System Strength Requirements in SA | Regulatory Investment Test – Transmission

Project Specification Consultation Report

NOVEMBER 2023

ElectraNet

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Executive summary

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options that can deliver sufficient system strength services to the South Australian power system, required to maintain power system stability and security during the ongoing clean energy transition.

Publication of this Project Specification Consultation Report (PSCR) is the first step in the RIT T process. This PSCR is accompanied by an Expression of Interest (EOI), seeking non-network options from potential System Strength Contractors to address system strength requirements in South Australia (i.e. third party businesses that can provide system strength services to ElectraNet under a network support contract).

The RIT-T will examine network and non-network options to meet the system strength requirements while providing the greatest net economic benefit to the energy market.

Identified need: meeting system strength requirements in South Australia

National Electricity Rules (NER) Schedule 5.1.14 requires us to provide sufficient system strength services to ensure the forecast efficient amount of new Inverter Based Resources (IBR) will remain stable in steady state conditions and remain synchronised following credible contingency events[1].

The identified need for this RIT-T is to provide sufficient system strength services to ensure we can achieve stable voltage waveforms for the level and type of IBR and market network service facilities projected by AEMO for South Australia, in accordance with Schedule 5.1.14 (b) (2) of the NER.

AEMO published a forecast of IBR for South Australia over the next decade in its 2022 System Strength Report[2].

Available Fault Level (AFL) is a proxy quantity that enables the required level of system strength to be expressed as a fault level.

Based on AEMO's IBR forecast and using AEMO's guidelines and methodology, we have estimated the additional required AFL to provide the efficient level of system strength at system strength nodes in South Australia to be 1133 MVA at Robertstown, 537 MVA at Para and 66 MVA at Davenport from 2025-26 (Figure 1 and Table 4).

The actual amount and design of needed additional system strength services will be confirmed by detailed electromagnetic transient program studies in PSCAD, which will form part of the RIT-T assessment to be included in the Project Assessment Draft Report (PADR). This could show that the quantity of system strength services needed differs from the amount indicated by the analysis of AFL included in this PSCR.

We will also consider any variations in forecast IBR growth that may be included in AEMO's 2023 System Strength Report, which is due to be published by 1 December 2023.

We are publishing this PSCR ahead of the AEMO report to enable earlier engagement with proponents of potential non-network solution options.

AEMO has not forecast a shortfall for minimum fault current under NER S5.1.14 (b) (1). We are not expecting any shortfall against the minimum fault level requirements over the forecasting horizon.

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[1] AEMC, 21 October 2021, Efficient management of system strength on the power system, rule determination, https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

[2] AEMO, December 2022, 2022 System Security Reports

Credible options

We have identified two credible options to meet the identified need.

The first credible option is to install additional synchronous condensers on the South Australian transmission system.

Our preliminary assessment shows we would require up to five additional synchronous condensers (of similar size to the 125 MVA units already installed in South Australia) before July 2028 as more IBR connect with up to three of these required by 2 December 2025.

The assessment of this option will consider the optimal sizing of the synchronous condensers, recognising that installing a smaller number of larger sized units may be a more efficient solution.

The second credible option relies on the availability of cost competitive non-network solutions that can be implemented within the required timeframe to reduce the need for network investment in synchronous condensers. In large part the purpose of this PSCR is to enable these to be identified.

Non-network solutions that could help address the identified need

Potential options to provide an efficient level of system strength may be realised by existing or new plant and could include but are not limited to:

- synchronous generators
- synchronous gas units operating in 'synchronous condenser' mode
- conversion of existing synchronous generators to synchronous condensers
- clean fuel (e.g. hydrogen) based synchronous generators
- synchronous condensers (with or without fly wheels)
- grid forming Battery Energy Storage Systems
- grid forming inverter-based renewable generators, and
- other modifications to existing plants.

We have set out the characteristics that non-network options would need to be capable of to provide the required system strength services.

The accompanying EOI provides greater detail and specifies the type and form of information we are seeking from proponents to have their solution options assessed in the PADR.

The two credible options that could make up the forecast shortfall in AFL, providing an efficient level of system strength are described in Table 1.

We also note that there may be a credible option involving the use of grid forming STATCOMs. We plan to investigate the technical and commercial feasibility of this option.

Reliability Corrective Action

We consider this RIT-T to be a 'reliability corrective action' as the objective is to meet the regulatory obligations and service standards contained in clause 11.14, 3.15 and schedule 5.1.14 of the NER.

Submissions and next steps

The purpose of this PSCR is to set out the identified need, present credible options that address the identified need, outline the technical characteristics non-network options would need to provide, and allow interested parties to make submissions and provide input to the RIT-T assessment.

We welcome written submissions on the information contained in this PSCR by 23 February 2024. Submissions are sought on the options presented, any other credible options available to address the identified need, the classification of this identified need for reliability corrective action and the assessment of materiality of market benefit categories.

Table 1: Summary of credible options

Option	Description	Cost ($FY24 ±30%)
Option 1 Synchronous condensers[3]	**By 2 December 2025** Install 2x 125 MVA synchronous condensers[4] in the Adelaide Metropolitan area ($160m) Install 1x 125 MVA synchronous condenser at Robertstown or Bundey ($80m) **By 1 July 2028** Install a further 1x 125 MVA synchronous condenser in the Adelaide Metropolitan area ($240m) Install a further 1x 125 MVA synchronous condenser at Robertstown or Bundey ($160m)	$400m
Option 2 Non network solutions	Non network solutions may provide all or part of the forecast shortfall, which would reduce the need for a network solution. The assessment of non-network options will depend on responses received to this PSCR and associated EOI. Section 4 of the PSCR and the accompanying EOI provide details of the technical information that the proponents of non-network options need to provide for their option to be considered in this RIT-T.	To be estimated based on responses to the EOI

Submissions should be emailed to consultation@electranet.com.au.

In the subject field, please reference 'Meeting system strength requirements in SA'. Submissions will be published unless a proponent marks their submission (or part of it) as confidential at the time of the submission.

In addition, we are undertaking an EOI for non-network proponents to contribute to meeting system strength needs as set out in this PSCR. Proposals are due by 6pm, 23 February 2024. Submissions to the EOI will not be published on our website.

Proponents are welcome and encouraged to make early submissions and/or engage early with ElectraNet to discuss requirements before the due date above.

The PADR, which is the second stage of the RIT-T process, will include a full options analysis. We expect to publish the PADR in the second half of 2024.

[3] The assessment of this option will consider the optimal sizing and timing of the synchronous condensers, recognising that installing a smaller number of larger sized units may be a more efficient solution, and based on PSCAD analysis and AEMO's latest available IBR forecasts.

[4] The PADR stage of this RIT-T may also consider the benefits vs incremental cost of making them high inertia synchronous condensers.

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Glossary

AACE	The Association for the Advancement of Cost Estimation
AEMO	Australian Energy Market Operator
BESS	Battery Energy Storage System
CB	Circuit Breaker
EFCS	Emergency Frequency Control Scheme
ESCOSA	Essential Services Commission of South Australia
GFM	Grid Forming Inverter
GFL	Grid Following Inverter
GTPS	Generator Technical Performance Standards
H_2 Gen	Hydrogen Gas Synchronous Generator
IBR	Inverter Based Resources
N	System Normal (all transmission elements in service)
N-1	System Normal minus one transmission element
NEM	National Electricity Market
NER	National Electricity Rules
NGM	National Grid Metering
NSP	Network Service Provider (may be a transmission or a distribution entity)
NSCAS	Network Support and Control Ancillary Services
OEM	Original Equipment Manufacturer
OTR	Office of the Technical Regulator
PADR	Project Assessment Draft Report
PSCR	Project Specification Consultation Report
PoW	Point on Wave
PSCAD	Manitoba HVDC Research Centre Ltd. Power System Computer Aided Design software
PSS®E	Siemens PTI Power System Simulator for Engineering load flow software package
PV	Photo-Voltaic

PVT	Power Voltage Transformer
PWM	Pulse Width Modulation
RIT-T	Regulatory Investment Test for Transmission
SA	South Australia
SC	Synchronous Condenser
SCR	Short Circuit Ratio
SSSP	System Strength Service Provider
SSN	System Strength Node
SSQ	System Strength Quantity
STATCOM	Static Synchronous Compensator
STN	Shared Transmission Network
TAPR	Transmission Annual Planning Report
TCA	Transmission Connection Agreement
TEM	Transverse Electromagnetic Mode of propagation
TNSP	Transmission Network Service Provider
WAPS	Wide Area Protection Scheme
WF	Wind Farm
X”	Sub-transient Reactance
Xs	Synchronous Reactance

1. Introduction

National Electricity Rules (NER) Schedule 5.1.14 requires us to provide sufficient system strength services to ensure the forecast efficient amount of new inverter-based renewables will remain stable in steady state conditions and remain synchronised following credible contingency events[5]. The required level is based on AEMO's projected investment in transmission connected Inverter Based Resources (IBR). IBR may require additional system strength to maintain a stable voltage waveform in accordance with clauses 5.2.3 and S5.1.14 of the National Electricity Rules (NER).

We are applying the Regulatory Investment Test for Transmission (RIT-T) to identify the credible option that satisfies our obligations and maximises the present value of net economic benefit to all those who produce, consume and transport electricity.

This Project Specification Consultation Report (PSCR) has been prepared in accordance with the requirements of clause 5.16 of the NER. In line with these requirements, it describes:

- The identified need that ElectraNet is seeking to address, and the assumptions used in identifying the need
- The technical characteristics that a non-network option would be required to deliver to meet the identified need
- All credible options that ElectraNet is aware of that can meet the identified need including technical characteristics
- The classes of market benefit that are likely not to be material.

Publication of this PSCR is the first step in the RIT-T process.

Together with this document, we have released an EOI to provide additional detail on the technical requirements for non-network options and to seek submissions from proponents of these options.

1.1. System strength and Inverter Based Resources

Historically in Australia, the supply of power in High Voltage AC inter-connected power systems has been from synchronous generators that utilise rotating machinery and produce voltage waveforms synchronised to the power system at a more or less constant frequency of 50 Hz.

System strength is the strength[6] of electromagnetic waves propagated as an induced quantity through the transmission conductors. HV transmission lines and transformers support this propagation, allowing the electromagnetic strength to be transferred to locations away from the synchronous generators. With increasing distance from the synchronous generators, this strength declines.

In a network with sufficient system strength, disturbances are isolated by protection equipment and generator performance is managed by control systems to ensure that the system maintains a satisfactory operating state and maintains frequency and phase within secure limits with a stable voltage waveform. In a system with low system strength, these control and protection mechanisms may not work effectively.

Currently, system strength and inertia in the South Australian power system are primarily provided by thermal generators and ElectraNet's four synchronous condensers. As thermal generators retire or change their operating patterns, new sources of system strength will be required to ensure the power system remains secure.

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[5] AEMC, 21 October 2021, Efficient management of system strength on the power system, rule determination, https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

[6] Often represented by the Poynting Vector

As IBR have joined the network, the voltage waveform has come under increasing focus. A stable voltage waveform is the primary reference that “grid following” IBR use to coordinate their power electronics. Until recently, the majority of IBR type equipment has been of the “grid following” type.

Existing “grid following” IBR do not contribute positively to system strength. Instead, they diminish it, relying on the system strength provided by others for their stable operation. At the same time, IBR is displacing the historical providers of system strength services.

1.2. Existing and emerging technologies

Technologies for providing system strength into the future may include:

- Synchronous condensers which are a cost-effective, proven technology. Synchronous condensers (2x 125 MVA at Robertstown and 2x 129 MVA at Davenport) have been deployed in South Australia from 2021 to meet a previous system strength shortfall
- Synchronous generators dispatched in the energy market, such as gas or steam turbine providing system strength as an intrinsic by-product of their operation. System strength services may be provided as part of typical dispatch in the energy market, or as additional generation services[7]
- Emerging technologies such as batteries, STATCOMs or renewable generation with grid-forming inverters. Detailed analysis including wide area EMT studies will be required to evaluate and benchmark the effectiveness of grid forming inverter-based solutions against established technologies, such as synchronous condensers.

1.3. System strength requirements

System strength requirements are considered in AEMO’s Integrated System Plan (ISP) and System Strength Reports. Section 1.1 of AEMO’s 2022 ISP identifies system strength as a fundamental power system requirement. In developing the ISP, AEMO considers the need for system strength/fault levels to be maintained above minimum requirements. AEMO detailed its system strength outlook in Appendix 7 of the 2022 ISP.

AEMO forecasts two system strength requirements:

- Minimum fault level: for the safe and secure operation of power system
- Efficient level of system strength: to facilitate the stable voltage waveform of new inverter-based renewable generators surrounding specified system strength nodes.

Under this framework, system strength is effectively ‘unbundled’ from the operation of the energy market. We are required to make reasonable endeavours to provide system strength with the assumption that IBR will require system strength services to be provided by the System Strength Service Provider.

[7] Synchronous generators could be repurposed as synchronous condensers in some cases

1.4. Submissions and next steps

ElectraNet welcomes written submissions on this PSCR, which are due on or before 23 February 2024. Submissions are sought on the credible options presented, options to address the need, the classification of this identified need as for reliability corrective action and the assessment of materiality of market benefit categories.

Submissions should be emailed to consultation@electranet.com.au.

In the subject field, please reference 'Meeting system strength requirements in SA'. Submissions will be published unless a proponent marks their submission (or part of it) as confidential at the time of the submission.

A Project Assessment Draft Report (PADR), including full option analysis, is expected to be published in the second half of 2024.

2. The identified need

NER S5.1.14 requires us to provide sufficient system strength services to ensure the projected amount of new IBR will remain stable in steady state conditions and remain synchronised following credible contingency events[8].

With the projected growth of IBR connections forecast for SA in AEMO's 2022 System Strength report and based on our projections of required Available Fault Level (AFL), we anticipate a need for additional system strength services in South Australia in the near future.

The actual amount and design of needed additional system strength services will be confirmed by detailed electromagnetic transient program studies in PSCAD, which will form part of our RIT-T assessment to be included in the PADR. This could show that the quantity of system strength services that is needed differs from the amount indicated by the analysis of AFL included in this PSCR.

The identified need for this RIT-T is to provide sufficient system strength services to ensure that we can achieve stable voltage waveforms for the level and type of IBR and market network service facilities projected by AEMO for South Australia, in accordance with Schedule 5.1.14 (b) (2) of the NER.

Based only on the analysis of AFL, our best understanding of the identified need at present is to provide additional system strength equivalent to an additional 1133 MVA of AFL at Robertstown, an additional 537 MVA of AFL at Para and an additional 66 MVA at Davenport from 2 December 2025.

The system strength quantity required to accommodate the forecast IBR will be analysed in detail using PSCAD for the PADR.

We will also consider any variations in forecast IBR growth that may be included in AEMO's 2023 System Strength Report, which is due to be published by 1 December 2023.

We are publishing this PSCR ahead of the AEMO report to enable earlier engagement with proponents of potential non-network solution options.

AEMO has not forecast a shortfall for minimum fault current under NER 5.1.14 (b) (1). We are not expecting any shortfall against the minimum fault level requirements over the forecasting horizon.

2.1. Background to the identified need

2.1.1. Efficient level of system strength

The System Strength Rule Change[8] introduced a new obligation on ElectraNet to provide additional system strength to support the connection of new IBR. New connecting generators have the choice of either procuring system strength services from ElectraNet (which in turn may be procured from non-network option proponents) or providing their own system strength.

AEMO has not specified 'fault level' alone as the metric to ensure a stable voltage waveform and has instead defined four criteria that must be met: voltage magnitude, change in voltage phase angle, voltage waveform distortion and voltage oscillations.[9] Figure 1 illustrates these four criteria for a stable voltage waveform conceptualised around the traditional concept of minimum fault level.

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[8] AEMC, 21 October 2021, *Efficient management of system strength on the power system*, rule determination, https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

[9] AEMO, 30 September 2022, *System Strength Requirements Methodology v2.0*, pp. 20-21, available at https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/system-security-planning

The required Available Fault Level (AFL) covers the efficient level of system strength above and beyond the minimum fault level requirement. This allows TNSPs to innovate in the way that an efficient level of system strength services is provided and provides greater flexibility to value system strength support.

For steady state stable operation of the power system, system strength must meet a standard of minimum fault level. To maintain synchronism during and after a contingency event, further system strength is required above and beyond the minimum level (see light blue shaded area in Figure 1). This extra system strength supports maintaining the four criteria of stable voltage waveform to remain within stable limits of operation for efficient management of IBR connections (Appendix D).

AEMO publishes detailed System Security Reports each year that forecast system strength requirements.

We have relied on AEMO's 2022 System Strength Reports and IBR predictions to estimate the future shortfall in AFL against the efficient level of system strength in preparing this PSCR.

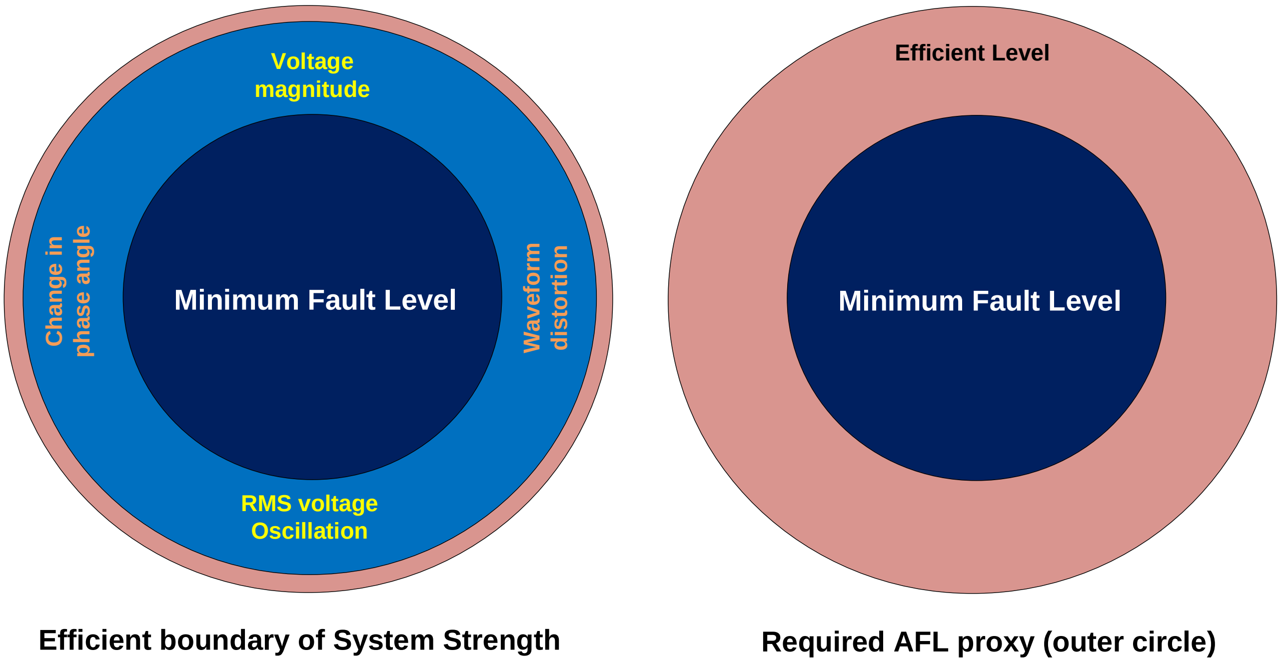

Figure 1: Conceptual representation for efficient level of system strength

2.1.2. Our role in maintaining system strength

Under the NER, we are responsible for meeting specified levels of power system security services in SA, including system strength, inertia and voltage control. As the System Strength Service Provider for SA, we ensure sufficient system strength services are available at all times to maintain the stability of the power system. AEMO forecasts the required levels of system strength under two separate means:

- until 1 December 2025, by specifying the minimum fault level requirements and declaring a fault level shortfall when they forecast that these minimum requirements will not be met as per NER Clause 5.20C.2
- from 2 December 2025, by specifying the minimum (NER S5.1a.9) stable voltage wave form criteria of system strength and through standards determined by AEMO under NER S5.1.14.

AEMO provides system strength forecasts for each of the three 'system strength nodes' in SA, as shown in Figure 2.

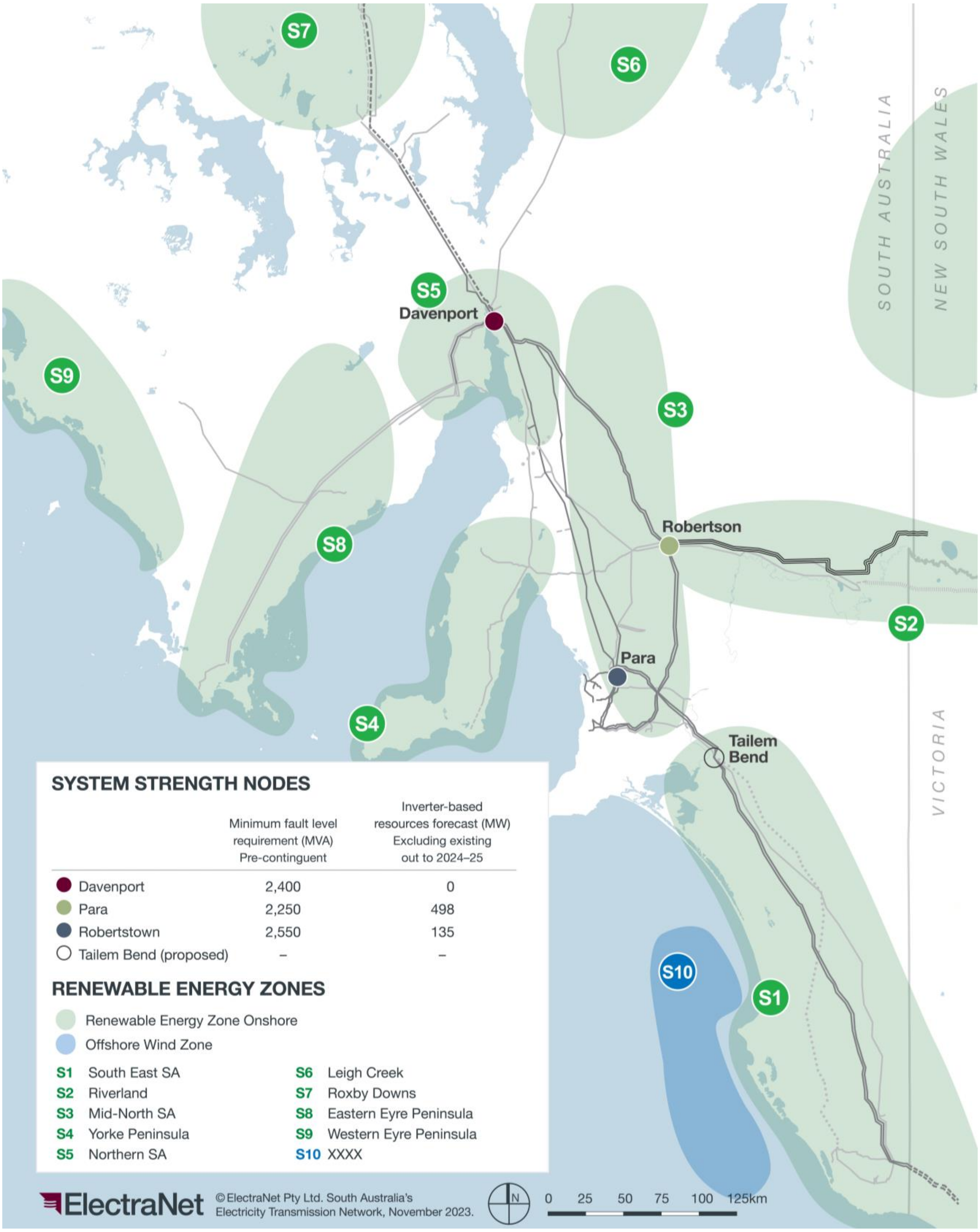

Figure 2: System strength node (SSN) locations and system strength standard in South Australia

Source: AEMO's 2022 System Strength report, pages 45-47.

2.1.3. Efficient management of System Strength

We are responsible for delivering system strength on a forward-looking basis to the standards determined by AEMO, as set out in NER S5.1.14.

AEMO forecasts two system strength requirements:

1. Minimum fault level: for the safe and secure operation of the power system
2. Efficient level of system strength: to facilitate the stable voltage waveform of new IBR generators surrounding specified system strength nodes (Figure 3).

Under this framework, system strength is effectively 'unbundled' from the operation of the energy market. We are responsible for ensuring that the above requirements are met in full at all times.

We are required to meet the system strength requirements in both steady state conditions as well as during contingencies. As such, the number of feeders at each site is an important consideration in determining the location for credible network options.

Requirement 1: Minimum fault level requirements

AEMO sets the minimum three-phase fault level (MVA) required for a secure system at each of the declared system strength nodes in the NEM. There are currently three nodes declared in SA at Davenport, Robertstown and Para, and a new node has been proposed but not yet declared at Tailem Bend.

From 2 December 2025, we must have a solution(s) in place, either network and/or non-network, to meet the minimum level of system strength at each system strength node, in full, at all times of the year. This is a change from the system strength Shortfall methodology, where only the 'shortfall' or gap in South Australia's system strength had to be filled.

Requirement 2: Efficient level of system strength

ElectraNet has an obligation on us to provide additional system strength above the minimum level to support the connection of new inverter-based resources. New connecting generators will have the choice of either procuring system strength services from us (which in turn may be procured from non-network option proponents) or providing their own system strength.

AEMO's specification of the four criteria that relate to a stable voltage waveform, instead of specifying 'fault level' alone as the metric, allows us to innovate in the way that system strength services are provided and provides greater flexibility to value system strength support. For example, studies published by Powerlink[10] indicate that grid forming batteries hold significant promise to contribute towards maintaining stable voltage waveforms, and AEMO has contracted with a grid forming battery for system strength services[11].

[10] Powerlink, 2021, PSCAD assessment of the effectiveness of grid forming batteries, https://arena.gov.au/knowledge-bank/pscad-assessment-of-the-effectiveness-of-grid-forming-batteries/

[11] Edify, June 2022, Financial Close on the largest approved grid forming battery, https://edifyenergy.com/energy-storage-systems/financial-close-on-the-largest-approved-grid-forming-battery/

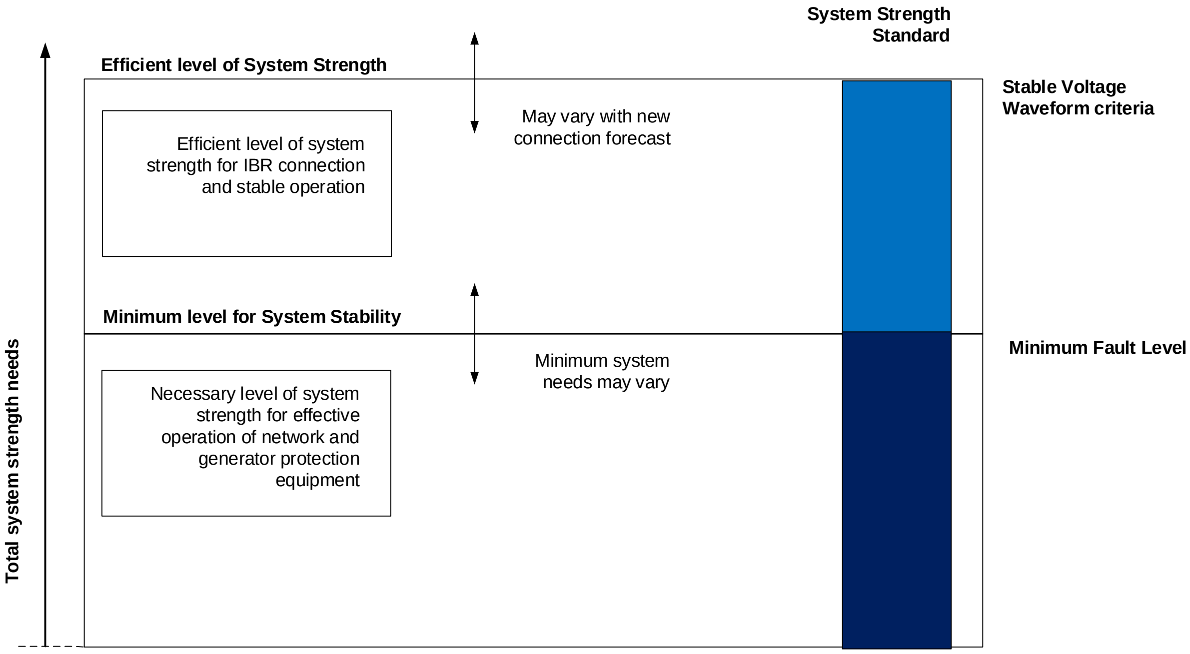

Figure 3: Efficient level of system strength (effective from 2 December 2025)

Novel technologies if applicable to supply system strength services need calibration against proven technologies such as synchronous condensers and synchronous generators[12]. Establishing required levels of electromagnetic fields and propagating energy in response to system contingencies, post-contingency recovery and during steady state operation are essential characteristics of the solutions that may provide system strength to the network of the future for the stable operation of grid connected renewable energy Inverter Based Resources (IBR).

2.2. Reliability Corrective Action

We consider this 'reliability corrective action' as the proposed investment is for the purpose of providing efficient levels of system strength in line with regulatory obligations and service standards, i.e. NER Clause 11.143.15 and NER Schedule 5.1.14.

2.3. Assumptions underpinning the identified need

2.3.1. Forecast IBR growth and system strength requirement

There are currently three declared system strength nodes (SSN) in South Australia: Davenport, Para and Robertstown represented in Figure 2. Table 2 presents AEMO's forecast of IBR allocated to these SSNs.

The IBR growth can be represented for the analysis using only the key years FY26, FY27, FY28, and FY29 as plotted in Figure 4.

[12] Powerlink, 2021, PSCAD assessment of the effectiveness of grid forming batteries, https://arena.gov.au/knowledge-bank/pscad-assessment-of-the-effectiveness-of-grid-forming-batteries/.

Table 2: IBR Forecast (MW) based on Step-Change scenario (Source: AEMO's 2022 System Strength Report)

System Strength Node	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33
Davenport	0	0	0	0	0	0	50	50	50	50	50
Para	0	387	498	498	562	562	1089	1107	1107	1107	1107
Robertstown	0	0	135	954	954	954	1163	1163	1163	1163	1163
Total	**0**	**387**	**633**	**1452**	**1516**	**1516**	**2302**	**2320**	**2320**	**2320**	**2320**

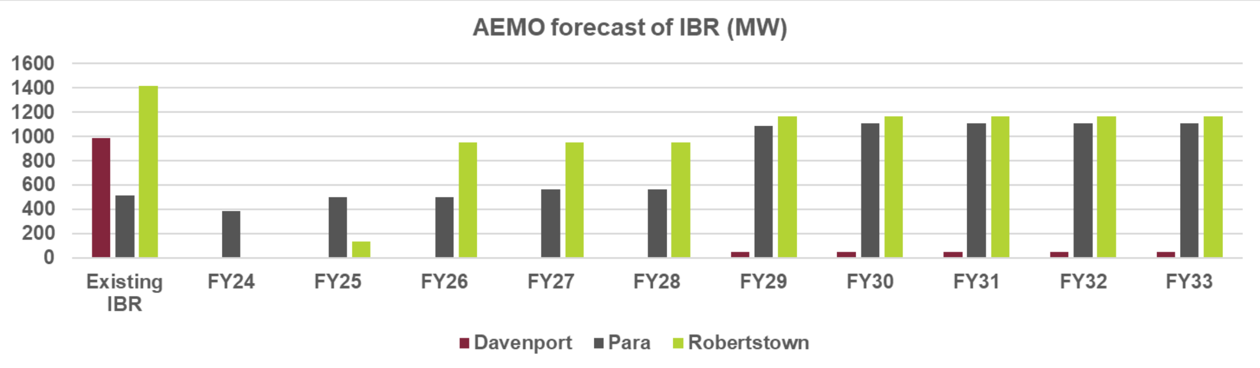

Figure 4: AEMO's forecast of IBR growth in SA (AEMO System Strength Report 2022)

Figure 4 indicates that system strength requirements are expected to increase from 1 July 2025 due to the growing volume of IBR. After 30 June 2029 AEMO forecasts that IBR growth will flatten.

2.3.2. Determination of Available Fault Level and system strength supply

ElectraNet's estimate of AFL at each SSN, which is based on synchronous machines connected to the network, is presented in Table 3. This estimation is presented for both system normal (N) and single contingency (N-1) scenarios.

Table 3: AFL calculated based on existing Synchronous Machines on the Network

AFL (MVA)		FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33
Davenport	N	2556	2556	2671	2672	2672	2672	2672	2672	2672	2672	2672
	N-1	1976	1976	2091	2092	2092	2092	2092	2092	2092	2092	2092
Para	N	2823	2823	2631	2632	2632	2632	2632	2632	2632	2632	2632
	N-1	2269	2269	2402	2435	2435	2435	2435	2435	2435	2435	2435
Robertstown	N	2864	2864	3571[13]	3571	3571	3571	3571	3571	3571	3571	3571
	N-1	2307	2307	3015	3015	3015	3015	3015	3015	3015	3015	3015

[13] New Interconnector PEC commissioning helps improve the AFL proxy values.

2.3.3. Additional required AFL and system strength requirement

The additional required AFL at each SSN has been calculated using the methodology presented in AEMO's System Strength Impact Assessment Guidelines version 2.[14] Table 4 presents the additional required AFL that we have estimated will be needed to provide an efficient level of system strength over the years. Each IBR is modelled as an asynchronous generator with an assumed SCR requirement for stable operation of 3.0 and the required additional AFL is estimated based on short circuit fault levels from PSSE simulation studies (Appendix D).

Table 4: Additional required AFL (MVA) to provide an efficient level of system strength

System Strength Node	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33
Davenport	-	-	-	66	74	74	237	237	237	237	237
Para	-	-	-	537	652	652	1652	1652	1652	1652	1652
Robertstown	-	-	-	1133	1160	1160	1739	1739	1739	1739	1739

The actual amount and design of needed additional system strength services will be confirmed by detailed electromagnetic transient program studies in PSCAD, which will form part of our RIT-T assessment. This could show that the quantity of system strength services needed differs from the amount indicated by the analysis of AFL.

2.3.4. A note on the identified need

The AFL shortfalls presented in Table 4 were calculated[15] based on AEMO's 2022 forecast of IBR volume[16]. This PSCR presents options to meet the identified need based on that forecast.

Pre-feasibility enquiries received by ElectraNet also indicate a higher volume of IBR in the future. We plan to consider a possible scenario of increased volume of IBR connections as a sensitivity in the PADR.

[14] See section 3.4 of AEMO's System Strength Impact Assessment Guidelines, available at https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/ssr/system-strength-impact-assessment-guideline_v2.pdf?la=en&hash=A747F142CFC74FB7A8C8578B6B7A6FB3

[15] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/ssrmiag/amendment/system-strength-impact-assessment-guidelines-v21.pdf?la=en

[16] AEMO 2022 System Strength Report, Published by AEMO, 1 December 2022.

3. Options that meet the identified need

Through this RIT-T we will assess the timing and requirements for the optimal mix of credible option(s) that will address the identified need. In doing so we will ultimately identify the preferred option, which may consist of a combination of network and non-network options.

A credible option is an option which addresses the identified need, is commercially and technically feasible and can be implemented in time to meet the identified need[17]. All known credible options are identified in this chapter. Others may be put forward by proponents in response to this PSCR and associated EOI.

Section 4 and the accompanying EOI provide details on the technical characteristics that a non-network option would need to satisfy to be eligible to form part of the preferred option.

3.1. Base case

Consistent with the RIT-T requirements, the assessment undertaken in the PADR will compare the costs and benefits of each credible option to a 'do nothing' base case. The base case is the hypothetical projected case if no action is taken other than "business-as-usual" activities.

Under the base case, we would not be able to provide sufficient system strength services into the future potentially to the extent shown in Table 4.

Figure 5 indicates the potential escalating AFL gap (indicative of insufficient system strength) due to IBR volume forecast by AEMO in a "do nothing" base case[18].

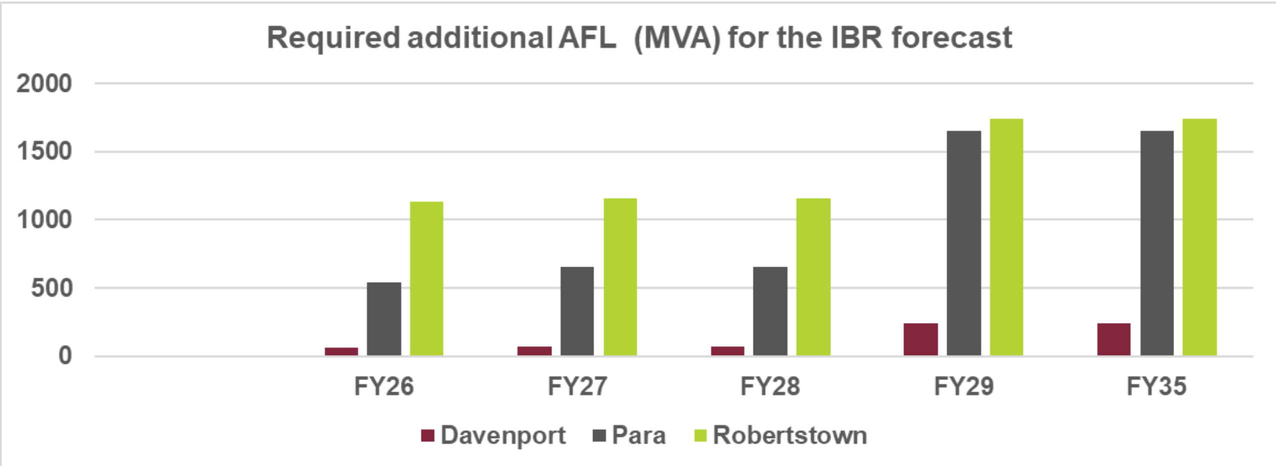

Figure 5: Required additional AFL (MVA) under Base Case – Do nothing Scenario

Insufficient system strength in certain areas of the network could lead to generators being unable to meet their technical performance standards as well as being unable to remain connected to the system at times. This could also lead to voltage instability and a decrease in the effectiveness of the protection systems used by network businesses, generators and large customers. If not addressed, these effects could in turn lead to system instability and major supply interruptions. In this scenario, we expect that AEMO would constrain IBR-based generation in South Australia and/or potentially constrain on or direct synchronous generators into service if required.

[17] As per clause 5.15.2(a) of the NER.

[18] Potential delays in supplying Synchronous Condensers may require procurement of system strength through interim contracts as indicated in Alternatives 1 and 2 in section 3.2.

3.2. Options to address system strength shortfall

We have identified two credible options to meet the forecast AFL requirement.

IBR is forecast at three nodes in South Australia. The credible option and mode of delivery described below will involve investments that are located electrically close to the forecast IBR. The optimal location and timing of the relevant interventions can be expected to be influenced by actual growth in IBR noting that the expectation is to deliver investment in efficient locations identified by AEMO and alternative locations would require self-remediation.

We expect that a combination of the two credible options may be required to address the identified need, including the initial requirement by 2025-26.

3.3. Option 1 - Synchronous Condensers

Option 1 involves constructing synchronous condensers in the metropolitan region and at Robertstown or Bundey substations as the likely optimal locations to address the initial requirement from 2025-26, followed by adding further synchronous condensers in 2028-29.

Table 5 shows the number of 125 MVA synchronous condensers estimated to be required at each SSN. Table 6 summarises the credible option we currently consider can meet the identified need to address the forecast shortfall including details on the proposed investment, estimated capex and fault level contributions for each location.

Table 5: Estimated new synchronous condensers[19] required by location according to AFL analysis

AEMO forecast IBR	2025-26	2026-27	2027-28	2028-29	2034-35
Davenport	0	0	0	0	0
Robertstown	1	1	1	2	2
Metropolitan region	2	2	2	3	3
Total synchronous condensers	3	3	3	5	5

Table 6: Summary of Option 1

When	Least cost configurations	Cost ($FY24 ±30%)
By 2 December 2023	Install 2x 125 MVA synchronous condensers in the Adelaide Metropolitan area ($160m) Install 1x 125 MVA synchronous condenser at Robertstown or Bundey ($80m)	$240m
By 1 July 2028	Install a further 1x 125 MVA synchronous condensers in the Adelaide Metropolitan area ($80m) Install a further 1x 125 MVA synchronous condenser at Robertstown or Bundey ($80m)	$160m

The results of this assessment indicate that Option 1 is expected to provide adequate AFL at each SSN (Figure 6).

[19] Based on an assumed size for each synchronous condenser of 125 MVA.

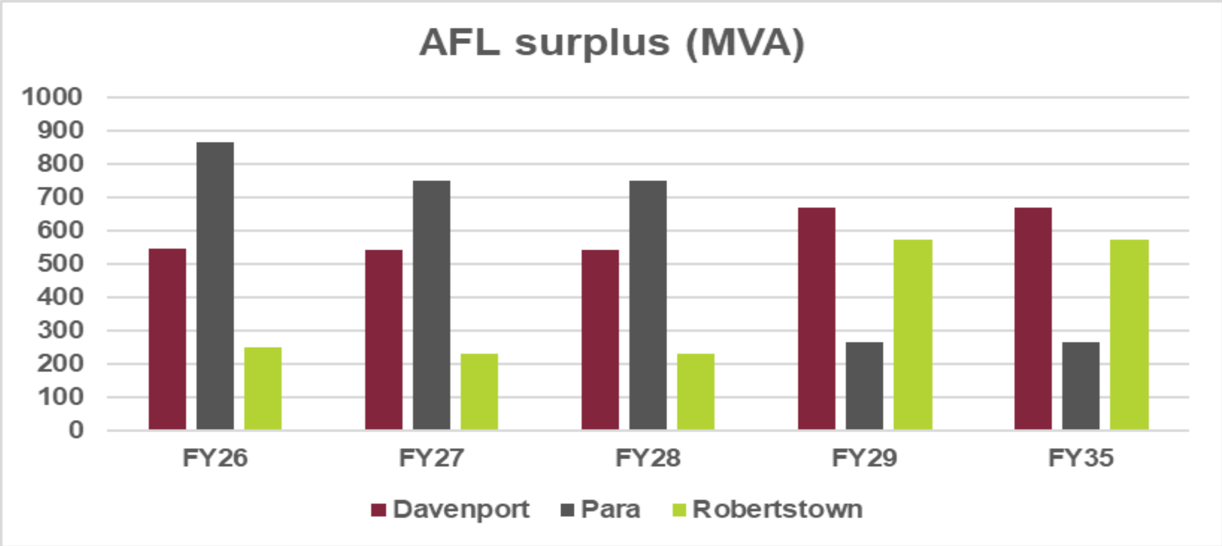

Figure 6: AFL surplus (MVA) with Option 1 – based on AEMO forecast of IBR volume

Option 1 is an entirely network-based solution designed to meet the minimum and efficient levels of system strength under the System Strength Rule Change (using synchronous condensers), requiring the equivalent of three additional 125 MVA synchronous condensers from 2 December 2025, growing to five 125 MVA synchronous condensers from 2028-29 as more inverter-based renewables connect. This is in addition to the existing four synchronous condensers (two each at Davenport and Robertstown). However, timing of these additional synchronous condensers may be optimised if aided with a GFM STATCOM.

In the PADR we will also consider the incremental costs and benefits of making the synchronous condensers high-inertia units.

3.4. Option 2 – Non-network solutions

Non-network solutions may be able to form credible options for this RIT-T, either as standalone options or in combination with network options.

While the ultimate assessment of non-network options will depend on responses received to this PSCR and the accompanying EOI, at this stage we consider these technologies may include, but are not limited to, the following:

- synchronous generators, including hydrogen fuel synchronous generators
- synchronous gas turbine units operating in 'synchronous condenser' mode
- synchronous condensers (with or without fly wheels)
- grid forming battery energy storage systems
- grid forming inverter-based renewable generators
- grid forming STATCOMs, and
- other modifications to existing plant.

Section 4 and the accompanying EOI provide details of the technical characteristics and requirements that a non-network option would need to deliver to address the identified need, and the information that proponents of non- network options would need to provide to enable their option to be considered in this RIT-T.

4. Characteristics for non-network options

This section describes the technical characteristics and requirements that a non-network option would need to deliver to address the identified need.

While this section summarises the expected requirements, the accompanying EOI provides further detail regarding the information we require from proponents in order to have their solutions assessed at the PADR stage. We encourage interested parties to submit their existing or potential non-network solutions.

System strength requirements are as defined in the AEMO's System Strength Requirements Methodology and explained in section 2.1.1.[20] Both network and non-network options will be evaluated based on these technical criteria using EMT models of the plant[21] provided in proposals during the PADR stage of the RIT-T process.

The information provided in response to the EOI will be used to assess non-network options.

Consistent with the AER's RIT-T instrument for non-network options that rely on projects that are not 'committed' we will assess the full cost of the option and the full range of benefits. Proponents should note that this will require them to provide substantial information in relation to these projects.

Economically and technically feasible network and non-network options will be considered together to determine an overall solution that maximises the present value of net economic benefits to all those who produce, transport and use electricity in the market.

4.1. Eligible non-network options

Non-network options must:

- Address the identified need by providing system strength services at one or more nodes in South Australia (from 2 December 2025 onwards) in part or full
- meet the requirements set out in section 4.5 (as applicable)
- be commercially and technically feasible
- provide a material quantity of system strength services, for example from solutions with a rated capacity greater than 100 MVA or AFL contribution amount (e.g. 450 MVA material strength) demonstrated via factory tests or EMT model simulations
- be in the name of one contracting party, and
- be willing to indemnify ElectraNet.

Based on our current understanding of the identified need, the first opportunity for non-network options will commence on 2 December 2025. There may also be the opportunity for non-network system strength services to contribute to providing the increased amount of system strength that is projected to be required from 1 July 2028 (subject to detailed studies to confirm the size and applicable date of the increased system strength requirement).

4.2. Location of non-network options

System strength naturally diminishes with electrical distance based on the network's impedance, which is a function of physical distance and the capacity of the network. As such, non-network

[20] See page 20-23, "System Strength Requirements Methodology", AEMO publication, https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/system-strength-requirements-methodology.pdf?la=en

[21] Proponents are required to submit PSCAD/EMTDCTM models of the plants in addition to RMS models such as PSSe models.

options that are located closer (electrically) to the respective system strength node will provide a greater system strength contribution to that node. Solutions may also contribute to meeting system strength requirements at more than one system strength node.

4.3. Characteristics of non-network options

Potential non-network options should, as applicable to the technology type, commit to:

- be available for enablement for 95% of each year (or part thereof) for which the service is offered. We will, at our discretion, consider lower availability measures where significant cost savings can be demonstrated by doing so
- maintain the service continuously immediately upon notification from AEMO or ElectraNet to enable the services
- remain activated until a signal to disable is received
- continue to meet any relevant Generator Performance Standards (GPS) when providing the system strength support services
- have facilities to transmit specified measured quantities via SCADA to AEMO and/or ElectraNet's control room which conform to the required standards of reliability, accuracy and latency as would be applied to a scheduled generating system
- have metering facilities suitable for resolving any compensation payments associated with the provision of services and have minimum fire risk operation throughout
- demonstrating their capability of maintaining stable voltage waveforms during contingency and normal operations. The four metrics introduced in AEMO's requirements methodology[22] need to be used to prove the capability. This may be further supported by model validation and factory test results
- if a novel solution, being supported by simulation models that comply with the requirements stipulated in AEMO's Power System Model Guidelines. This includes the provision of Electromagnetic Transient (EMT) models for power electronic interfaced equipment, including Battery Energy Storage Systems, and
- if a generation service is proposed (either standalone or in conjunction with other services), to operate "on demand" at certain times to satisfy ElectraNet's power system security requirements regardless of the pool price at the time.

[22] See page 20 of System Strength requirements methodology at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/system-strength-requirements-methodology.pdf?la=en

5. Materiality of market benefits

The NER requires that all categories of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific category (or categories) is unlikely to be material in relation to the RIT-T assessment for a specific option[23].

The PSCR is required to set out the classes of market benefit that the TNSP considers are not likely to be material for a particular RIT-T assessment[24].

At this stage, we consider that all categories of market benefit identified in the RIT-T have the potential to be material with the exception of competition benefits, changes in ancillary services costs and unserved energy.

5.1. Wholesale electricity market impacts

The options considered in this PSCR are expected to affect outcomes in the wholesale market, relative to the base case.

We expect the following categories of market benefit to be estimated using wholesale market modelling as part of the PADR:

- changes in fuel consumption arising through different patterns of generation dispatch
- changes in price-responsive voluntary load curtailment
- avoided/deferred capital and operating expenditure associated with new generation/storage in the NEM[25], and
- differences in the timing of unrelated transmission expenditure (e.g., intra-regional transmission investment associated with the development of REZs).

We will take into account option value as part of the PADR for any options that exhibit the requisite flexibility for option value to exist, e.g. installing larger synchronous condensers to allow for future expansion.

As the credible options considered in this PSCR do not address network constraints between competing generators, and all credible options are expected to meet the system strength requirements, competition benefits are not expected to be material for this RIT-T assessment.

A discussion of why we consider changes in ancillary service costs are not expected to be material for this RIT-T assessment is provided in the section below.

5.2. Changes in ancillary service costs are not expected to be material

While the cost of Frequency Control Ancillary Services (FCAS) may change because of changed generation dispatch patterns and changed generation development following any increase to transfer capacity from the options, we consider that changes in FCAS costs are not likely to be materially different between options and are not expected to be material in the selection of the preferred option. FCAS costs are relatively small compared to total market costs.

There is unlikely to be material changes to the costs of Network Control Ancillary Services (NCAS) or System Restart Ancillary Services (SRAS) because of the options being considered.

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[23] NER clause 5.16.1(c)(6).

[24] NER clause 5.16.4(b)(6)(iii).

[25] Referred to as 'changes in costs for parties, other than for ElectraNet, due to differences in the timing of new plant, capital costs and operating and maintenance costs' under the RIT-T.

Depending on the responses received to this PSCR and the associated EOI, we will consider whether these ancillary service costs are material as part of the PADR.

5.3. Changes in involuntary load shedding are not expected to be material

We do not expect involuntary load shedding will be materially different between options. Each credible option will, by definition, address the system strength shortfall with each option avoiding the same amount of unserved energy. Therefore, quantifying the full extent of avoided involuntary load shedding under each option will not assist in identifying the preferred option under the RIT-T. We note, though, that this means that the analysis will not capture the full benefit of the proposed investment and is likely to show a negative NPV value. This is consistent with this RIT-T being a reliability corrective action.

6. Overview of the assessment approach

This section outlines the approach that we intend to apply for the PADR when assessing the net benefits associated with each of the credible options against the base case.

6.1. Assessment against the base case

As outlined in Section 3.1, all costs and benefits will be measured against a base case where the shortfall or the new requirements to provide a minimum and efficient level of system strength into the future are not provided. Under the base case scenario, SA will experience system strength shortfalls from July 2025, and the magnitude of this shortfall will increase over the next decade.

Under these conditions, it is expected that AEMO would constrain on or direct existing synchronous generators, if any to operate, where possible, to maintain system security. If insufficient system strength is available as thermal generators retire or are unexpectedly unavailable, there is expected to be significant interruption of supply to loads in SA under normal and contingency conditions.

6.2. Assessment period and discount rate

The RIT-T analysis will consider a 20-year assessment period. This period was selected considering the period for which forecasts are available and the size, complexity and expected asset lives of the options and provides a reasonable indication of the costs and benefits over a long outlook period.

Where the capital components of the credible options have asset lives extending beyond the end of the assessment period, the NPV modelling will include a terminal value to capture the remaining asset life. This ensures that the capital cost of long-lived options over the assessment period is appropriately captured, and that all options have their costs and benefits assessed over a consistent period, irrespective of option type, technology or asset life. The terminal values will be calculated based on the undepreciated value of capital costs at the end of the analysis period and expected operating and maintenance cost for the remaining asset life.

At the time of producing the PADR, we would adopt the central scenario discount rate in AEMO's latest Input Assumptions and Scenarios Report (IASR) (currently 5.5 per cent per the latest 2022 IASR). We will also undertake a sensitivity analysis on the discount rates using a lower bound and an upper bound that reflects the upper bound scenario discount rate in AEMO's latest IASR (currently 2.0 per cent and 7.5 per cent per respectively the latest 2022 IASR). The discount rates presented here will be updated to reflect any more recent IASR and AER determination that is published prior to the PADR.

6.3. Approach to estimating option costs

The initial cost estimates presented in this PSCR are subject to change following further analysis. It is intended that cost estimates will be further refined at the PADR stage, and this process may be informed by submissions received from this PSCR. The cost estimates used in this document are AACE International Class 5 cost estimates with a range of -30% to +50%. We will undertake sensitivity analysis on this range of capital costs in the PADR. Estimates have been based on

- Advice from multiple Original Equipment Manufacturers (OEM)
- Recent experience with brownfield developments at Robertstown and Davenport
- Cost escalation.

Initial routine operating and maintenance cost estimates have been estimated at one per cent of the capital expenditure. These costs will also be refined during the PADR stage to reflect what would be incurred under each option.

6.4. Wholesale market modelling based on AEMO's IASR assumptions

We note the importance of ensuring that the outcome of this RIT-T assessment is robust to different assumptions about how the energy sector may develop in the future. Network investments are long-lived assets, and it is important that the market benefits associated with these investments do not depend on a narrow view of potential future outcomes, given that the future is uncertain.

It may be necessary to model the market benefits of the credible options across different scenarios using wholesale market modelling. If so, these scenarios would be based on those consulted on and summarised in the 2023 IASR released by AEMO in July 2023, and would incorporate the forecast of IBR that will be included in AEMO's forthcoming 2023 System Strength Report. The scenarios would be designed to reflect a sufficiently broad range of potential outcomes across the key uncertainties that are expected to affect the future market benefits of the investment options being considered.

6.4.1. Sensitivity analyses

As part of the scenario analysis, we will carry out sensitivity analyses on the results of the most likely scenario to determine whether the outcome of the RIT-T will change, and if so, the extent of this change. This involves carrying out a threshold analysis for network capex and discount rate sensitivities to identify the extent to which the level of network capex and discount rate estimates need to change, to be able to affect the RIT-T outcome.

Given the recent commitment by State Energy Ministers to include an emissions objective in the National Electricity Objective, we also propose to consider the sensitivity of the results if the greenhouse gas emissions implications of each option are considered. The inclusion of an emissions objective will naturally involve trade-offs, requiring a weighing up of the emissions objective along with price, reliability, safety and security. It is unclear at this stage how the emissions objective will be implemented, and therefore how the trade-offs will be weighed up. Considering this, we are currently examining how we might estimate and value the costs of greenhouse gas emissions associated with each option as well as how we would account for this in the RIT-T.

6.4.2. Transparency on the drivers for the timing of the proposed investments

We will outline the factors driving the timing of investments for each of our options in our RIT T. For example, the timing of the proposed investments could also relate to the inflexible timings inherent to the end-to-end process of designing, manufacturing, and constructing the network solution i.e., synchronous condensers.

We will investigate how the timing of the proposed investments for each option would be impacted by changes in the parameters for each scenario e.g., differences in capex spend.

Appendix A: Compliance checklist

This appendix sets out a checklist which demonstrates the compliance of this PSCR with the requirements of the National Electricity Rules.

Rules clause	Summary of requirements	Relevant section
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2
	(3) the technical characteristics of the identified need that a non-network option would be required to deliver, such as: the size of load reduction or additional supply; location; and operating profile;	4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent Integrated System Plan;	N/A
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alternative transmission options, interconnectors, generation, system strength services, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: i. the technical characteristics of the credible option; ii. whether the credible option is reasonably likely to have a material inter-network impact; iii. the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.15A.2(b)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefits are not likely to be material; iv. the estimated construction timetable and commissioning date; and v. to the extent practicable, the total indicative capital and operating and maintenance costs.	3 & 5

Appendix B: Regulatory Terms and Definitions

All laws, regulations, orders, licences, codes, determinations and other regulatory instruments (other than the Rules) which apply to Registered Participants from time to time, including those applicable in each participating jurisdiction as listed below, to the extent that they regulate or contain terms and conditions relating to access to a network, connection to a network, the provision of network services, network service price or augmentation of a network. A comprehensive list of applicable regulatory instruments is provided in the Rules.

Applicable regulatory terms and definitions	
AEMO	Australian Energy Market Operator
Base case	A situation in which no option is implemented by, or on behalf of the transmission network service provider.
Commercially feasible	An option is commercially feasible if a reasonable and objective operator, acting rationally in accordance with the requirements of the RIT-T, would be prepared to develop or provide the option in isolation of any substitute options. This is taken to be synonymous with ‘economically feasible’.
Costs	Costs are the present value of the direct costs of a credible option
Credible option	A credible option is an option (or group of options) that: ▪ address the identified need; ▪ is (or are) commercially and technically feasible; and ▪ can be implemented in sufficient time to meet the identified need.
Economically feasible	An option is likely to be economically feasible where its estimated costs are comparable to other credible options which address the identified need. One important exception to this Rules guidance applies where it is expected that a credible option or options are likely to deliver materially higher market benefits. In these circumstances the option may be “economically feasible” despite the higher expected cost. This is taken to be synonymous with ‘commercially feasible’.
Identified need	The reason why the Transmission Network Service Provider proposes that a particular investment be undertaken in respect of its transmission network.
Market benefit	A benefit to those who consume, produce and transport electricity in the market, that is, the change in producer plus consumer surplus.
Net market benefit	Net market benefit equals the market benefit less costs.
Preferred option	The preferred option is the credible option that maximises the net economic benefit to all those who produce, consume and transport electricity in the market compared to all other credible options. Where the identified need is for reliability corrective action, a preferred option may have a negative net economic benefit (that is, a net economic cost).
Reasonable Scenario	Reasonable scenario means a set of variables or parameters that are not expected to change across each of the credible options or the base case.

Appendix C: Process for implementing the RIT-T

The approximate schedule for the purposes of applying the RIT-T, the NER establishes a typically three stage process, ie: (1) the PSCR; (2) the PADR; and (3) the PACR. This process is basically summarised in the Figure 7 below (in gold).

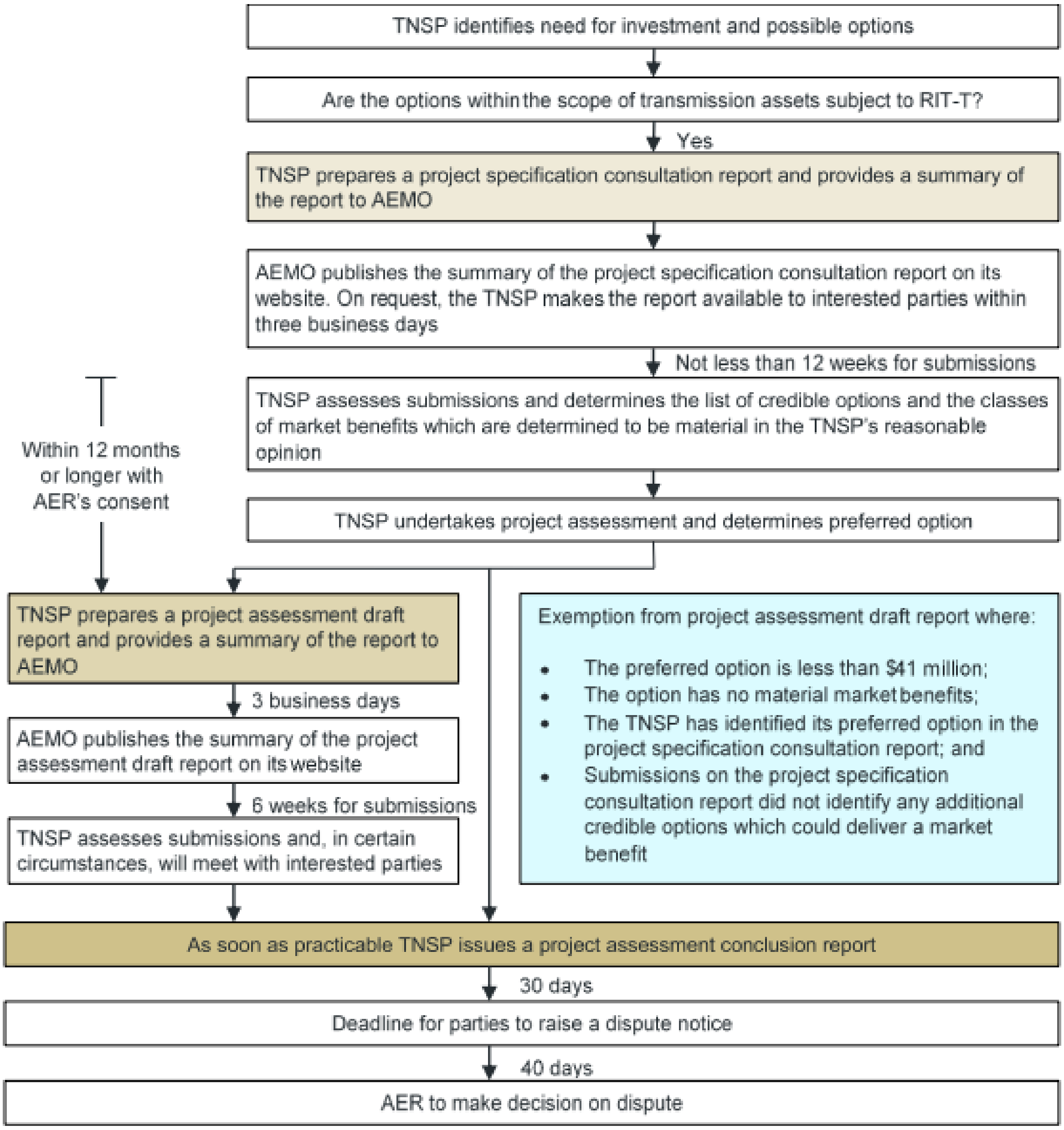

Figure 7: The RIT-T assessment and consultation process

Appendix D: Calculation of Available Fault Level 'proxy' values

Stable voltage waveforms are checked using EMT simulation and the minimum withstand SCR will be recorded.

In the absence of EMT studies, a proxy AFL method with an SCR requirement for stable operation of 3.0 is used (a different SCR requirement for stable operation can be used where it is known for a given connection). Referring to Appendix A of AEMO's System Strength Assessment Guidelines[26] a proxy value of AFL is calculated at each SSN using the following steps:

- Calculate synchronous fault level at the SSN with all synchronous generators at 1.0 pu flat voltage.
- Estimate the fault level at the same SSN with additional connected Asynchronous generation (IBR) modelled as equivalent sources as per AEMO's guidelines[26] on system strength impact assessment.
- The difference between these two values gives the system strength requirement of the IBR connected to the SSN. If that value is numerically above the synchronous fault level, then there is a shortfall in system strength at that SSN.

The impact of IBR on the required AFL at a given SSN is impacted by the forecast IBR at all SSNs but is closely proportional to the SSN's own IBR volume forecast.

[26] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/ssrmiag/amendment/system-strength-impact-assessment-guidelines-v21.pdf?la=en

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