Transfer Limit Advice – South Australia System Strength

December 2018

For the National Electricity Market

Important notice

PURPOSE

AEMO has prepared this document to provide information about the levels of system strength required to securely operate the South Australian region of the NEM with high levels of non-synchronous generation, as at the date of publication.

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VERSION CONTROL

Version	Release date	Changes
19	5 December 2018	Added higher cap levels (1350 to 1460 MW) for 21 combinations.
18	26 November 2018	Revised section on excluded generators/batteries and added Bungala to this list. Added link to System Strength methodology
17	13 September 2018	New AEMO template. Removed HIGH_14 (subset of HIGH_13). Added LOW_39 to LOW_50. Replaced LOW_25, LOW_26, LOW_30 and LOW_35 with new combinations with less generators (mainly removed QPS5). Removed LOW_23B and LOW32. Added note on Dalrymple battery.
16	12 July 2018	Added HIGH_13 and HIGH_14
15	5 July 2018	Added LOW_38
14	28 June 2018	Added LOW_36 and LOW_37
13	30 May 2018	Added LOW_35
12	25 May 2018	Added LOW_34
11	22 May 2018	Added LOW_31, LOW_32 and LOW_33
10	18 May 2018	Renamed LOW_18 as LOW_18A, LOW_17A as LOW_17 and LOW_20A as LOW_20. Removed LOW_17B and LOW_20B. Added ten new combinations LOW_18B and LOW_23 to LOW_30 (these include Mintaro).
9	8 May 2018	Renamed LOW_22 as LOW_22B, LOW_23 as LOW_22A, LOW_17 as LOW_17A and LOW_20 as LOW_20A. Added two new combinations LOW_17B and LOW_20B.
8	27 April 2018	Added five new combinations LOW_19, LOW_20, LOW_21, LOW_22 and LOW_23
7	24 April 2018	Removed LOW_12 (subset of LOW_14) Added two new combinations LOW_17 and LOW_18
6	4 April 2018	Renamed LOW_5 as LOW_5A and added LOW_5B
5	5 March 2018	Added three new combinations (LOW_14, LOW_15 and LOW_16). Added text on how to land securely post-contingency and replaced Table 2 with more detailed examples.
4	8 December 2017	Updated based on new studies. Includes an increase to the non-synchronous generation (for both levels), relabelled conditions, added three new conditions (LOW_11, LOW_12 and LOW_13), and added recommended N-1 scenarios.
3	13 October 2017	Added conditions LOW_9 and LOW_10
2	2 October 2017	Fix to 1700_9 condition (was missing TIPS B)
1	18 September 2017	Initial version

Contents

Tables

1. Introduction

This document describes the requirements for system strength in South Australia (SA) and the methodology for determining these requirements.

System strength reflects the sensitivity of power system variables to disturbances. It indicates inherent local system robustness, with respect to properties other than inertia.

System strength affects the stability and dynamics of generating systems' control systems, and the ability of the power system to both:

- Remain stable under normal conditions, and
- Return to steady-state conditions following a disturbance (such as a fault).

Large synchronous machines (hydro, gas, and coal generation, and synchronous condensers) inherently contribute to system strength.

Non-synchronous generation (batteries, wind, and solar photovoltaic (PV) generation) does not presently provide inherent contribution to system strength.

1.1 Related AEMO publications

AEMO has published a detailed assessment of system strength requirements in South Australia in its South Australia System Strength Assessment[1] report. Requirements for system strength in all regions is included in the System Strength Requirements and Fault Level Shortfalls[2] document.

Other limit advice documents are located at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information/Limits-advice.

The system strength requirements methodology, requirements and fault level shortfalls is located at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/System_Strength_Requirements_Methodology_PUBLISHED.pdf

This document does not describe how AEMO implements these limit equations as constraint equations in the National Electricity Market (NEM) market systems. That is covered in the Constraint Formulation Guidelines, Constraint Naming Guidelines, and Constraint Implementation Guidelines, all available in the Congestion Information Resource on AEMO's website, at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information.

1.2 Methodology

For a complete discussion on the methodology AEMO used to determine system strength requirements in South Australia, see its South Australia System Strength Assessment report.

To develop the Power Systems Computer Aided Design (PSCAD) model of South Australia, AEMO:

1. For a given non-synchronous dispatch level (such as 1,200 MW), identified and downloaded a recent matching load flow (PSS®E) case from AEMO's Operations and Planning Data Management System (OPDMS).

[1] AEMO. South Australia System Strength Assessment, September 2017. Available at: http://www.aemo.com.au/Media-Centre/South-Australia-System-Strength-Assessment.

[2] AEMO. System Strength Requirements Methodology and System Strength Requirements and Fault Level Shortfalls, 1 July 2018. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/System_Strength_Requirements_Methodology_PUBLISHED.pdf

2. Manually modified the PSS®E case to convert it from a snapshot to a system normal case with the required generator dispatch, including:
   - Switching reactive plant to ensure all transmission elements were operating at nominal voltage levels.
   - Dispatching necessary generation in the Adelaide metro area to meet Heywood flow targets.
   - Constraint checks to ensure no existing network limits were being violated.
3. Converted the PSS®E model to an equivalent PSCAD model using the Electranix E-TRAN software and associated libraries.
   - The Murraylink HVDC interconnector was considered to be out of service, to simplify the model, and because Murraylink provides no active power response, and only a minor contribution to fault current during disturbances.
   - The non-SA network was equivalenced at Moorabool in Victoria, with the 500 kV network from Moorabool to Heywood represented in PSCAD. This was the only equivalent bus in the case. It was set to regulate frequency to 50 Hz and maintain a terminal voltage of 1.03 pu.
4. Within this (now) PSCAD case, replaced simplified generating system model with full PSCAD models.
   - Non-synchronous generating systems were replaced with models provided by the manufacturer/asset owner, and wind farms with Suzlon S88 turbines were replaced with a S88 model developed by Manitoba Hydro Research Centre (MHRC) and AEMO based on information from each installation.
   - AEMO developed synchronous generating system models with data from OPDMS, R2 validation reports, datasheets, and protection settings provided by generators. These models were taken from both the South Australia black system models and the models developed for system restart ancillary services (SRAS) procurement studies in 2014–15.
   - Para and South East SVC models were replaced with vendor-specific PSCAD models provided by ElectraNet. Model responses were verified as part of the South Australia black system review work.
5. Added the Heywood Interconnector loss of synchronism relay model with current settings to the PSCAD model. Care was taken with the equivalencing process of the remainder of the NEM, to ensure the behaviour and modelling of the loss of synchronism relay remained realistic
6. Due to the large processing power and differing timestep requirements and incompatibility between some models running in the same case, placed generator models in individual PSCAD cases and linked back to the "top" case using the E-TRAN Plus for PSCAD tool.
   - This tool allows each PSCAD case to be allocated to its own core within a CPU, and communicates with the master PSCAD case using TCP/IP. This method isolates each PSCAD case, avoiding issues relating to two or more incompatible versions of a model being in the same PSCAD case.
7. Replaced load models within the case with a custom PSCAD load component, developed by MHRC that allows the load to be scaled at runtime while still allowing voltage and frequency indexes to be applied.
   - Loads within the South Australia network were set to a Voltage Index for Real Power (Np) of 1.0 and a Voltage Index for Reactive Power (Nq) of 3.0. Load relief was set to 1.5%.

1.3 Non-synchronous generation

The limitation on non-synchronous generation includes all semi-scheduled and non-scheduled plant in South Australia, except where studies show the plant has no impact (positive or negative). Excluded plant includes:

- Hornsdale battery
- Dalrymple battery
- Bungala solar farm (stage 1 and 2)

2. SYSTEM STRENGTH REQUIREMENTS

Table 1 summarises the combinations of synchronous generating units that would provide sufficient system strength to withstand a credible fault and loss of a synchronous unit, at different non-synchronous generation levels.

Table 1 South Australia system strength minimum generator combinations for a secure state

Non-sync generation	Combination	Torrens Island A				Torrens Island B				Pelican Point			Osborne		Quarantine or Dry Creek*	Quarantine and Dry Creek*	Mintaro
		Ax	Ax	Ax	Ax	Bx	Bx	Bx	Bx	GTx	GTx	ST18	GT	ST			
≤ 1,295 MW	LOW_2					■	■			■		■					
≤ 1,350 MW	LOW_3					■	■						■	■	■		
≤ 1,295 MW	LOW_4									■		■	■	■	■		
	LOW_5A	■	■	■		■	■										
≤ 1,350 MW	LOW_5B	■	■			■	■	■									
≤ 1,450 MW	LOW_6					■				■	■	■					
≤ 1,295 MW	LOW_7	■	■							■		■			■		
≤ 1,350 MW	LOW_8	■				■				■		■	■	■			
	LOW_9	■	■	■		■							■	■			
	LOW_10	■	■			■	■						■	■			
≤ 1,295 MW	LOW_11	■								■	■	■					
≤ 1,460 MW	LOW_13	■				■	■	■					■	■			

Non-sync generation	Combination	Torrens Island A				Torrens Island B				Pelican Point			Osborne		Quarantine or Dry Creek*	Quarantine and Dry Creek*	Mintaro
≤ 1,295 MW	LOW_14	■	■			■				■		■					
	LOW_15	■				■				■		■			■		
	LOW_16	■	■	■						■		■	■	■			
≤ 1,350 MW	LOW_17	■	■	■									■	■	■		
≤ 1,295 MW	LOW_18A	■	■	■		■									■		
≤ 1,350 MW	LOW_18B	■				■	■	■							■		
≤ 1,295 MW	LOW_19	■				■	■									■	
≤ 1,400 MW	LOW_20	■	■			■							■	■	■		
	LOW_21	■	■			■	■								■		
≤ 1,350 MW	LOW_22A	■											■	■		■	
	LOW_22B					■							■	■		■	
≤ 1,400 MW	LOW_23A	■	■			■							■	■			■
≤ 1,350 MW	LOW_24	■	■			■									■		■
≤ 1,295 MW	LOW_25					■	■								■		■
	LOW_26	■				■							■	■			■
≤ 1,350 MW	LOW_27	■				■	■								■		■
	LOW_28	■				■	■	■									■
	LOW_29					■	■	■					■	■			■
≤ 1,295 MW	LOW_30	■	■										■	■			■

Non-sync generation	Combination	Torrens Island A	Torrens Island B	Pelican Point	Osborne	Quarantine or Dry Creek*	Quarantine and Dry Creek*	Mintaro
	LOW_31							
	LOW_33							
≤ 1,000 MW	LOW_34							
≤ 1,295 MW	LOW_35							
≤ 1,350 MW	LOW_36							
	LOW_37							
≤ 1,295 MW	LOW_38							
	LOW_39							
	LOW_40							
	LOW_41							
	LOW_42							
	LOW_43							
	LOW_44							
	LOW_45A							
	LOW_45B							
	LOW_46							
≤ 1,350 MW	LOW_47							
≤ 1,295 MW	LOW_48A							
	LOW_48B							
	LOW_49							

Non-sync generation	Combination	Torrens Island A				Torrens Island B				Pelican Point			Osborne		Quarantine or Dry Creek*	Quarantine and Dry Creek*	Mintaro
	LOW_50	■	■													■	■
≤ 1,870 MW – V-SA transfer#	HIGH_2	■	■	■						■		■			■		
	HIGH_3					■	■	■		■	■	■					
	HIGH_4	■	■	■		■	■			■		■					
	HIGH_5					■	■			■		■	■	■	■		
	HIGH_6					■	■	■		■		■	■	■			
	HIGH_7									■	■	■	■	■	■		
	HIGH_9					■	■			■	■	■			■		
	HIGH_10	■	■			■	■			■		■			■		
	HIGH_12					■	■			■	■	■	■	■			
	HIGH_13	■	■			■	■	■		■		■					

* Quarantine 5 and all three Dry Creek units >= 35 MW are interchangeable.

The Vic to SA (Heywood) transfer has only been studied up to 600 MW

While the combinations in Table 1 are secure, the ability to return to a secure state within 30 minutes following a contingency is limited, because many of the synchronous plant take longer than 30 minutes to start up. As such the system needs to land in a secure combination post contingent or return to secure combination within 30 minutes by utilising fast start plant.

Example 1:

If 1 x Torrens Island A, 1 x Torrens Island B, all Pelican Point units and Osborne were online this would satisfy the LOW_6, LOW_8 and LOW_11 combinations. If any of these units were to trip one of the combinations would be still satisfied e.g. if Osborne trips LOW_6 and LOW_11 are satisfied, if the Torrens Island A generator trips LOW_6 is satisfied.

Example 2:

If 2 x Torrens Island B, 1 GT and one ST at Pelican Point were online this would only satisfy LOW_2 pre-contingency. Adding Osborne pre-contingency and Quarantine 5 (or 3 x Dry Creek) post-contingency will satisfy the LOW_2, LOW_3 and LOW_4 combinations pre and post-contingency.

Glossary

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

Term	Definition
Constraint equation	The mathematical representations AEMO uses to model power system limitations and frequency control ancillary services (FCAS) requirements in the National Electricity Market Dispatch Engine (NEMDE).
System normal	The configuration of the power system where: • All transmission elements are in service, or • The network is operating in its normal network configuration.