TRANSFER LIMIT ADVICE – SOUTH AUSTRALIA SYSTEM STRENGTH

FOR THE NATIONAL ELECTRICITY MARKET

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

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 RELEASE HISTORY

Version number	Release date	Author	Comments
13	30 May 2018	Terry Liu	Added LOW_35
12	25 May 2018	Ben Blake	Added LOW_34
11	22 May 2018	Ben Blake	Added LOW_31, LOW_32 and LOW_33
10	18 May 2018	Ben Blake	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	Ben Blake	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	Lochana Perera	Added five new combinations LOW_19, LOW_20, LOW_21, LOW_22 and LOW_23
7	24 April 2018	Ryan Burge	Removed LOW_12 (subset of LOW_14) Added two new combinations LOW_17 and LOW_18
6	4 April 2018	Ben Blake	Renamed LOW_5 as LOW_5A and added LOW_5B
5	5 March 2018	Ben Blake	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	Ben Blake	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	Ben Blake	Added conditions LOW_9 and LOW_10
2	2 October 2017	Ben Blake	Fix to 1700_9 condition (was missing TIPS B)
1	18 September 2017	Ben Blake	Initial version

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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]

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

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*.

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).
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.

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

   - 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 wind farms in South Australia.

The Hornsdale battery is excluded from the non-synchronous generation limit. Studies on the 30 MW (non-system security component) have shown the battery has no impact (positive or negative) on South Australian system strength.

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	QPS5 or Dry Creek 1–3	QPS5 and Dry Creek 1–3	GT
≤ 1,295 MW	LOW_2					■	■			■		■					
	LOW_3					■	■						■	■	■		
	LOW_4									■		■	■	■	■		
	LOW_5A	■	■	■		■	■										
	LOW_5B	■	■			■	■	■									
	LOW_6					■				■	■	■					
	LOW_7	■	■							■		■			■		
	LOW_8	■				■				■		■	■	■			
	LOW_9	■	■	■		■							■	■			
	LOW_10	■	■			■	■						■	■			
	LOW_11	■								■	■	■					
	LOW_13	■				■	■	■					■	■			
	LOW_14	■	■			■				■		■					
	LOW_15	■				■				■		■			■		
	LOW_16	■	■	■						■		■	■	■			
	LOW_17	■	■	■									■	■	■		
	LOW_18A	■	■	■		■									■		
	LOW_18B	■				■	■	■							■		
	LOW_19	■				■	■									■	
	LOW_20	■	■			■							■	■	■		
	LOW_21	■	■			■	■								■		
	LOW_22A	■											■	■		■	

Non-sync generation	Combination	Torrens Island A				Torrens Island B				Pelican Point			Osborne		Quarantine or Dry Creek*	Quarantine and Dry Creek*	Mintaro
	LOW_22B					■							■	■		■	
	LOW_23A	■	■			■							■	■			■
	LOW_23B	■				■	■						■	■			■
	LOW_24	■	■			■									■		■
	LOW_25					■	■									■	■
	LOW_26	■				■							■	■	■		■
	LOW_27	■				■	■								■		■
	LOW_28	■				■	■	■									■
	LOW_29					■	■	■					■	■			■
	LOW_30	■	■										■	■	■		■
	LOW_31	■	■			■	■										■
	LOW_32	■	■	■									■	■			■
	LOW_33					■				■		■				■	
≤ 1000 MW	LOW_34	■	■	■		■											■
≤ 1,295 MW	LOW_35	■								■		■	■	■			■
≤ 1,870 – Vic to SA transfer#	HIGH_2	■	■	■						■		■			■		
	HIGH_3					■	■	■		■	■	■					
	HIGH_4	■	■	■		■	■			■		■					
	HIGH_5					■	■			■		■	■	■	■		
	HIGH_6					■	■	■		■		■	■	■			
	HIGH_7									■	■	■	■	■	■		
	HIGH_9					■	■			■	■	■			■		
	HIGH_10	■	■			■	■			■		■			■		
	HIGH_12					■	■			■	■	■	■	■			

* 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 / Dry Creek post-contingency will satisfy the LOW_2, LOW_3 and LOW_4 combinations pre and post-contingency.

MEASURES, ABBREVIATIONS, AND GLOSSARY

Units of measure

Abbreviation	Unit of measure
MW	A megawatt (MW) is one million watts. A watt (W) is a measure of power. It is defined as one joule per second, and it measures the rate of energy conversion or transfer.

Abbreviations

Abbreviation	Expanded name
HVDC	High Voltage Direct Current
MHRC	Manitoba Hydro Research Centre.
NEM	National Electricity Market.
OPDMS	Operations and Planning Data Management System
PSCAD	Power Systems Computer Aided Design
PSS®E	Power System Simulator for Engineering
QPS	Quarantine Power Station
SA	South Australia
TNSP	Transmission Network Service Provider

Glossary

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.