RELIABILITY PANEL AEMC

DETERMINATION

Reliability Panel AEMC

FINAL REPORT

SYSTEM RESTART STANDARD REVIEW 2020

28 JANUARY 2021

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

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SUMMARY

1 This report sets out the Reliability Panel's final review of the System Restart Standard (Standard) determination on changes to Standard settings for the Queensland sub-network of the NEM. This element of the review – which was only of the Queensland sub-network – followed the Australian Energy Market Operator's (AEMO) decision in October 2020 to combine the existing north and south Queensland sub-networks to form a single Queensland sub-network. A more fulsome review of the Standard will occur following AEMO's next procurement round.

2 The Standard provides qualitative guidance and prescribes quantitative settings to guide AEMO's procurement of System Restart Ancillary Services (SRAS). SRAS are special resources able to commence the process of 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. 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.

3 The NEM is divided into electrical sub-networks for SRAS procurement purposes. The NEM's regulatory framework provides 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 sub-networks, being north Queensland and south Queensland, into a single subnetwork in the Queensland region of the NEM. The Standard applying at the time, which was determined by the Panel in December 2016, specified quantitative settings for restoration level, restoration time frame, and aggregate reliability separately for the north Queensland and south Queensland sub-networks. Amendments to the quantitative settings for Queensland in the Standard was 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.

4 The Panel is 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.[1] 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 final determination. This updates the standard settings for restoration level, restoration timeframe and aggregate reliability.

5 In addition to the updated Standard settings, the Panel's final determination includes an additional locational requirement for AEMO to procure at least one SRAS source north of

1 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.*

Bundaberg. The Panel has identified such a requirement to be consistent with the SRAS Objective to minimise the expected costs AEMO's procurement of SRAS. A locational requirement for AEMO to procure SRAS north of Bundaberg would also enhance the security of the restoration process given potential difficulty in restoring the former north Queensland sub-network exclusively from resources in the south of the state under certain circumstances. AEMO provided advice to the Panel on the characteristics of this requirement.

6 The Panel's final determination on quantitative Standard settings for a combined Queensland sub-network are summarised in Box 1. The Panel has determined these settings using an approach consistent with the method used in its 2016 review of the Standard, but using updated information and inputs in the modelling. This updated information incorporated learnings from the South Australian black system event in 2016 and revised information from updated generator local black start procedures.

7 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, modelling used longer network switching times than were used in 2016. This impacted the Standard settings. While the level of SRAS being procured in a combined Queensland sub-network is similar to the levels for north and south Queensland in the previous Standard, 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 1: FINAL DETERMINATION ON QUANTITATIVE STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

The Panel has made a final 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: Final 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

8 The Standard that is the subject of this final determination becomes effective following its publication on 28 January 2021. AEMO will then procure SRAS in Queensland in accordance with the published Standard settings for the combined Queensland sub-network as part of its 2021 SRAS procurement process. Following the conclusion of AEMO's 2021 procurement round, the Panel intends to conduct a fulsome review of the Standard settings applying to all NEM sub-networks. The Panel will update stakeholders on the anticipated timing of this fulsome review during 2021.

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1 INTRODUCTION

This report sets out the Reliability Panel's final System Restart Standard (Standard) review determination on changes to the Standard settings for the Queensland sub-network of the NEM.

This chapter provides background and introduces the review and its elements including:

- introduction to SRAS and the Standard
- scope of the review
- the review process, and
- structure of the determination.

1.1 Introduction to SRAS and the System Restart Standard

The Standard is determined by the Reliability Panel (Panel) and provides guidance and sets requirements for the Australian Energy Market Operator's (AEMO) procurement of System Restart Ancillary Services (SRAS). This section provides a brief introduction to the role and function of SRAS and the Standard. Further information is provided in Chapter 3 and Appendices A and B.

AEMO is responsible for procuring SRAS to meet the standard for the purpose of re-establishing supply following a major supply disruption or black system event.[2] SRAS is provided by generators, and other facilities, that are capable of restarting themselves without drawing power from the network or are able to support the process of restoration.[3] AEMO procures SRAS from market participants in the NEM on commercial terms and enters into contracts for SRAS through periodic rounds of procurement.

The Standard sets quantitative requirements and provides qualitative guidance applying to AEMO's procurement of SRAS. The Standard's quantitative requirements are for AEMO to procure sufficient SRAS to achieve a minimum level of re-energisation following a major supply disruption or black system event within a minimum timeframe to a specified level of reliability. Qualitative guidance is also provided on AEMO's interpretation of Standard requirements and considerations in determining sub-network boundaries, and diversity of and strategic location of SRAS in the network. AEMO is required to develop a system restart plan for each 'sub-network' in the NEM that is consistent with the qualitative and quantitative requirements of the Standard.[4]

The Standard applies to 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

2 Clause 3.11.7(a1) of the NER.

3 The NER definition of SRAS in Chapter 10 provides for two types of SRAS being black start SRAS which is able to commence the process of restoration and restoration support services which are a new type of SRAS that support the stable restoration of the grid. The definition of SRAS was updated in the Commission's system restart standards and testing rule (SRAS Rule) published on 2 April 2020.

4 Clause 4.8.12(c) of the NER.

Standard does not set operational targets to be achieved during an actual restoration event.[5] AEMO is therefore 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.

The NEM is divided into electrical sub-networks for the purposes of AEMO's preparations for system restoration and procurement of SRAS.[6] AEMO is responsible for determining the sub-network boundaries and the Standard's quantitative requirements apply uniformly across a sub-network.[7] The selection of locations for SRAS within a sub-networks is left to AEMO's discretion, subject to the Standard's qualitative guidance on assessing diversity of services and strategic location of services. While the Standard's quantitative settings apply uniformly across a sub-network, the Panel can impose locational requirements for AEMO to procure minimum levels of SRAS in certain locations within a sub-network. In 2016, the Panel imposed a locational requirement for AEMO to procure a minimum level of SRAS from at least one source north of Sydney and within the NSW sub-network.[8]

Following AEMO's determination on 16 October 2020 to combine the former north and south Queensland SRAS sub-networks into a single combined sub-network covering the state of Queensland,[9] SRAS sub-networks are now aligned with each region of the NEM. The quantitative Standard settings applying prior to this determination for each sub-network in the NEM, including the now redundant north and south Queensland sub-networks, are set out in Table 1.1 below. These quantitative settings were implemented in the final determination of the Panel's 2016 review of the Standard, which was the last time the Standard was comprehensively reviewed for all regions.[10] The Panel's final determination is to replace these Standard settings applying to north and south Queensland with new settings for a single Queensland sub-network in order to update the Standard for AEMO's recent decision to create a single Queensland sub-network.

Table 1.1: **Former 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%

5 It should also be noted that the Standard's quantitative settings do not specify the level of load that needs to be restored. The Standard is specified in this manner as: 1) the Rules require that the Standard is specified in terms of the maximum amount of time to restore supply, which is defined in chapter 10 of the Rules as "the delivery of electricity"; 2) the Rules make it clear that the purpose of SRAS is to restart the power system in the affected electrical sub-network so that further generation can be restarted and so that load can ultimately be restored; and 3) .the process for reconnecting load is managed by the distribution network businesses, and so is beyond AEMO's direct control.

6 Clause 3.11.8(a) of the NER.

7 Clause 3.11.8(b) of the NER.

8 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.

9 AEMO, SRAS Guideline consultation - final determination.

10 AEMC Reliability Panel 2016, System Restart Standard, Final Determination, 15 December 2016.

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

1.2 Scope of the review

On 24 June 2020, the Commission provided terms of reference to the Panel to initiate a review of the Standard, which was necessary following the Commission's recent final determination on its *System restart services, standard and testing* rule.[11] This section summarises the scope of the review and role of this final determination in satisfying the review's terms of reference.

The Commission requested the Panel undertake a limited review of the Standard on this occasion. The scope of this review was limited by the need to conclude the review prior to AEMO commencing its next round of SRAS procurement in early 2021. Given the limited time available for the review, terms of reference requested the Panel focus on the review on amending the Standard to:

- publish an interim Standard by 2 November 2020 updating relevant qualitative elements of the Standard to reflect changes made to include system restoration support services in the definition of SRAS under the NER as a consequence of the recent National Electricity Amendment (System restart services, standards and testing) Rule 2020 (SRAS rule).[12]
- amend 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 be published in early 2021.

The first element of the review's scope, being to update relevant qualitative elements of the Standard to reflect changes made in the Commission's SRAS rule to make sure the SRAS framework was still fit for purpose given the changing generation mix was finalised in the Panel's final determination for this element published on 29 October 2020.[13] Further

11 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 Standard.

12 The Commission's SRAS rule (available at: https://www.aemc.gov.au/rule-changes/system-restart-services-standards-and-testing) made a number of changes to the SRAS frameworks in the NER. 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

13 These amendments were to remove any language that was inappropriate or imposed barriers to AEMO's procurement of non-traditional black start service providers and/or system restoration support services provided for by the Commission's SRAS Rule.

information on amendments to the Standard's qualitative guidance to account for changes made in the Commission's SRAS rule can be found at: https://www.aemc.gov.au/market-reviews-advice/review-system-restart-standard-2020

This final determination is in respect of the second element of the Commission's terms of reference. 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] As the rules require AEMO to procure SRAS in accordance with the quantitative targets set out in the Standard, the existing Standard required amendment to specify specific requirements applying to a combined Queensland sub-network. This amendment is necessary for AEMO to procure SRAS in Queensland following its determination to combine the Queensland sub-networks. As required by the review's terms of reference, the Panel has determined and published quantitative requirements for a single Queensland sub-network in this final determination. This final determination follows the Panel's draft determination on quantitative Standard settings for a combined Queensland sub-network which was published on 29 October 2020.

1.3 The review process

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 1.2:

- **Stage 1** - publication of a final determination and interim Standard, which updated relevant qualitative elements of the Standard to reflect changes made in the SRAS rule. Review Stage 1 was completed on 29 October 2020 with the publication of a determination and interim Standard.
- **Stage 2** - a final Standard in January 2021, which updates the quantitative Standard settings for a combined Queensland sub-network. The publication of this final determination completes Stage 2 of the review.

In carrying out this Review, the Panel followed 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 1.2.

Table 1.2: Review process table

MILESTONES	DETAILS	KEY DATES
Consultation paper publication	A consultation paper was published giving notice to all registered participants of commencement of this review	20 August 2020

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. Further information on AEMO's determination can be found at: https://aemo.com.au/en/consultations/current-and-closed-consultations/sras-guideline-2020

MILESTONES	DETAILS	KEY DATES
	and invited submissions on key issues and questions for a period of four weeks.	
Interim Standard and final determination publication on changes to qualitative elements of the standard	An interim Standard and final determination were published updating relevant qualitative elements of the Standard to reflect the Commission's amendment to the definition of SRAS in its SRAS Rule.	29 October 2020
Draft determination publication on changes to quantitative Standard settings for a combined Queensland sub-network	A draft determination was published setting out proposed restoration timeframes, restoration level and aggregate reliability requirements for a combined Queensland sub-network. This draft determination was published alongside and at the same time as the final determination and interim Standard on changes to qualitative elements of the standard.	29 October 2020
Submissions close	Submissions closed on the draft determination on quantitative Standard settings for a combined Queensland sub-network. Three submissions were received to the Panel's draft determination.	26 November 2020
Final determination and Standard published on changes to quantitative Standard settings for a combined Queensland sub-network	Publish a final determination and final Standard setting out proposed restoration timeframes, levels of restoration and aggregate reliability requirements for a combined Queensland sub network.	28 January 2020

1.4 Stakeholder views and the Reliability Panel's draft determination

The Reliability Panel has made this final determination on Standard settings for a combined Queensland sub-network following consideration of stakeholder views expressed in submissions to the review's draft determination and consultation paper. The Panel presents specific stakeholder views in Chapters 3 and 4 when presenting its considerations in making this final determination.

1.5 Determination structure

The remainder of this final determination is structured as follows:

- Chapter 2 - Final determination
- Chapter 3 - Quantitative standard settings for a combined Queensland sub-network
- Chapter 4 - Additional locational requirements for AEMO's procurement of SRAS in Queensland

Additional information is provided in the following appendices

- Appendix A - Background to SRAS frameworks
- Appendix B - Modelling approach and method
- Appendix C - Economic assessment outcomes

2 FINAL STANDARD DETERMINATION

The Panel has made a final determination to amend the Standard's quantitative arrangements applying to AEMO's procurement of SRAS in Queensland. The Panel has made its final determination in line with the review's terms of reference, NER requirements, and following consideration of stakeholder submissions to the Panel's consultation paper and draft determination.

This chapter presents the Panel's final determination and contains:

- the Panel's final determination on Standard settings for a combined Queensland sub-network
- the SRAS Objective and assessment framework used by the Panel, and
- a summary of the Panel's reasons in making its final determination.

2.1 The Panel's final determination on Standard settings for a combined Queensland sub-network

This section summarises the Panel's final determination on quantitative Standard settings for a combined Queensland sub-network. A summary of reasons is provided in section 2.3 with the Panel's detailed considerations in making this final determination provided in Chapters 3 and 4.

The Panel's final determination is to amend Table 1 in the Standard to replace the existing quantitative requirements specified for the north and south Queensland sub-networks of the NEM with the restoration level, restoration timeframe and aggregate reliability requirements specified in Box 1 below for the combined Queensland sub-network.

In addition, the Panel has also made a final determination to amend Section 5 of the Standard on the 'applicability of the standard in electrical sub-networks' to impose a locational requirement for AEMO to procure a minimum level of SRAS north of Bundaberg, which is also set out in Box 2.

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

Table 2.1: Quantitative targets for a combined Queensland sub-network - Table 1

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

Amendment to Section 5 - applicability of the standard in electrical sub-networks:

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

2.2 Assessment framework

This section sets out the assessment framework used by the Panel in making its final determination. The following are described:

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

2.2.1 The SRAS Objective and National Electricity Objective

The NER requires the Panel to determine the Standard in accordance with the SRAS Objective specified in Chapter 10 of the NER and set out below:[15]

> *"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.

The Panel is also 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 the efficient investment in, and operation of, electricity services, particularly with respect to the price of SRAS, reliability, and the safety, and security of supply.

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

2.2.2 Requirements of the NER and terms of reference applying to the Panel's determination of the Standard

The Panel has made a final determination for the Queensland sub-network consistent with the following specific NER requirements applying to the Standard:[16]

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

In this review, the Panel has determined a Standard for the Queensland sub-network that addresses 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.

2.2.3 Other factors relevant to the Panel's determination

The Panel has also considered a number of other factors relevant to addressing the scope of the review (i.e. settings for the Queensland sub-network) in making its final determination. These other factors include:

- 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 time frame for system restoration
- critical time frames for re-energisation of non-SRAS generating systems

16 Clauses 8.8.3(aa)(2) to (7) of the NER.

- 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.

2.3 Summary of reasons

The Panel made this final determination following consideration of stakeholder submissions to its draft determination. This section summarises the Panel's reasons for making its final determination. Detailed considerations are provided in Chapters 3 and 4.

This summary of reasons sets out how the Panel has applied the key elements of the assessment framework including its consideration of the SRAS Objective and National Electricity Objective, specific NER requirements, and other factors in making the final determination for the Queensland sub-network presented in section 2.1.

Quantitative standard settings for a combined Queensland sub-network

The Panel's final determination is the same as its draft determination. The Panel notes that no stakeholder objections were raised to its draft determination Standard settings for a combined Queensland sub-network.

The Panel considers that its final determination on restoration level, restoration timeframe, and aggregate reliability for a combined Queensland sub-network are consistent with the SRAS Objective and the specific requirements for the Standard for the following reasons:

- Standard settings are determined from an economic assessment that minimises the expected costs of a major supply disruption or black system event. Specifically, the economic assessment allowed the restoration time and aggregate reliability to be identified from the system restoration curves and individual unit reliabilities associated with the efficient portfolio of SRAS.
- The Panel has had regard to the NEO in making its final determination. In particular, the efficient operation of, electricity services, particularly with respect to the price of SRAS and the reliability, safety, and security of supply. In particular, the Panel has had regard to the reliability, safety and security of supply during restoration following a black system event through AEMO's modelling and advice on the restoration level required to support ongoing restoration, system restoration curves that include unit constraints and limitations, and network switching assumptions that reflected latest understanding on practical circumstances that apply during system restoration following a black system event.
- The Panel has determined changes to the Standard that satisfy the specific NER requirements set out in clauses 8.8.3(aa)(2) to (4) of the NER. In particular, the Panel has:[17]

17 NER requirements set out in clauses 8.8.3(aa)(5) to (7) are relevant to qualitative guidance and are not relevant to the determination of quantitative Standard settings for a combined Queensland sub-network.

- identified the maximum amount of time within which system restart ancillary services are required to restore supply in an electrical sub-network to a specified level, under the assumption that supply (other than that provided under a system restart ancillary services agreement acquired by AEMO for that electrical sub-network) is not available from any neighbouring electrical sub-network and include the aggregate required reliability of system restart ancillary services for each electrical sub-network,[18]
- conducted modelling which reflects the technical system limitations and specific economic circumstances that apply in a Queensland sub-network. The Panel has used Queensland specific SRAS cost and VCR information in its economic assessment. The treatment of technical system limitations are addressed in the locational requirement set out in Chapter 5.[19]

Locational requirements

The Panel's final determination on locational requirements for AEMO's procurement of SRAS north of Bundaberg is also the same as its draft determination. The Panel notes that all stakeholders who expressed a view supported the proposed requirement.

The Panel considers that its final determination locational requirement for the combined Queensland sub-network is consistent with the SRAS Objective, NEO and the specific NER requirements for the Standard for the following reasons:

- In making this final determination, the Panel agrees with AEMO that imposing a locational requirement to procure a minimum level of SRAS north of Bundaberg allows the operational benefits of combining the sub-networks to be achieved while also providing equivalent levels of SRAS north of Bundaberg as was the case prior to AEMO's determination to combine the sub-networks.
- In this regard, the Panel's final determination is for AEMO to procure SRAS sufficient to restart 825 MW of generation capacity north of Bundaberg which is in line with the MW restoration level specified for the former north Queensland sub-network. AEMO's justification for combining the former north and south Queensland sub-networks was to allow increased restoration path flexibility and better access to stabilising loads. The Panel considers that the locational requirement in the final determination will provide for a more stable and secure restoration while also providing stakeholders confidence in the level of SRAS procured north of Bundaberg.
- The Panel considers its final determination locational requirement to be consistent with the SRAS Objective to minimise the expected cost of a major supply disruption. The procurement of SRAS north of Bundaberg is consistent with the optimal portfolio identified in the Panel's economic assessment. In addition, the Panel's economic assessment identified significant cost savings from the procurement of at least one unit of SRAS north of Bundaberg relative to the case when all SRAS is procured in the south of the state. The final determination locational requirement is therefore consistent with a lowest cost outcome.

18 Clause 8.8.3(aa)(2) to (3) of the NER.

19 Clause 8.8.3(aa)(4) of the NER.

- The Panel acknowledges stakeholder observations that network limitations may make the restoration of the central and northern Queensland regions exclusively from SRAS in the south challenging, if not impossible in certain circumstances. The Panel does not consider such an outcome to be consistent with the NEO as it is inconsistent with the system security objective of the NEO. Therefore, the Panel's locational requirement addresses these concerns.

3 STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

This chapter provides details of the Panel's considerations in making its final determination on quantitative Standard settings for a combined Queensland sub-network. The chapter is divided into the following sections:

- approach to determining quantitative Standard settings
- draft determination on Standard settings
- stakeholder views, and
- final determination on Standard settings.

3.1 Approach to determining quantitative Standard settings

This section summarises the Panel's approach to determining quantitative Standard settings for restoration level, timeframe, and aggregate reliability for a combined Queensland sub-network in accordance with the SRAS Objective and other requirements of the NER.

3.1.1 Approach to the satisfying the SRAS Objective

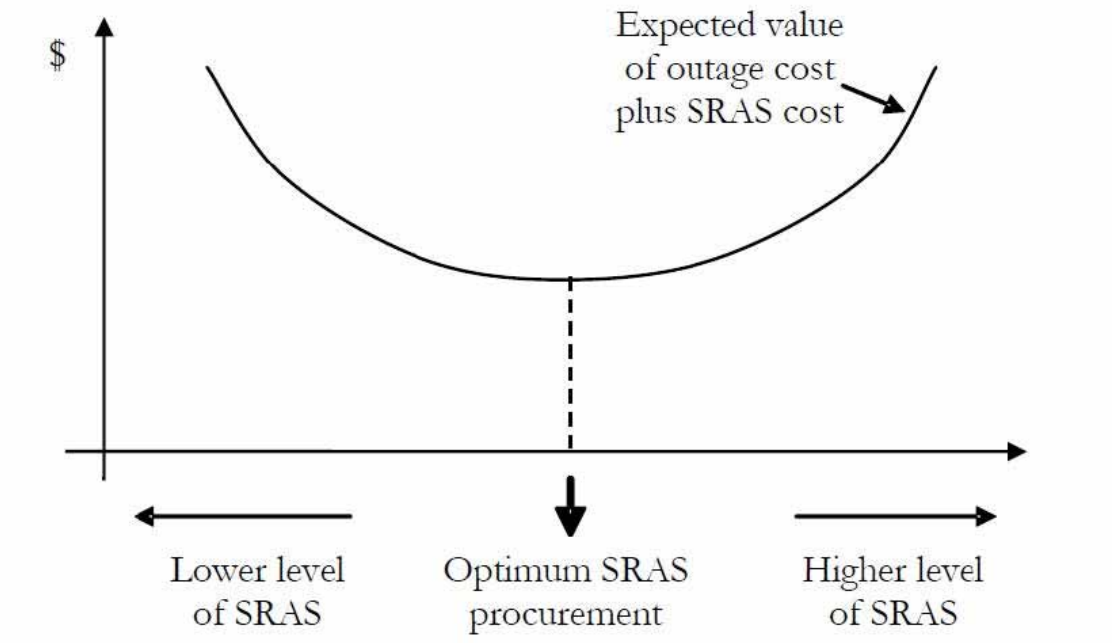
The Panel is required to determine the Standard in accordance with the SRAS Objective,[20] which is to minimise the expected costs of a major supply disruption to the extent appropriate having regard to the NEO.[21]

The Panel needs to identify the efficient level of SRAS procurement to determine Standard settings that minimise overall costs in accordance with the SRAS Objective. Efficient, or 'optimum', SRAS procurement is the level that minimises the total costs of procuring SRAS plus the economic costs to society of a prolonged disruption to electricity supply. The efficient level of SRAS that minimises total costs is conceptually illustrated in Figure 3.1.

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

21 Chapter 10 (Glossary) of the NER.

Figure 3.1: Approach to identifying the efficient level of SRAS



Source: Reliability Panel

The Panel has performed an economic assessment to identify the efficient level of SRAS for use as a basis for determining Standard settings for restoration level, timeframe, and aggregate reliability in the combined Queensland sub-network. This economic assessment identifies the efficient level of SRAS for this sub-network by assessing 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.

If no SRAS is procured, a very long duration major supply disruption, or black system, can be expected with correspondingly high levels of unserved energy and economic losses for consumers. By procuring a unit of SRAS, AEMO is able to more quickly restore supply to consumers limiting the amount of unserved energy. The total cost to consumers declines if the costs of procuring that SRAS is less than the economic losses avoided through its procurement. This situation is depicted on the left-hand side of Figure 3.1.

On the other hand, the total cost to consumers will increase if so much SRAS is procured that the economic benefit achieved by procuring an additional unit of SRAS is less that the cost of procuring that unit. This situation is depicted on the right-hand side of Figure 3.1.

The optimum level, which minimises the total cost to consumers, can therefore be identified as the level where the 'marginal' benefit achieved from the procurement of one additional unit of SRAS is the same as the cost to procure that unit. The Panel's economic assessment identifies the portfolio of SRAS in a combined Queensland sub-network that represents the

optimum level of procurement. Details on the method used by the Panel to perform its economic assessment are provided in section 3.1.2, and Appendix B with results from the economic assessment provided in Appendix C.

Limitations on the Panel's economic assessment

AEMO is only required to procure SRAS sufficient to achieve the restoration level, timeframe, and aggregate reliability requirements set out in the Standard. AEMO is not bound to procure the same units identified in the Panel's economic assessment. The Panel's economic assessment for the Queensland sub-network is therefore best viewed as a hypothetical exercise to inform Standard settings rather than specifying a specific SRAS procurement outcome.

The Panel has performed its economic assessment using information from previous procurement rounds provided by AEMO. It should be noted that AEMO procures SRAS on a lowest cost basis following commercial negotiations with prospective SRAS providers. These commercial negotiations, and the resulting pricing outcomes, may not reflect the historic information used by the Panel in its assessment. Therefore, it should be noted that the optimal portfolio identified by the Panel is an estimate and may not reflect the SRAS procurement outcome arising from AEMO's commercial negotiations.

3.1.2 Economic assessment

This section summarises the economic assessment method used by the Panel. The Panel performed its economic assessment by applying the same approach used by the Panel's consultant, Deloitte Access Economics (Deloitte), in the Panel's 2016 fulsome review of the Standard. Further details are available in Appendix B, the review's consultation paper, and the Panel's 2016 review project page which can be found at: https://www.aemc.gov.au/markets-reviews-advice/review-of-the-system-restart-standard.

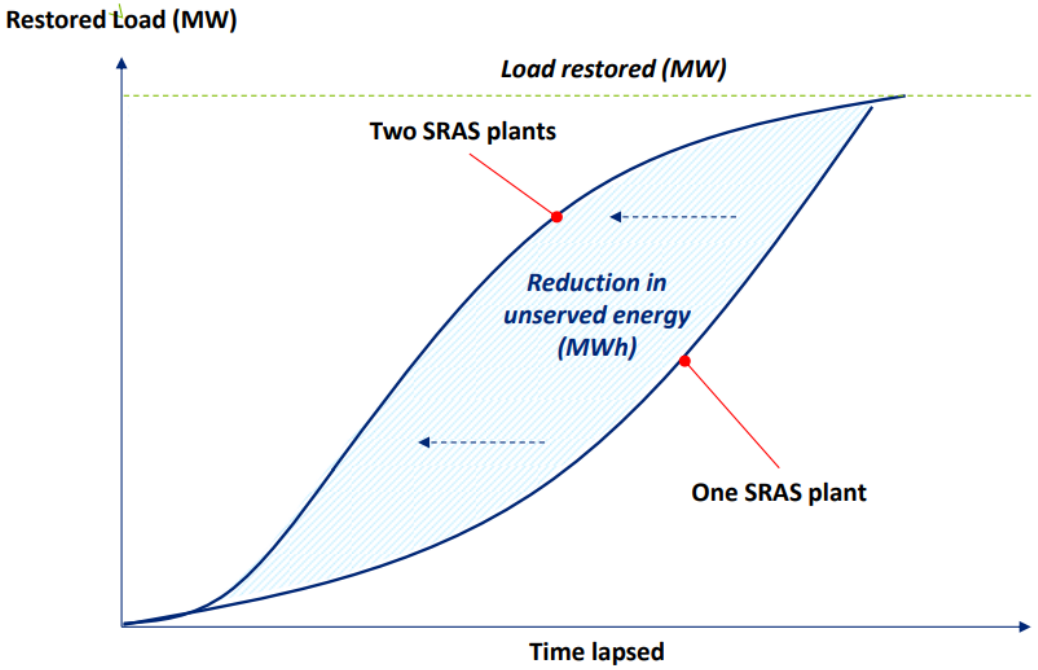
The economic assessment involved valuing the reliability weighted unserved energy avoided by procuring a set of candidate SRAS portfolios available in the combined Queensland sub-network. The efficient level of SRAS is then identified by comparing the reliability weighted benefits achieved from the procurement of each candidate portfolio against the cost of procurement.

The unserved energy avoided through the procurement of a candidate portfolio of SRAS is assessed from the supply restoration curves associated with the use of these SRAS to restart the power system. Supply restoration curves describe the process of network re-energisation as a function of time for one or more SRAS included in the assessed portfolio. Unserved energy can be identified as the area to the left-hand side of the supply restoration curve. Figure 3.2 conceptually depicts two supply restoration curves.[22] The right-hand curve represents the speed of restoration achieved by a single SRAS. The left-hand curve represents the speed of restoration achieved from the procurement of two SRAS.

22 Supply restoration curves of actual assessed portfolios are provided in Appendix C.

In general, procuring additional SRAS reduces the level of unserved energy by allowing a faster and more reliable restoration of supply. Figure 3.2 conceptually depicts the reduction in unserved energy from the procurement of two SRAS capable generating units, relative to one unit, as the area between the two supply restoration curves. This economic value of this reduction in unserved energy represents the marginal benefit of procuring the additional unit of SRAS.

Figure 3.2: Marginal reduction in unserved energy achieved by procuring two units of SRAS relative to one



Source: Deloitte Access Economics

Source: Reliability Panel

The reduction in unserved energy, identified for each SRAS procurement option, is reliability weighted prior to being valued. If an 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 probability that each of the units in the procurement option will successfully start.

The reliability weighted unserved energy avoided under each SRAS procurement option is then valued using the estimates of VCR for Queensland calculated and published by the AER in 2020.[23]

23 Further information on the VCR published by the AER can be found at: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability

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 using an estimated probability of a black system event for comparison with the annual cost of procuring SRAS in the assessed portfolio.

The Panel estimated the probability of a black system event in Queensland in a particular year for this purpose. Consistent with the approach used by Deloitte in 2016, the Panel estimated the probability of a black system event in Queensland using a power law relationship to extrapolate from data on historic lost load events in the sub-network.

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. Uncertainty was assessed for the VCR used to value unserved energy and the assessed probability of a black system event in Queensland.

Further information is available on the details of the economic assessment method in Appendix B.

3.1.3 AEMO advice and key assumptions

AEMO assisted the review of the Queensland sub-network by providing the Panel with advice including 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
- the 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 from detailed modelling of the restoration pathways used to re-energise a single 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. This experience has led AEMO to update the network switching time (this refers to the time AEMO takes to progressively re-energise each network element in a restart pathway) used in its modelling to increase it from 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.[24]

This change has impacts on the outcomes of the modelling, resulting in a slower overall restoration and longer restoration timeframe for the Queensland sub-network. 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.

Key assumptions in the economic assessment

The Panel made a set of key input assumptions in its analysis of the Queensland sub-network. 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.[25]
- The restoration of generation and load in the Queensland sub-network, is performed assuming that supply from neighbouring sub-networks is not available. This is a requirement set out in the NER.[26]
- 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.
- Each restart service has been assumed to have an availability of 95 per cent.
- 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.[27] Consistent with its 2016 review, the Panel has assumed T_{max} to be 10 hours in the Queensland sub-network.

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

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

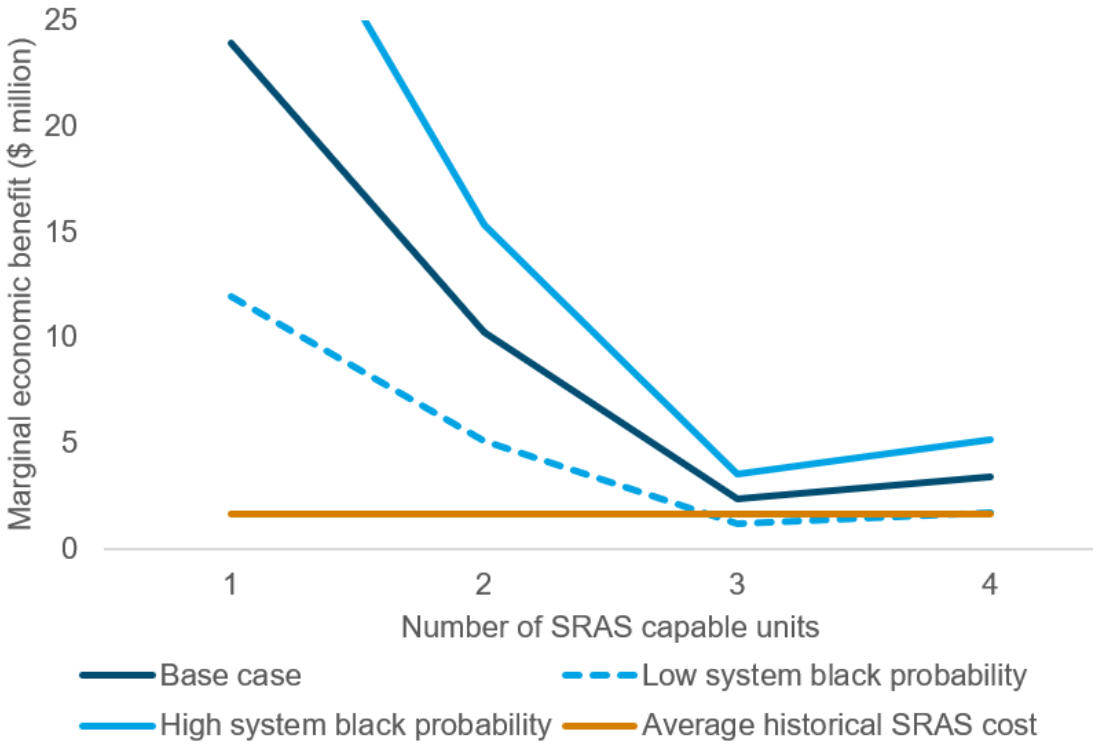
26 Clause 8.8.3(aa)(2) of the NER.

27 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

3.1.4 Economic assessment results

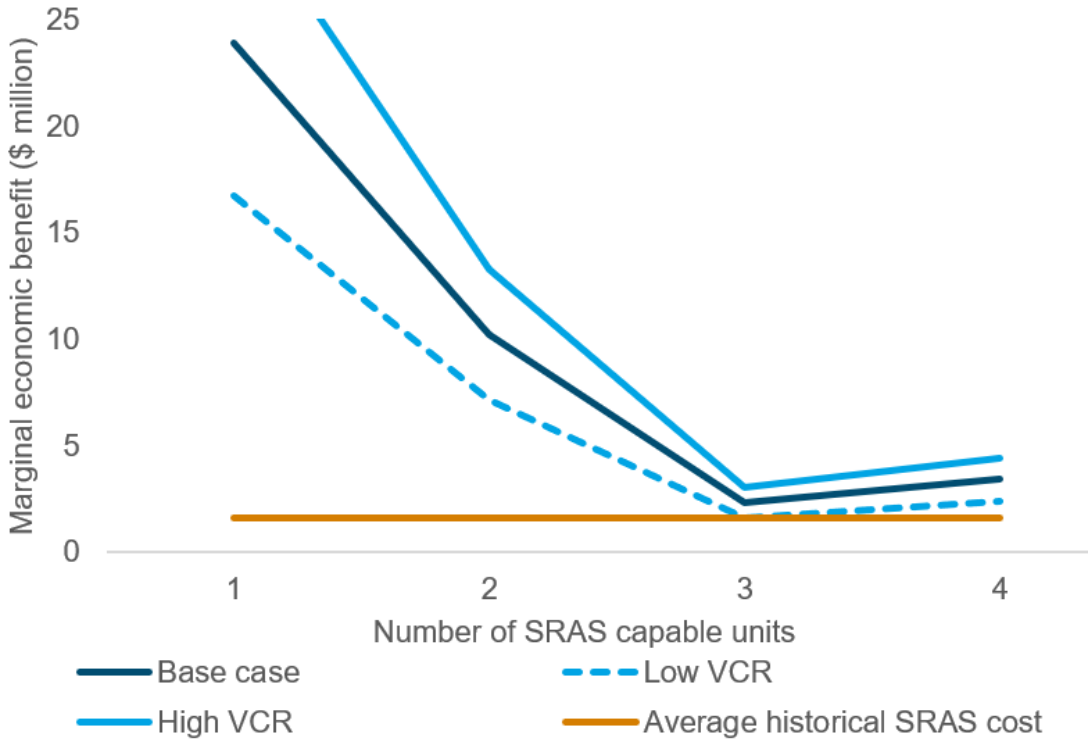
Figure 3.3 compares the range of costs and benefits, from which the efficient number of SRAS sources can be identified accounting for uncertainty in the probability of a black system event. Figure 3.4 compares the same range of costs and benefits, accounting for uncertainty in the VCR.

Figure 3.3: 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 3.4: Marginal benefit of procuring different levels of SRAS in Queensland given uncertainty in the VCR accounting for social costs



Reliability Panel analysis

As more units of SRAS are added, the marginal economic benefit is observed to decrease, 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.

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

Limitations on the Panel's economic assessment

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. 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.

3.2 Draft determination on Standard settings for a combined Queensland sub-network

The Panel published draft quantitative Standard settings for a combined Queensland subnetwork in its determination on 29 October 2020. This section sets out the Panel's draft determination on settings for restoration level (MW), restoration timeframe (hours), and aggregate reliability in Box 3.

BOX 3: DRAFT DETERMINATION ON STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

Table 3.1: Draft Standard settings

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

3.2.1 Draft restoration level

The restoration level, in MW, represents the minimum online generation capacity required to support ongoing restoration. This level is represented in Figure 3.5 as G_{min} and was provided by AEMO in its advice to the Panel.

The draft MW restoration level is a technical parameter obtained from modelling restoration of the Queensland power system. On this basis, the Panel accepted AEMO's advice with its draft determination being for a restoration level in a combined Queensland sub-network of 1650 MW.

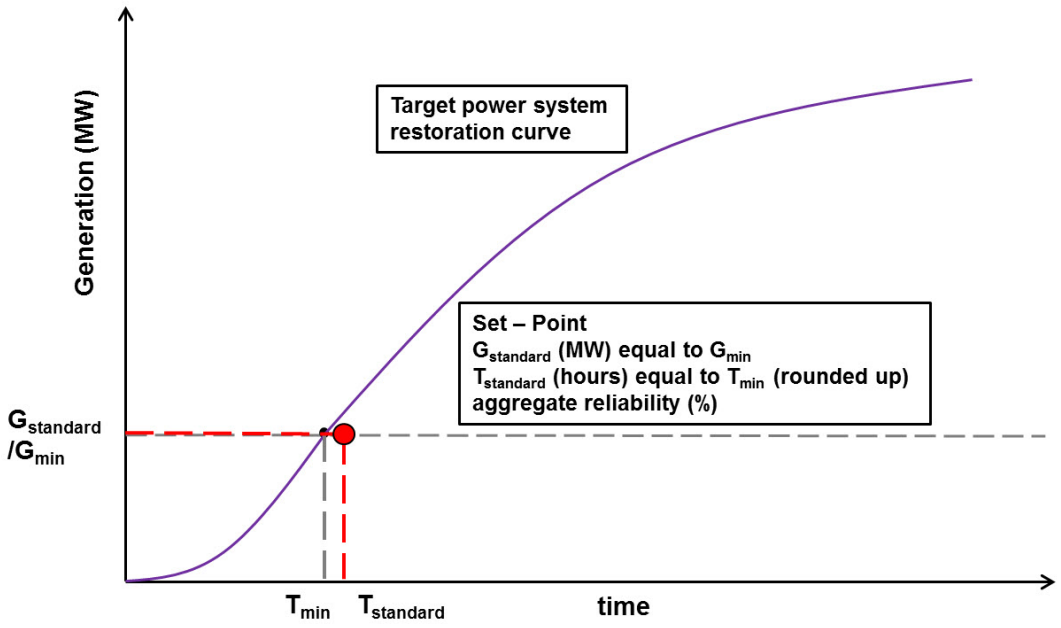
3.2.2 Draft restoration timeframe

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.[28] Figure 3.5 illustrates the Panel's approach to setting restoration level and time settings relative to G_{min} and T_{min}. The Panel's draft determination was for a restoration timeframe of 4 hours in a combined Queensland sub-network.

28 The 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.

In making its draft determination, the Panel noted 4 hours was a longer restoration timeframe than that previously applied to exiting north and south Queensland sub-networks. This outcome is due to AEMO using the latest available information in its modelling for this review. Specifically, and as noted in section 3.1.3, AEMO has updated its network switching time given 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.[29] Stakeholders should note that 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.

Figure 3.5: Panel approach to determining restoration time and level settings



Reliability Panel

3.2.3 Draft 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 and the individual reliabilities of the SRAS available for AEMO to procure in a combined Queensland subnetwork. Following this

29 Approximately 10 minutes was allowed to energise one transmission line (branch) during restoration instead of 5 minutes as was used in 2016.

consideration, the Panel's draft determination was for an aggregate reliability of 90% in a combined Queensland sub-network.

3.3 Stakeholder submissions

This section summarises relevant stakeholder views on the Panel's assessment approach, set out in its consultation paper, and the draft Standard settings published in the Panel's draft determination. Stakeholder views on locational requirements in a combined Queensland sub-network are presented in Chapter 4. All stakeholder submissions are available on the review's project page: https://www.aemc.gov.au/market-reviews-advice/review-system-restart-standard-2020

3.3.1 Stakeholder submissions to consultation paper

The Panel received seven submissions in response to the review's consultation paper. Submissions were received from Origin Energy, Delta Electricity, Snowy Hydro, PIAC, Tesla, the AER, and CS Energy. Stakeholders supported the Panel using its 2016 method to determine quantitative Standard settings in a combined Queensland sub-network. Stakeholders commented on the method used by the Panel in determining Standard settings for a Queensland sub-network and the scope of the technologies that should be considered by the Panel in setting the Standard.

The Panel's assessment approach

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.[30]
- 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 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.[31]
- Delta 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 performance

30 Origin Energy, submission to the consultation paper, p. 1.
31 Delta Electricity, submission to the consultation paper, p. 4.

characteristics that may lead to extended delays of days is restart sources are delayed in re-energising the power station.[32]

The Panel noted 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 in its draft determination. However, the Panel noted that it is 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 rules therefore require the Panel 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's draft determination therefore utilised a full economic assessment in determining the draft Standard settings for a combined Queensland sub-network.

The Panel notes Delta'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 also 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.

Scope of technologies considered in Panel assessment

Stakeholders raised a number of 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.[33]
- 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.[34]
- 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

32 Ibid.
33 PIAC, submission to the consultation paper, p. 1.
34 Snowy Hydro, submission to the consultation paper, p. 1.

definition of black-start, system restart support, restoration services should be considered to ensure AEMO can procure necessary services efficiently, with adequate testing procedures undertaken with potential SRAS providers.[35]

The Panel acknowledges stakeholder views that an increasing scope of technologies eligible to provide SRAS may, over time, change the economically efficient level of SRAS procured by AEMO for a particular sub-network. 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 therefore 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 Rules. 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 forward looking consideration of issues that may inform a future rule change.

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.

3.3.2 Stakeholder submissions to the Panel's draft determination

The Panel received three submissions in response to its draft determination on Standard settings for a combined Queensland sub-network. Submissions were received from PIAC, Powerlink, and Powerlink acting as the Queensland Jurisdictional System Security Coordinator (JSSC). These stakeholders did not specifically comment on the draft Standard settings published by the Panel in its draft determination.

- PIAC reiterated its support for expanding the range of providers of System Restart Ancillary Services (SRAS) but considered it short sighted for the Panel to rule out interconnectors as possible SRAS sources to complement the currently eligible providers. PIAC noted that it looks forward to this issue being examined in more detail in the next review of the Standard. Before it commences, however PIAC recommended the AEMC begin early work on how interconnectors could be incorporated as eligible SRAS sources including any changes necessary to the current modelling and procurement processes.[36]
- Powerlink considered that the Standard should state that only reactive power support can be provided by inverter-based technologies. They identify that while grid forming inverters can operate islanded, they are unlikely to help with the restart process.

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

36 PIAC, submission to the draft determination, p. 1.

Powerlink considered it important to note that most inverter based technologies are not currently able to be used in early stages of restart due to low fault levels.[37]

- Powerlink was also concerned that the combination of regions may lead to all SRAS being procured in what is currently the southern subnetwork and that electrical limitations would make the restoration of the central and northern Queensland regions challenging, if not impossible under certain circumstances.[38] Powerlink also noted the importance of this issue for sensitive loads in Queensland. Powerlink's concerns, and the Panel's considerations, on this issue are addressed in Chapter 4 on the locational requirements.

The Panel acknowledges PIAC's points on the potential for interconnectors as restart sources. The Panel however is constrained by rule requirements in determining the Standard settings in this review. Specifically, clause 8.8.3(aa)(2)of the NER requires the Panel to set the Standard on the assumption that no restoration is possible from a neighbouring sub-network. This requirement precludes the Panel from considering interconnector contributions in this review. The Panel anticipates giving further consideration to this issue in its next fulsome review of the Standard as suggested by PIAC.

The Panel acknowledges Powerlink's point on the limitations of certain inverter-based technologies in providing system restart services. The standard however does not either limit nor prescribe specific technology choices that AEMO may procure as SRAS. AEMO is responsible for specifying the technical requirements for SRAS in its SRAS Guideline and procuring SRAS which is sufficient to meet the requirements of the Standard.

3.4 Final determination on Standard settings for a combined Queensland sub-network

The Panel's final determination on Standard settings for a combined Queensland sub-network is to replace the current settings for north and south Queensland sub-networks in Table 1 of the Standard with the settings for restoration level, restoration timeframe, and aggregate reliability set out in Box 4.

BOX 4: FINAL DETERMINATION ON STANDARD SETTINGS FOR A COMBINED QUEENSLAND SUB-NETWORK

Table 3.2: Final determination Standard settings for Queensland

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

37 Powerlink, submission to the draft determination, p. 2

38 Powerlink, submission to the draft determination, p. 1.

The Panel's final determination is the same as its draft determination. The Panel notes that no stakeholder objections were raised to its draft determination Standard settings for a combined Queensland sub-network.

The Panel considers that its final determination on restoration level, restoration timeframe, and aggregate reliability for the Queensland sub-network are consistent with the SRAS Objective, the NEO and the specific requirements for the Standard for the following reasons:

- Standard settings are determined from an economic assessment that minimises the expected costs of a major supply disruption or black system event. Specifically, the economic assessment for the Queensland sub-network allowed the restoration time and aggregate reliability to be identified from the system restoration curves and individual unit reliabilities associated with the efficient portfolio of SRAS.
- The Panel has had regard to the NEO in making its final determination. In particular the efficient operation of, electricity services, particularly with respect to the price of SRAS reliability, and the safety, and security of supply. In particular, the Panel has had regard to the reliability, safety and security of supply during restoration following a black system event through AEMO's modelling and advice on the restoration level required to support ongoing restoration, system restoration curves that include unit constraints and limitations, and network switching assumptions that reflected latest understanding on practical circumstances that apply during system restoration following a black system event.
- The Panel has determined changes to the Standard that satisfy the specific NER requirements set out in clauses 8.8.3(aa)(2) to (4) of the NER. In particular, the Panel has:[39]
    - identified the maximum amount of time within which system restart ancillary services are required to restore supply in an electrical sub-network to a specified level, under the assumption that supply (other than that provided under a system restart ancillary services agreement acquired by AEMO for that electrical sub-network) is not available from any neighbouring electrical sub-network and include the aggregate required reliability of system restart ancillary services for each electrical sub-network,[40]
    - conducted modelling reflecting the technical system limitations and specific economic circumstances that apply in a Queensland sub-network. The Panel has used Queensland specific SRAS cost and VCR information in its economic assessment. The treatment of technical system limitations are addressed in the locational requirement set out in Chapter 4.[41]

Further consideration of efficient investment in SRAS capabilities

The Panel has considered the Standard's impact on efficient investment in SRAS capabilities. In particular 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

39 NER requirements set out in clauses 8.8.3(aa)(5) to (7) are relevant to qualitative guidance and are not relevant to the determination of quantitative Standard settings for a combined Queensland sub-network.

40 Clause 8.8.3(aa)(2) to (3) of the NER.

41 Clause 8.8.3(aa)(4) of the NER.

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 final 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 in the immediate term, but also recognizes that changes to the modelling approach will be required 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.

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.[42]

42 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.

4 LOCATIONAL REQUIREMENTS

The Panel has made a final determination to include a requirement for AEMO to procure a SRAS north of Bundaberg. This chapter sets out the Panel's considerations in making a final determination that includes this locational requirement. This chapter is divided into the following sections:

- approach to determining a locational requirement
- draft determination on a locational requirement
- stakeholder submissions, and
- final determination on a locational requirement.

4.1 Approach to determining a locational requirement for a combined Queensland sub-network

This section sets out the Panel's approach to assessing whether locational considerations justify a requirement be added to the Standard for AEMO to procure SRAS in specific areas of a combined Queensland sub-network.

Section 9 of 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. This qualitative guidance provides for AEMO to account for locational issues in its procurement process when deciding which SRAS providers to contract with.

In addition to the Standard's exiting guidance on locational considerations, the Panel may also prescribe specific locational requirements for a sub-network. As an example, in 2016 the Panel determined to include a requirement in the Standard for AEMO to procure SRAS north of Sydney in the New South Wales sub-network sufficient to independently restart 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 was included since the Panel identified the long distance between the large generators in the Hunter Valley and hydro-generation in the south of the state as potentially leading to unacceptably long delays in the absence of an SRAS source 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. In this instance, the Panel considered the significance of this issue to justify an explicit requirement be specified in the Standard.

4.1.1 Panel considerations in setting a locational requirement

The Panel considers a number of factors to be relevant in determining whether to impose a locational requirement in a sub-network, in this case, a combined Queensland sub-network. These include:

- whether an explicit locational requirement will advance the SRAS Objective and National Electricity Objectives
- specific network characteristics that may require geographic diversity
- the presence of sensitive loads in particular areas of the network, and
- stakeholder sensitivity and confidence.

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 Panel may consider imposing an explicit locational requirement if the procurement of SRAS in a particular part of the combined Queensland sub-network is critically important to minimising the extent and overall cost associated with a major supply disruption or black system event. The Panel's decision to impose a locational requirement for AEMO to procure SRAS north of Sydney was justified given the additional cost to the community arising from a far longer duration black out that would occur should no SRAS be procured north of Sydney.

The Panel notes that the Queensland transmission network is characterised by long transmission flow paths, the presence of large industrial loads in central Queensland and transmission corridors that may be vulnerable to separation. An explicit locational requirement may therefore be justified if these network characteristics make restoration in parts of the sub-network difficult or impractical under certain circumstances.

The Panel may also consider a range of other factors when deciding whether to impose a locational requirement in a sub-network. These factors include whether an explicit locational requirement is needed to provide confidence that SRAS is procured in parts of the sub-network that contain sensitive loads. Clause 8.8.3(aa)(4)(B) of the NER lists specific economic circumstances in an electrical sub-network, including but not limited to the existence of one or more sensitive loads, as a consideration for the Panel in setting the Standard.

4.1.2 AEMO recommendation

In making its determination to combine the former north and south Queensland sub-networks, AEMO considered 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.[43] 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.[44]

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 advice

43 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

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

identified this recommendation 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.

4.2 Draft determination on a locational requirement in a combined Queensland sub-network

The Panel's draft determination was to impose the locational requirement recommended by AEMO in its advice to the Panel. Box 5 sets out the Panel's draft determination.

BOX 5: DRAFT DETERMINATION ON A LOCATIONAL REQUIREMENT IN A COMBINED QUEENSLAND SUB-NETWORK

The Panel's draft determination is 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%.

The Panel has included this locational requirement in its draft determination for the following reasons:

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

In making its draft determination to impose a locational requirement, the Panel noted that the efficient portfolio of SRAS included an SRAS unit located in central Queensland and the Panel's economic assessment indicates that a restoration strategy solely from the south is sub-optimal and therefore not consistent with the Panel's obligation to set the Standard to minimise costs.

The Panel's draft determination noted 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 of the state. 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.[45]

In making its draft determination the Panel also noted AEMO's advice and stakeholder views on the importance of SRAS procured north of Bundaberg. In particular the Panel noted stakeholder views on the technical risks of relying on restarting from the South, and concerns

45 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.

regarding the timeliness of restoring supply to major loads located in central Queensland. Further information on stakeholder views on this matter is provided in section 4.3.

4.3 Stakeholder feedback

The Panel's consultation paper sought stakeholder feedback on whether a locational requirement was warranted in a combined Queensland sub-network, with the Panel's draft determination seeking specific feedback on the draft locational requirement proposed.

4.3.1 Stakeholder feedback to the consultation paper

Two stakeholder submissions to the Panel's consultation paper, from Origin Energy and CS Energy, expressed a view on whether a locational requirement for AEMO to procure SRAS north of Bundaberg was justified. Both stakeholders were supportive of this 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. 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.[46]
- CS Energy identified what it considered to be technical risks to restarting a single Queensland sub-network should all SRAS be procured in the south of the State.[47]

In making its draft determination, the Panel agreed with Origin Energy and CS Energy that the Queensland power system has characteristics which justify a locational SRAS requirement. The Panel noted the natural 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.

4.3.2 Stakeholder feedback to the draft determination

Two submissions were received on the locational requirement proposed in the draft determination. These submissions were received from Powerlink, and Powerlink acting as the Queensland JSSC. Both of these submissions supported the proposed requirement. No stakeholder submissions were received that opposed the locational requirement set out in the Panel's draft determination.

Powerlink supported the Standard requiring AEMO to contract SRAS for the area north of Bundaberg, similar to the arrangement already in place for New South Wales. Powerlink's submission noted their overarching concern that AEMO's combination of the north and south Queensland sub-networks may allow a case where SRAS is solely procured in what is currently the southern sub-network and that electrical limitations would make the restoration of the central and northern Queensland regions challenging, if not impossible in certain circumstances.[48]

46 Origin Energy, submission to the consultation paper, p. 1.
47 CS Energy, submission to the consultation paper, p. 3.
48 Powerlink, submission to the draft determination, p. 1.

Powerlink also expressed concerns regarding the re-connection of any sensitive loads located in central or norther Queensland in the absence of a specific locational requirement set out in the Standard. Powerlink particularly noted its obligations to give priority to the reconnection of a region's sensitive loads. Powerlink considered a requirement for SRAS to be procured in what was formerly the north Queensland sub-network to be important in it meeting these obligations.[49]

In its submission acting as the Queensland JSSC, Powerlink supported the Panel's draft determination to include a requirement for AEMO to procure SRAS north of Bundaberg, in view of the materiality of the issues it had identified in discussion with the sensitive load customer. In addition, it welcomed the opportunity (as JSSC) to participate in SRAS testing.[50]

In respect of Powerlink's (acting as the JSSC) participation in SRAS testing, the Panel notes that the JSSC is invited to participate in AEMO's regional system restart working groups to inform development and revision of the regional system restart plans, which are verified in part through these tests. In respect of Powerlink's (acting as Queensland TNSP) participation in SRAS testing, the Panel notes that the AEMC's SRAS rule, published on 2 April 2020, has recently updated NER arrangements applying to NSP participation in the testing of contracted SRAS. In particular, the SRAS rule clarifies the role of NSPs in identifying and resolve issues that may prevent the delivery of effective SRAS and participating in and facilitating testing of contracted SRAS providers as required by AEMO. Further information on the changes to NSP participation in SRAS testing is available in the SRAS Rule final determination which may be found at:
https://www.aemc.gov.au/sites/default/files/documents/system_restart_services_standards_and_testing_-_final_determination.pdf

4.4 Final determination

The Panel's final determination on a requirement for AEMO to procure SRAS north of Bundaberg is to amend Section 5 of the Standard 'applicability of the standard in electrical sub-networks' to include the requirement set out in Box 6. The Panel's final determination on a locational requirement in a combined Queensland sub-network is the same as its draft determination.

BOX 6: FINAL DETERMINATION ON A LOCATIONAL REQUIREMENT IN A COMBINED QUEENSLAND SUB-NETWORK

The Panel has made a final 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%.

49 Ibid.

50 Powerlink acting as the Queensland JSSC, submission to the draft determination, p. 1.

The Panel's final determination on a locational requirement for AEMO to procure SRAS north of Bundaberg is also the same as its draft determination. The Panel notes that all stakeholders who expressed a view supported the proposed requirement.

The Panel considers that its final determination locational requirement for a combined Queensland sub-network is consistent with the SRAS Objective, NEO and the specific requirements in the NER for the Standard for the following reasons:

- In making its final determination, the Panel agrees with AEMO that imposing a locational requirement to procure a minimum level of SRAS north of Bundaberg allows the operational benefits of combining the sub-networks to be achieved while also providing equivalent levels of SRAS north of Bundaberg as was the case prior to AEMO's determination to combine the sub-networks.
- In this regard, the Panel's final determination is for AEMO to procure 825 MW of generation north of Bundaberg which is in line with the MW restoration level specified for the former north Queensland sub-network. AEMO's justification for combining the former north and south Queensland sub-networks was to allow increased restoration path flexibility and better access to stabilising loads. The Panel considers that the locational requirement in the final determination will provide for a more stable and secure restoration while also providing stakeholders confidence in the level of SRAS procured north Bundaberg.
- The Panel considers its final determination locational requirement to be consistent with the SRAS Objective to minimise the expected cost of a major supply disruption. The procurement of SRAS north of Bundaberg is consistent with the optimal portfolio identified in the Panel's economic assessment. In addition, the Panel's economic assessment identified significant cost savings from the procurement of at least one unit of SRAS north of Bundaberg relative to the case when all SRAS is procured in the south of the state. The final determination locational requirement is therefore consistent with a lowest cost outcome.
- The Panel acknowledges stakeholder observation that network limitations may make the restoration of the central and northern Queensland regions exclusively from SRAS in the south challenging, if not impossible in certain circumstances. The Panel does not consider such an outcome to be consistent with the NEO as it is inconsistent with the system security objective of the NEO. The Panel's locational requirement addresses these concerns.

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
JSSC	Jurisdictional System Security Coordinator
PIAC	Public Interest Advocacy Centre

A BACKGROUND TO SRAS FRAMEWORKS

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

- 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.

A.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.[51] 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.[52] 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,[53] 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.[54]

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.[55] 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.[56]

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

52 Clause 4.2.6(c) of the NER.

53 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.

54 Clause 4.2.6(e) of the NER.

55 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

56 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.

A.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.[57]

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.

A.1.2 Process of responding to a black system event

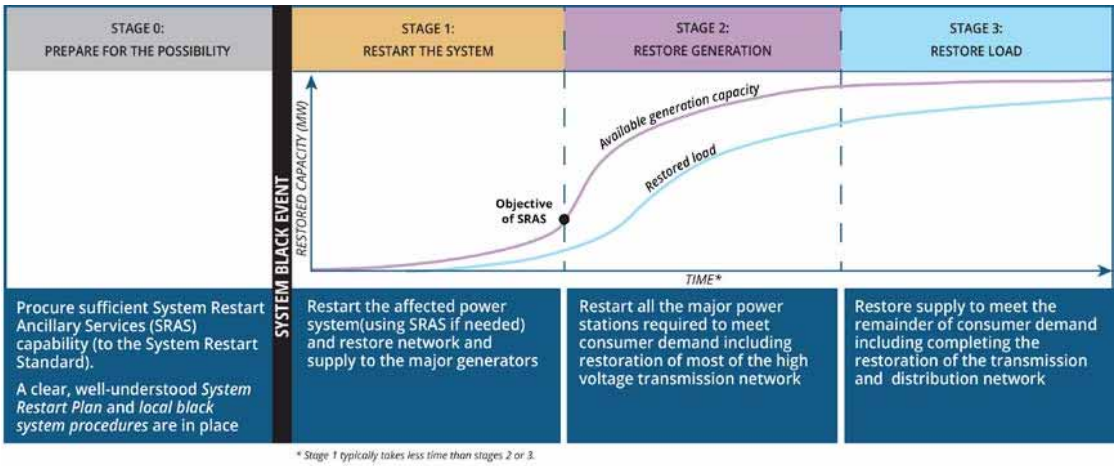
Frameworks in the NER set out a process for restoring the power system following a major supply disruption or black system event. This process has several stages and involves AEMO, transmission and distribution network service providers and generators each coordinating in

Blackout-Cost-State-$367-Million

57 Re-energisation can also occur from neighbouring regions.

their respective roles. An overview of the stages involved in preparing for and responding to a black system event is illustrated in Figure A.1.

Figure A.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.[58] 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.

58 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 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.

A.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[59] in accordance with the SRAS Objective and the requirements for the Standard set out in the NER.[60] 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 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.[61] 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, a system restart plan for each sub-network, and guidelines for preparing local black system procedures for this purpose.

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.

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59 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.

60 Clause 8.8.3(aa) of the NER.

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

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.[62]

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 using criteria specified in the Standard by the Panel.[63] 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 each sub-network for managing and coordinating system restoration activities following any major supply disruption or black system event. The system restart plans contain 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.[64] The system restart plans are required to be consistent with the Standard.[65]

AEMO also develops guidelines for use by networks and generators to develop their local black system procedures, which are discussed further below.[66]

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.[67]

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.

62 Clause 3.11.7(c) of the NER.

63 Clauses 3.11.8(b) and 8.8.3(aa)(6) of the NER.

64 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

65 Clause 4.8.12(c) of the NER.

66 Clause 4.8.12(e) of the NER.

67 Clause 3.11.9(i) of the NER.

B MODELLING APPROACH

This appendix 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.

B.1 Economic assessment to identify efficient level of SRAS

The Panel is required to determine the Standard in accordance with the SRAS Objective,[68] which is to minimise the expected costs of a major supply disruption to the extent appropriate having regard to the national electricity objective.[69]

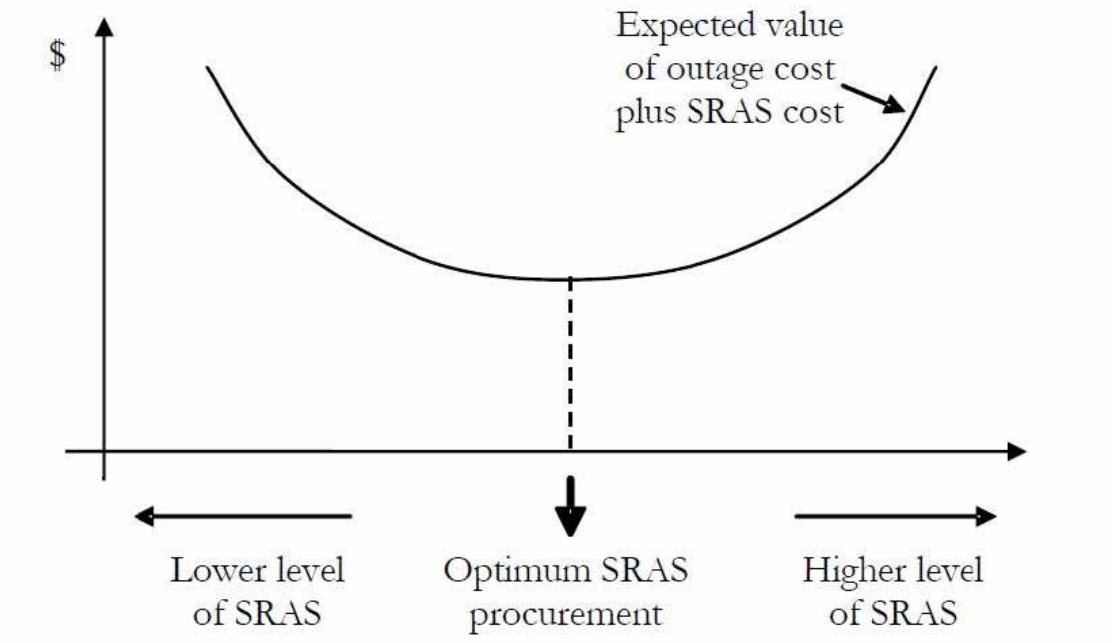
This section summarises the method used by the Panel to identify efficient levels of SRAS in a Queensland sub-network. The efficient level of SRAS, once identified, is then used to inform the Standard settings presented in Chapter 3. It should be noted that the efficient level is used to set the restoration 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 B.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.

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

69 Chapter 10 (Glossary) of the NER.

Figure B.1: Identifying the efficient level of SRAS



Source: Reliability Panel

The economic assessment performed by the Panel identifies the optimum level of SRAS procurement for a combined Queensland sub-network 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.[70]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

70 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.

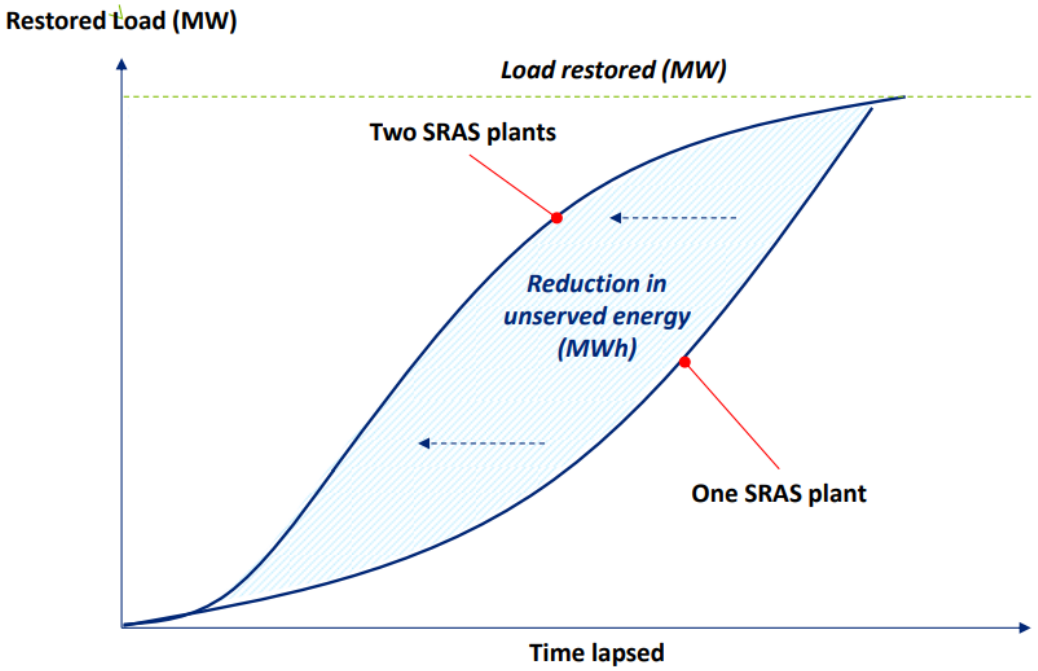
Estimate unserved energy for each of the different SRAS procurement options

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 unserved energy associated with an SRAS procurement option is assessed from the supply restoration curves for that option modelled by AEMO for the review. Supply restoration curves describe the process of re-energising the network from the one or more SRAS procured in the assessed option. AS shown in figure B.2, 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 unserved energy by allowing for a faster and more reliable restoration of supply. This minimises the disruption and economic losses from the event. Figure B.2 illustrates by conceptually depicting the unserved energy avoided from a faster restoration 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 B.2: Marginal benefit achieved by procuring two units of SRAS relative to one



Source: Deloitte Access Economics

Source: 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.

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. Reliability weighting accounts for the potential failure of one or more of the SRAS procured as part of the procurement option.

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 probability that each of the units in the procurement option will successfully start.

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 in 2020.

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, the Panel 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

C ECONOMIC ASSESSMENT RESULTS

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.

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.

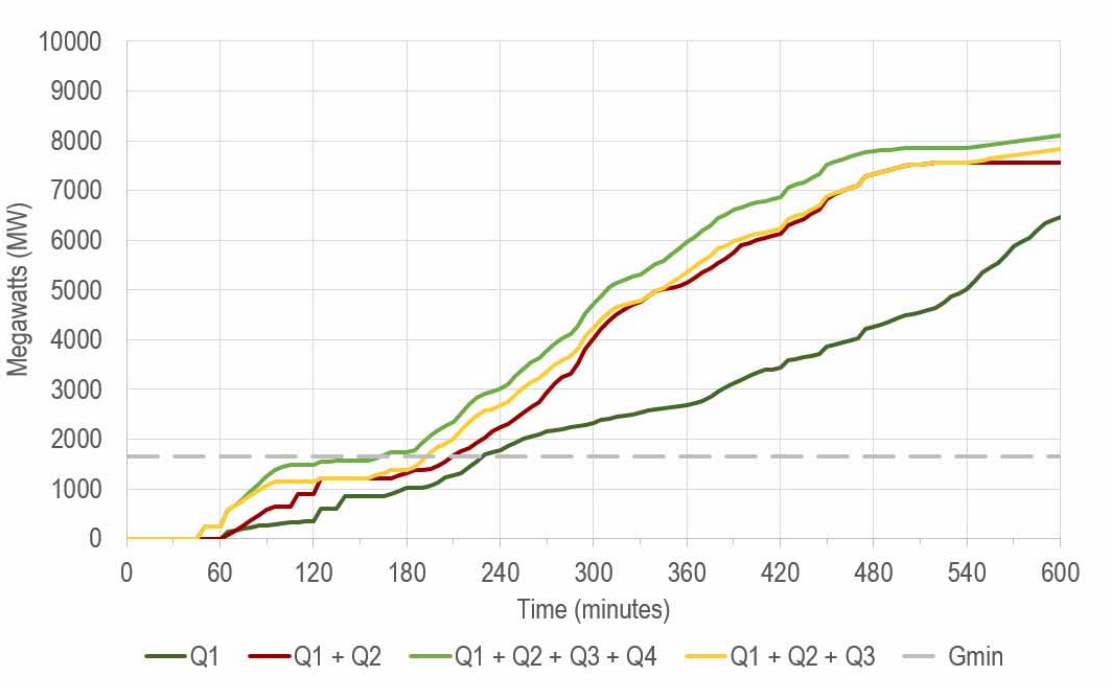
Estimate un-served energy for each assessed SRAS procurement option

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.[71] 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 C.1.

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

Figure C.1: Example portfolio supply restoration curves



Source: Reliability Panel from information provided by AEMO

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.

Table C.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%.[72]

Results are reliability weighted for each portfolio to account for the probability that SRAS units will fail to deliver as contracted.[73] 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.

Table C.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.[74] 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.[75] 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).

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

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

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

75 The Panel used the same threshold as Deloitte Access Economics 2016 analysis.

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.

Table C.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)

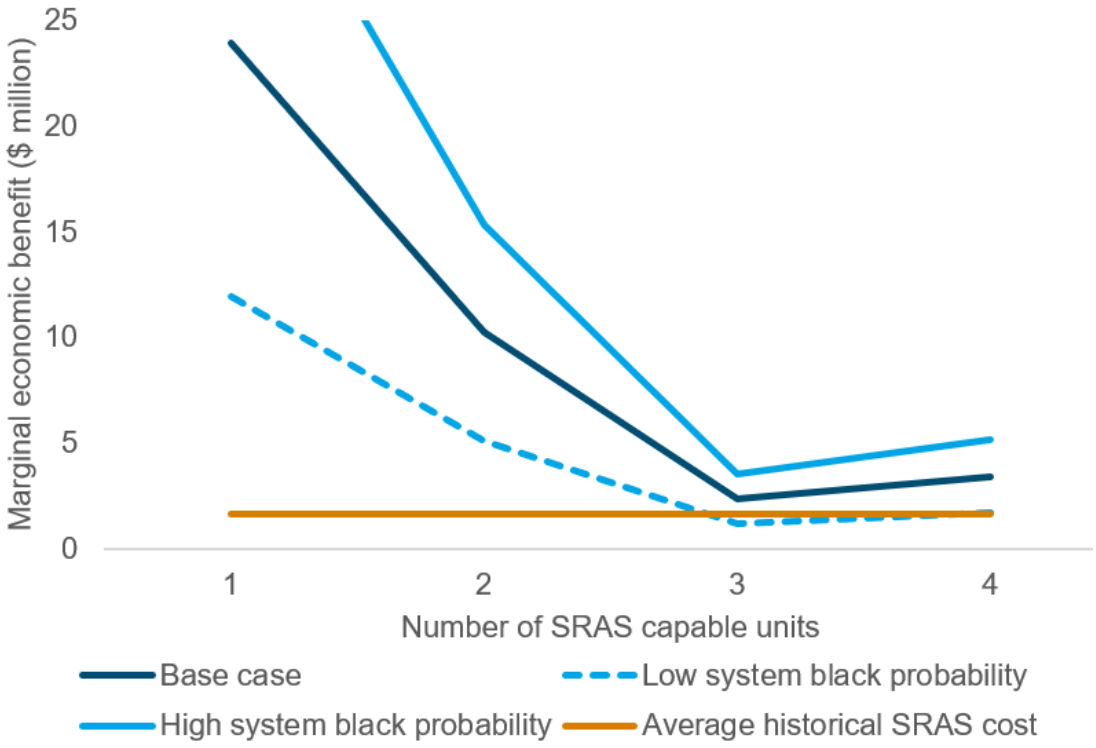
Source: Reliability Panel analysis of AEMO data, AER data

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.

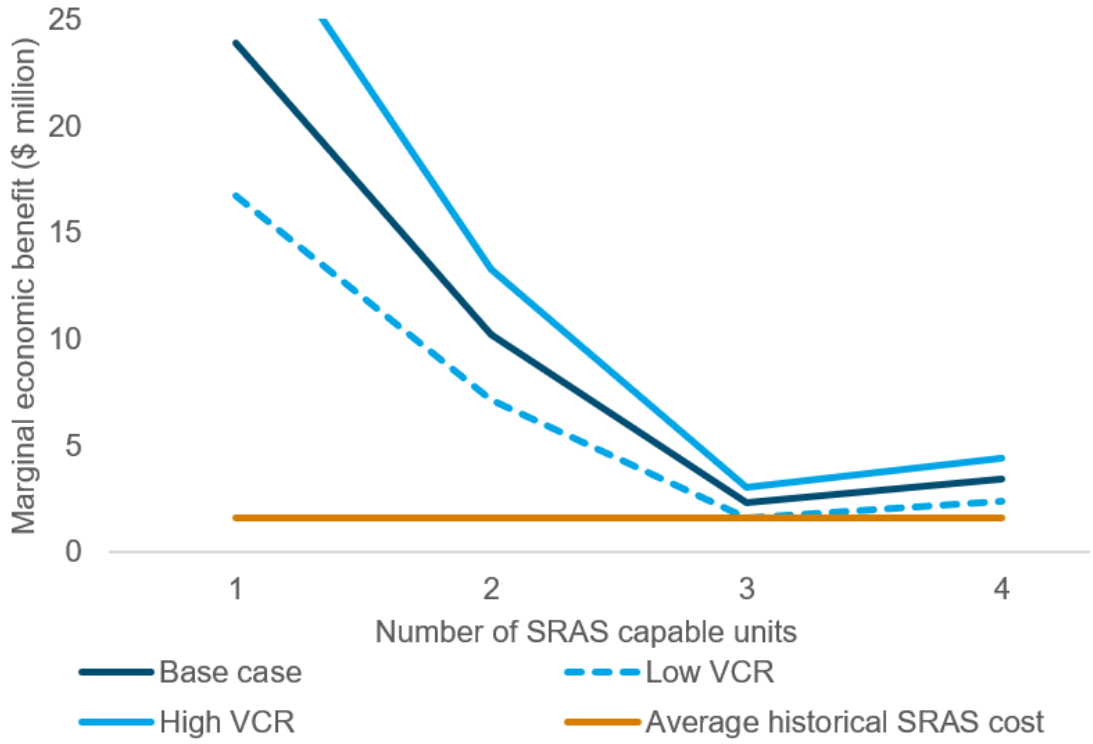
Figure C.2 compares the range of costs and benefits, from which the efficient number of SRAS units can be identified accounting for uncertainty in the probability of a black system event. Figure C.3 compares the same range of costs and benefits, accounting for uncertainty in the VCR.

Figure C.2: 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 C.3: 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 Figures C.2 and C.3, 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. 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.