination of SRAS in the optimal portfolio, excluding single unit sources, is identified from the economic analysis as a two unit combination Q1 and Q2 which takes 210 minutes, 3.5 hours, to re-energise the power system to G_{min}. The resulting restoration timeframe for a combined Queensland sub-network is therefore 4 hours. Figure 5.7 depicts the relationship between the supply restoration curve, T_{min}, and restoration timeframe.

The Panel notes that a 4 hour restoration timeframe is longer than existing standard arrangements which are 3.5 hours for North Queensland and 3.0 hours for South Queensland. AEMO's advice to the Panel identifies a slower supply restoration process due to changes in network switching practices made following the South Australia following the black system event on 28 September 2016.[88] While there is a longer restoration timeframe specified for a combined Queensland sub-network, this does not mean there will be a reduction in the actual level of SRAS delivered relative to that achieved from existing Standard settings. The Panel notes that its estimate of efficient levels of SRAS in a combined Queensland subnetwork is for the procurement of units from at least three separate power stations, as currently procured across both North and South Queensland.

88 AEMO, advice to the Reliability Panel, 8 October 2020, p. 3.

Figure 5.8: Restoration timeframe



Source: Reliability Panel analysis from AEMO data

BOX 12: PANEL'S DRAFT DETERMINATION ON RESTORATION TIMEFRAME

The Panel's draft determination is to set the restoration timeframe for a combined Queensland sub-network to 4 hours.

Aggregate reliability

Aggregate reliability specifies the probability that AEMO's procured SRAS will achieve the restoration level within the restoration timeframe. Aggregate reliability is an important driver for the number of restart services, as a higher level of aggregate reliability requires AEMO to either procure more reliable or additional restart services to meet the aggregate reliability requirement.

The Panel used the reliability of the SRAS procurement options considered in the economic assessment when determining an aggregate reliability setting for a combined Queensland sub-network. The reliability weighted probability that a four unit SRAS portfolio reaches the restoration level within the restoration timeframe is 96%. By contrast, the aggregate reliability of the three unit combinations ranged between 90% and 51%. Therefore, an aggregate reliability requirement of 90% in a combined Queensland sub-network is likely to

require AEMO to procure units from at least three separate power stations. This is consistent with the Panel's economic analysis of the optimal portfolio of SRAS units.

The Panel has therefore determined to maintain the aggregate reliability setting for a combined Queensland sub-network at 90% which is the same level currently set for North and South Queensland electrical sub-networks. In making this draft determination, the Panel considered an aggregate reliability of 90%:

- is not so high as be likely to unduly restrict the potential restart services that AEMO could procure; and
- meets stakeholders' expectations for SRAS reliability, while being consistent with the economic assessment.

BOX 13: PANEL'S DRAFT DETERMINATION ON AGGREGATE RELIABILITY

The Panel's draft determination is to set the aggregate reliability requirement for a combined Queensland sub-network to 90%

5.3.3 Locational requirements in a combined Queensland sub-network

The Panel has made a draft determination to include a requirement for AEMO to procure SRAS north of Bundaberg. The Panel has included this requirement for the following reasons:

- The efficient SRAS portfolio identified by the Panel includes an SRAS unit north of Bundaberg
- Significant cost savings are identified arsing from a faster and more reliable restoration given procurement of an SRAS north of Bundaberg.
- Stakeholder concern regarding major industrial loads and possible technical risks in relying on restoration solely from South Queensland.

Locational requirements in the Standard

The Standard includes qualitative guidelines that require AEMO to consider the strategic location of SRAS, based on an assessment of how the geographical and electrical location of an SRAS source best facilitates power system restoration. The Standard also includes guidelines that require AEMO to address diversity of the electrical characteristics and energy sources of SRAS within a sub-network.

In addition to the general guidance provided to AEMO on diversity and strategic location, the Panel may also prescribe specific locational requirements for a sub-network. As an example, in 2016 the Panel determined to include a requirement for AEMO to procure SRAS in New South Wales sufficient to independently restart 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.

The Panel identified the long distance between the large generators in the Hunter Valley and hydro-generation in the south as potentially leading to unacceptably long delays in restarting

generators in the Hunter Valley area in the absence of an SRAS generator being located north of Sydney. The requirement in the Standard that AEMO procure SRAS north of Sydney addressed this risk by making sure that auxiliary power is returned to the Hunter Valley generators quickly, as delays of up to 12 hours can result from a cold restart.

AEMO recommendation and stakeholder views on a locational SRAS requirement for Queensland.

In its advice to the Panel for the review, AEMO recommended the Panel impose a locational requirement for SRAS to be procured north of Bundaberg capable of restoring 825 MW of generation, within 4 hours, with an aggregate reliability of at least 80%.

AEMO's final determination to combine the two Queensland sub-networks noted that the procurement of at least one SRAS resource in central Queensland may preserve the perceived benefit of retaining two sub-networks, while also allowing the benefits of combining the sub-networks to be realised.[89] AEMO also identified that a requirement for AEMO to procure SRAS north of Bundaberg may provide stakeholders with additional confidence about the outcomes of AEMO's SRAS procurement.

In its advice to the Panel, AEMO identified its recommended parameters as being based on currently available SRAS (black start) capable sources north of Bundaberg, their capabilities and reliability data obtained during the 2015 and 2018 procurement process.

Stakeholders supported the proposal for a locational requirement for SRAS north of Bundaberg in the submissions recieved to the review's consultation paper. Stakeholders raised the following points in submissions supporting the proposal:

- Origin Energy supported use of a 'hybrid' approach to determining SRAS settings for a combined Queensland sub-network, similar to the approach currently used in New South Wales.[90]
- CS Energy identified what it considered to be legitimate risks to restarting a single Queensland sub-network from SRAS in the south of the State.[91]

Panel considerations and draft determination

The Panel may consider a range of factors when deciding whether to impose a locational requirement in a sub-network including whether there are significant economic, and power system considerations and a need for stakeholder confidence in a particular SRAS procurement outcome.

The Panel's efficient portfolio of SRAS includes located in Central Queensland and the identified increase in consumer costs, noted above, indicates that a restoration strategy solely from the south is sub-optimal and not consistent with the Panel's obligation to set the Standard to minimise costs.

89 AEMO considered that combining the sub-networks will reduce any inefficiency created by allocating SRAS exclusively to a single sub-network and will allow increased restoration path flexibility and better access to stabilising loads. AEMO considered this flexibility will be of benefit both under conditions where system restoration is required in any given part of the Queensland power system, or if necessary, to restart the entire system

90 Origin Energy, submission to the consultation paper, p. 1.

91 CS Energy, submission to the consultation paper, p. 3.

The Panel notes that characteristics of the Queensland network may result in a slow restoration of the north under some circumstances if restart sources solely located in the South are utilised. As an indication of the potential benefit of procuring a SRAS unit in the north, relative to restoring solely from SRAS in the south of the state, the Panel identified additional customer benefit equal to $8.8 million.[92]

In making its draft determination the Panel also notes AEMO's advice and stakeholder views on the importance of SRAS procured north of Bundaberg. In particular the Panel notes stakeholder views on the technical risks of relying on restarting from the South, and concerns regarding the timeliness of restoring supply to major loads located in central Queensland.

The Panel has therefore made a draft determination to require AEMO to procure SRAS north of Bundaberg.

BOX 14: PANEL'S DRAFT DETERMINATION ON LOCATIONAL REQUIREMENTS FOR SRAS NORTH OF BUNDABERG

The Panel has made a draft determination to require AEMO to procure SRAS north of Bundaberg capable of restoring 825 MW of generation, within 4 hours, with an aggregate reliability of at least 80%.

92 the expected customer value of lost load for two cases: the best assessed case of two SRAS sources (one in the north and one in the south, and the best assessed case of two SRAS sources in the south.

ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
Commission	See AEMC
NEL	National Electricity Law
NEO	National electricity objective
NGL	National Gas Law
SRAS	System Restart Ancillary Services
NSP	Network Service Provider
MW	Megawatts
MWh	Megawatt-hour
GWh	Gigawatt-hour
VCR	Value of Customer Reliability
WALDO	Wide Area Long Duration Outage
PIAC	Public Interest Advocacy Centre