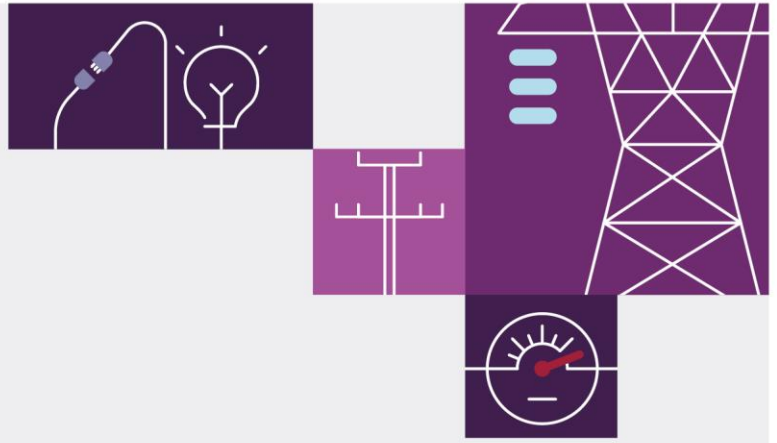


# Victorian Transfer Limit Advice – Outages

December 2024

A report for the National Electricity Market on transfer limits in the Victorian region.





# Important notice

## Purpose

This publication has been prepared by AEMO to provide information about the transfer limit equations for flows to, from and inside Victoria for voltage stability, transient stability, voltage oscillation and voltage unbalance limits or constraint equation performance and related issues, as at the date of publication.

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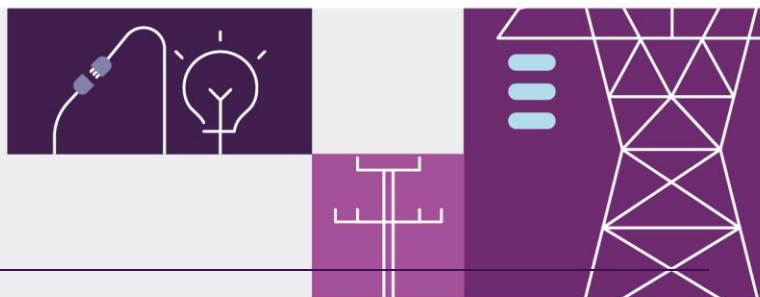
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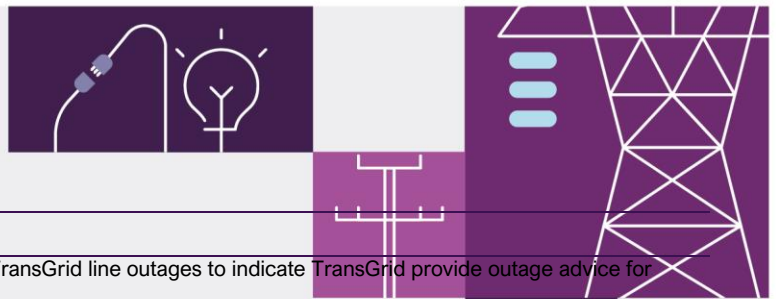
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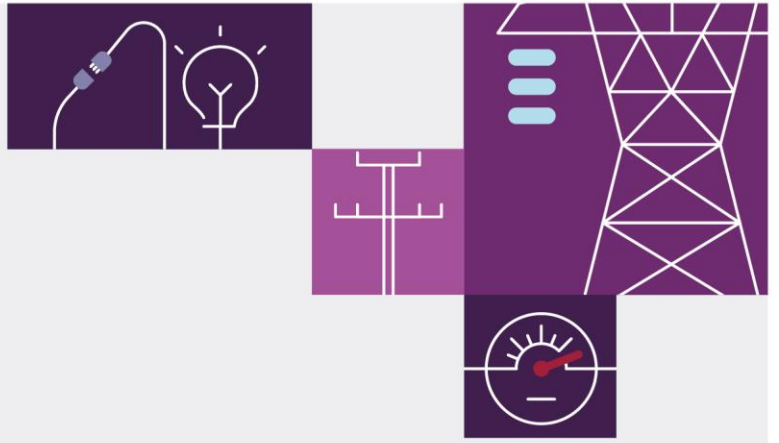


## Version control

Version	Release date	Changes
47	19 December 2024	Added definitions of inverter and turbine limits, removed Buronga – Red Cliffs outage
46	30 October 2024	MLTS-SYTS outage limit and other limits
45	23 August 2024	Updated 0x1 prior outage limit and other limits
44	02 May 2024	Updated several outage limits.
43	30 Oct 2023	Updated Kerang voltage collapse limit for Murraylink outage w.r.t Murraylink VFRB changes, document review, moved voltage oscillation/islanding limits into tables
42	10 April 2022	Updated to new AEMO template.
41	28 March 2022	Update system strength combo for outage of Moorabool – Sydenham 500 kV line. Update Voltage Oscillation Limit and <b>Murraylink voltage stability limit</b> for outage of Bendigo – Shepparton 220 kV line.
40	04 March 2022	Update voltage stability import limits for outage of Dederang to South Morang 330 kV line for the trip of the largest generator in Victoria or Basslink or the trip of the remaining line, and update of voltage stability export limit for the trip of APD.
39	15 January 2022	Update system strength combo for outage of Moorabool – Sydenham 500 kV line and Hazelwood – Loy Yang 500kV line. Updated Kerang voltage collapse limit for Murraylink outage. Updated NSW to VIC voltage stability limits for Murraylink outage.
38	01 October 2021	Updated voltage oscillation limits for the outage of Horsham SVC.
37	23 June 2021	Updated Murraylink voltage stability limits for Bendigo - Kerang 220 kV lines outage. New voltage oscillation limits for the outage of Ballarat – Bendigo 220 kV line.
36	31 May 2021	Updated Murraylink voltage stability limits for Ararat – Waubra – Ballarat, Ararat – Waubra, Ballarat to Waubra 220 kV lines outages.
35	20 May 2021	Updated voltage oscillation limits and update to offsets to Vic to NSW voltage stability export and import limits for Buronga-Red Cliffs 220 kV lines outages.
34	07 April 2021	Updated voltage oscillation limits for Red Cliffs-Wemen-Kerang 220 kV lines outages.
33	22 March 2021	Updated voltage oscillation limits for Kiamal to Red Cliffs outage.
32	25 February 2021	Added system strength requirement for outage of Hazelwood – Loy Yang 500 kV line and Moorabool – Sydenham 500 kV line.
31	19 February 2021	New voltage oscillation limits for outage of Moorabool – Sydenham 500 kV line.
30	5 February 2021	Updated Murraylink voltage stability limits for Ararat – Waubra – Ballarat, Ararat – Waubra, Ballarat to Waubra 220 kV lines outages. Updated table of Parameter Definitions.
29	19 January 2021	Updated voltage oscillation limits for Ararat – Waubra – Ballarat, Ararat – Waubra, Ballarat to Waubra and Ararat - Crowlands 220 kV lines outages. Merge outage section of Ararat to Waubra 220 kV line and Ballarat to Waubra 220 kV line into outage section of Ararat to Waubra to Ballarat 220 kV line.
28	9 December 2020	Updated voltage oscillation limits for Bulgana WF, Bulgana battery and Gannawarra battery for the Bendigo to Kerang outage.
27	24 November 2020	Updated voltage oscillation limits for Horsham and Kerang SVC outages.
26	2 November 2020	Moved outages in NSW and SA to new limits advice doc, added voltage oscillation and islanding limits for Bendigo to Kerang outage.
25	15 October 2020	Updates to X3, X5, Wodonga-Dederang, Wodonga-Jindera, Jindera-Wagga, and Wagga-Darlington Point prior outage voltage oscillation limits. Updated Victorian export voltage stability limit from Victoria to NSW for loss of both APD Potlines, offsets for NSW prior outages.
24	1 September 2020	Updates to voltage unbalance equations for Alcoa Portland to Heywood to Mortlake, Alcoa Portland to Heywood, Moorabool to Haunted Gully and Haunted Gully to Tarrone outages. Added voltage unbalance limits for Moorabool to Mortlake outage. Updated Kiamal limits for Ararat to Waubra to Ballarat and Horsham to Murra Warra to Kiamal. Changed all inverter limit text from “on-line” to “connected”.



Version	Release date	Changes
		Added notes on all TransGrid line outages to indicate TransGrid provide outage advice for these.
23	21 August 2020	Updates to the Kerang to Wemen to Red Cliffs outage limits.
22	31 July 2020	Updates to voltage oscillation and islanding limits for Kiamal to Red Cliffs and Horsham to Murra Warra to Kiamal outages.
21	1 May 2020	Removed the references to the system normal output and inverter limits of Broken Hill, Bannerton, Gannawarra, Karadoc and Wemen solar farms. Corrected minor typos.
20	20 April 2020	Added Ballarat – Bendigo voltage oscillation limits for the condition Bulgana WF is constrained to 5 MW.
19	8 January 2020	Added Buronga – Red Cliffs (OX1) voltage oscillation limits. Added information on when Balranald to Darlington Point (X5) is switched out with other line outages.
18	8 November 2019	Added new limits for Horsham SVC outage.
17	4 October 2019	Added new limits for Kerang SVC outage, updated voltage oscillation limits for 220 kV outages between Horsham and Red Cliffs, updated islanding limits for wind farms for north-west Vic outages.
16	13 September 2019	Added voltage oscillation limits for Buronga – Darlington Point (X5 and X3), Buronga – Red Cliffs (OX1) and Bendigo – Kerang outages, updated limits for Ararat – Waubra – Ballarat. Added limits for solar farms for north-west Vic outages.
15	9 August 2019	Added voltage oscillation limits for Bulgana to Crowlands line, updated information on operating Horsham SVC for north-west Vic outages. Updated Murra Warra limits for Crowlands to Bulgana to Horsham, Horsham to Murra Warra and Kerang to Wemen to Red Cliffs outages. Change inverters to maximum on-line instead of off. Removed voltage unbalance limits for APD-Heywood-Tarrone outage with one Mortlake in service. Added notes to north-west Vic outages that are being reviewed for voltage oscillation limits.
14	29 May 2019	Added voltage oscillation limits for Kerang to Wemen to Red Cliffs lines and changed to have all these line outages into one section in the doc. Added Murraylink voltage collapse limits for outages of Bendigo to Kerang, Ararat to Waubra and Ararat to Waubra to Ballarat lines.
13	14 May 2019	Added voltage oscillation limits for Horsham to Murra Warra line and Red Cliffs to Wemen lines.
12	1 May 2019	Added islanding limits for Ararat to Crowlands, Ararat to Waubra and Crowlands to Bulgana to Horsham outages. Further clean-up of section titles. Updated voltage oscillation limits for Bulgana to Horsham outage.
11	5/4/2019	Updated Murraylink limit for Ballarat to Waubra outage.
10	2/4/2019	Updated voltage oscillation limits for Ballarat to Waubra outage. Changed some section titles.
9	20/3/2019	Updated voltage oscillation limits for Horsham to Red Cliffs, editing and formatting fixes.
8	15/2/2019	Added voltage oscillation limits for Ballarat to Waubra, Horsham to Red Cliffs, Kerang to Wemen to Red Cliffs and Crowlands to Horsham outages.
7	23/11/2018	Updated Voltage stability limit equations, additional prior outage offsets and application of new template.
6	23/07/2018	Updated Voltage stability limit equations.
5	01/08/2017	Updated for Heywood Upgrade post series caps (system normal). Full document review. Updated to new AEMO template. Split multiple outages into separate document. Added voltage unbalance limits.
4	31/03/2015	Added further Victorian import and export limit equations.
3	21/08/2014	Added Victorian import limit equations and updated to new AEMO template.
2	14/11/2013	Updated initial equations, with term for Mount Mercer Wind Farm (MMWF) MW output, added additional prior outage equations.
1	12/03/2012	Initial version.



AEMO acknowledges the Traditional Owners of country throughout Australia and recognises their continuing connection to land, waters and culture. We pay respect to Elders past and present.

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# 1 Introduction

AEMO is responsible for calculating the maximum transient and voltage stability limits into and out of Victoria (National Electricity Rules (NER) S5.1.2.3) in accordance with Power System Stability Guidelines<sup>1</sup>. This document describes the values for these transfer limits for system normal conditions (that is, when all transmission elements are in service) in Victoria.

This limits advice document also describes the methodology used by AEMO to determine the transient and voltage stability limits.

The limit equations for Victoria for cases are described in this document and the following separate documents<sup>2</sup>:

- Victorian Transient Limit Advice – System Normal.
- Victorian Transient Limit Advice – Outages in Adjacent Regions.
- Victorian Transfer Limit Advice – Multiple Outages.

## 1.1 Other AEMO publications

Other limit advice documents are located at <https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource/limits-advice>.

## 1.2 Calculating transient and voltage stability limits

Transfer limit equations are developed for power transfers into and out of Victoria (known as import and export limits respectively). Maximum export is limited by transient stability, whereas maximum import is determined by voltage stability.

Transient stability limit equations are derived from a large number of transient stability studies. Stability studies are based on the application of a 2-phase to ground fault at the most critical fault location.

Voltage stability limit equations are derived from a large number of load flow studies. Studies consider the trip of a large generator, the loss of Basslink when exporting from Tasmania (Tas) to Victoria (Vic), and where appropriate the fault and trip of a critical transmission line or transformer.

### 1.2.1 Methodology

The methodology for calculating voltage and transient stability limits is given below:

1. Generate a set of Power System Simulator for Engineering (PSS/E) cases to represent a wide range of operating conditions.

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<sup>1</sup> AEMO, *Power System Stability Guidelines*, Available at: <https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource>, Viewed on: 6 October 2020.

<sup>2</sup> Available at: <https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource/limits-advice>.

2. Execute a binary search algorithm to search for limiting interconnector power transfer.
3. Linear regression and statistical limit determination.

## 1.3 Calculating voltage unbalance limits

Voltage unbalance is based on the levels of negative sequence voltage. As specified in S5.1a.1 of the NER, the negative sequence voltage needs to be limited to 0.5% of nominal voltage for busbars greater than 100 kV. With the introduction of generation in the southwest of Victoria, AEMO has determined that under specific outage conditions, the voltage unbalance at the Portland smelter (APD) 500 kV busbar can exceed these levels.

The limit equations are defined such that the simulated negative sequence voltage on the APD 500 kV bus does not exceed 0.4 % of nominal voltage<sup>3</sup> for system normal and prior circuit outage conditions. This allows for a margin of 0.1%, which is considered a minimum requirement to account for the following:

- Other sources of unbalance, including effect of loads and generation that were not represented. The simulation results only represent unbalance associated with the transmission network.
- Sufficient measurements of voltage unbalance in the APD area that are not presently available to enable verification or calibration of the simulation model.

As well, the maximum simulated voltage unbalance at APD without the additional generation in the south west of Victoria is 0.4%.

The voltage unbalance levels at APD are influenced by a combination of:

- Voltage balancing effect (or reduction of negative sequence voltage) at Mortlake caused by the Mortlake generators.
- Power flow and associated negative sequence voltage across the Mortlake (MOPS) to Moorabool (MLTS), and Mortlake (MOPS) to Heywood (HYTS) to APD No. 2 500 kV lines (which are not fully transposed).
- Power flow on the Moorabool (MLTS) to Tarrone (TRTS) to Heywood (HYTS) to APD No. 1 500 kV line and mutual coupling with the MOPS-MLTS and MOPS-HYTS-APD No. 2 500 kV lines.


These factors can produce additive or counteractive effects on negative sequence voltage at APD, depending on the direction of power flow in the MOPS-MLTS and MOPS-HYTS-APD No. 2 500 kV lines and adjacent MLTS-TRTS-HYTS-APD No. 1 500 kV line.

### 1.3.1 Methodology

A number of voltage unbalance simulations were performed using a Power Systems Computer Aided Design (PSCAD) model of the 500 kV network. From these results, limit equations were produced to keep the level of voltage unbalance at APD at or below 0.4% during specific outages on the 500 kV network. These equations quantify the relationship between generation, Vic to SA transfer (via Heywood), and where relevant, APD load, such that the simulated voltage unbalance at APD will not exceed 0.4%.

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<sup>3</sup> Line to Line = 2 kV and Line to Neutral = 1.15 kV



It is assumed that the net APD load can vary between 405 MW to 615 MW, and Portland wind farm is capable of generating up to 100 MW.

## 1.4 Calculating voltage oscillation limits

Voltage oscillations and associated instability can occur in parts of the power system that have low system strength, especially during prior outage conditions. To mitigate such oscillations in Western Victoria power system, voltage oscillatory stability limits are determined for low system strength conditions including prior outage conditions. Simulations of large disturbances such as two-phase to ground fault and trip of critical lines are undertaken using PSCAD to determine if the voltage oscillations occur in the power system post-contingency.

Large disturbance simulations of several operating conditions are undertaken to determine the limiting operating conditions of the power system which prevent voltage oscillations from occurring.

### 1.4.1 Methodology

Voltage oscillation stability limits were determined by performing electromagnetic-transient simulations using PSCAD on a model of the north-west Victorian and south-west NSW networks. Several possible power system scenarios including Murraylink power import and export conditions, wind farm and solar farm operating conditions, battery operating conditions and special protection schemes were considered in the simulations.

## 1.5 Inverter and Turbine limits

The following terminology is used by AEMO for limitations on plant with turbines and inverters.

**Disconnected** – The inverters or turbines are physically disconnected from the power system through the opening of a circuit breaker or through the participant advising AEMO that the inverters are physically disconnected from the power system via some other means.

**Blocked** – The inverters or turbines enter a state where they will not respond to any power system changes and are essentially no longer operating/online. For the avoidance of doubt when an inverter or turbine is blocked it will provide no MWs or MVARs and will be prevented from firing and therefore does not impact system strength. When “Blocked” the inverter or turbine may remain physically connected to the power system. In the past AEMO has referred to this in the limits advice as “Pause Mode”

**Constrained to Zero** – The inverter or turbines are constrained to 0 MW output via the local plant controller, or constraints and NEMDE.

## 1.6 Conversion to constraint equations

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. These documents are located in the Congestion Information Resource on the AEMO website, at: <https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource>.

# 2 Alcoa Portland to Heywood to Mortlake 500 kV line

The following limit equations are enabled during an outage of the Alcoa Portland to Heywood to Mortlake 500 kV line and associated line reactor.

## 2.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 1 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-100
Offset to the system normal equation NIL_O	-100

## 2.2 Voltage Unbalance

The following limit equation should be applied to manage the voltage unbalance at APD 500kV and Heywood 275kV buses:

$$\text{Mortlake + Dundonnell generation} - 3.1488 \times \text{Macarthur generation} + 1.9538 \times \text{Vic to SA (Heywood)} \leq 324$$

## 2.3 Islanding

Limitation to prevent islanding of local load following the next credible contingency.

Table 2 Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Macarthur Wind Farm	$\leq 0 \text{ MW}$	



## 3 Alcoa Portland to Heywood 500 kV line

The following limit only applies to the Alcoa Portland to Heywood No.1 500 kV line. No limits are applied to the No.2 line.

### 3.1 Voltage Unbalance

The following voltage unbalance limit should be applied to manage the voltage unbalance at APD 500kV and Heywood 275kV buses:

$$1.85 \times \text{APD Net Load} + \text{Mortlake} + \text{Dundonnell generation} \leq 1535$$

# 4 Alcoa Portland to Heywood to Tarrone 500 kV line

The following limit equations are enabled during an outage of the Alcoa Portland to Heywood to Tarrone 500 kV line.

## 4.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 3 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-80
Offset to the system normal equation NIL_O	-80

## 4.2 Voltage Unbalance

Note: for this outage, all three Heywood transformers remain on load.

For one Mortlake generator in service only:

No MW limit for a single unit in service. For two Mortlake generators in service:

**These limits are under review based on measurements made during the outage with only a single Mortlake generator in service,**

$$\text{Mortlake generation} + 0.353 \times \text{Vic. to SA (Heywood)} \leq 60 - 1.28 \times (\text{APD load} - \text{Portland WF} - 485)$$

Note: in actual outage conditions, it was revealed that the National Electricity Network Dispatch Engine (NEMDE) produced unfeasible market results with the above limit equations (such as exporting more generation from SA than was available with contingency frequency control ancillary services). As a result, the above limit equations have been replaced by constraining Mortlake generation to zero MW.

$$\text{Mortlake generation} = 0$$

## 5 Ararat to Crowlands 220 kV line

The following limit equations are enabled during an outage of the Ararat to Crowlands 220 kV line.

### 5.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

**Table 4** V::N ARTS-HOTS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-80
Offset to system normal equation NILQ	-40
Offset to system normal equation NILS	-80
Offset to system normal equation NILS_decel	-80

### 5.2 Islanding

Limitation to prevent islanding of local load following the trip of the Kiamal to Red Cliffs 220 kV line.

**Table 5** Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Bulgana Wind Farm	$\leq 0 \text{ MW}$	
Bulgana Battery	$=0 \text{ MW}$	<i>0 and disconnected</i>
Crowlands Wind Farm	$\leq 0 \text{ MW}$	
Kiata Wind Farm	$\leq 0 \text{ MW}$	
Kiamal Solar Farm	$\leq 0 \text{ MW}$	<i>0 and disconnected</i>

***Kiamal SynCon switched off***

### 5.3 Voltage Oscillation

To prevent voltage oscillations for trip of a Bendigo to Kerang 220 kV line the following limits are applied:

**Table 6** Voltage oscillation limits

Generator	MW Limit
Ararat Wind Farm	$\leq 60 \text{ MW}$
Bannerton Solar Farm	$\leq 20 \text{ MW}$



Generator	MW Limit
Broken Hill Solar Farm	≤ 25 MW
Coleambally Solar Farm	≤ 60 MW
Darlington Point Solar Farm	≤ 110 MW
Finley Solar Farm	≤ 55 MW
Gannawarra Solar Farm	≤ 15 MW
Karadoc Solar Farm	≤ 20 MW
Limondale 1 Solar Farm	≤ 85 MW
Limondale 2 Solar Farm	≤ 15 MW
Murra Warra 1+2 Wind Farm	≤ 60 MW
Murraylink (SA to Vic)	≤ 150 MW
Murraylink (Vic to SA)	≤ 150 MW
Silverton Wind Farm	≤ 80 MW
Sunraysia Solar Farm	≤ 80 MW
Waubra Wind Farm	≤ 0 MW and 0 MVar
Wemen Solar Farm	≤ 20 MW
Yatpool Solar Farm	≤ 20 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

## 6 Ararat to Waubra to Ballarat 220 kV line

The following limit equations are enabled during an outage of the Ararat to Waubra to Ballarat 220 kV line, or Ararat to Waubra 220 kV line or Ballarat to Waubra 220 kV line unless indicated.

### 6.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum} [\text{Term Values} * \text{System Normal Coefficients}] + \text{Offset}$$

Table 7 V::N ARTS-WBTS-BATS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-100
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	-100
Offset to system normal equation NILS_decel	-100

### 6.2 Voltage Stability – Murraylink

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Bendigo to Kerang 220 kV line, apply the following prior outage limit equations. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum} [\text{Term Values} * \text{Coefficients}]$$

Table 8 V^S [MRLK] ARTS-WBTS-BATS

Term	Coefficient
Intercept	243
RCTS-MLK_MVAR	-0.7445
WETS Load	-2.126
BETS Load	-0.7796
DARL_PT_3WTX_MW	0.253
HOTS-66CAP	1.565
Confidence Level (95%) offset	-53.6

## 6.3 Islanding

Limitation to prevent islanding of local load following the trip of the Kiamal to Red Cliffs 220 kV line.

**Table 9** Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Ararat Wind Farm	$\leq 0$ MW	
Bulgana Wind Farm	$\leq 0$ MW	
Bulgana Battery	$= 0$ MW	0 and disconnected
Crowlands Wind Farm	$\leq 0$ MW	
Kiata Wind Farm	$\leq 0$ MW	
Kiamal Solar Farm	$\leq 0$ MW	0 and disconnected

*Kiamal SynCon switched off*

## 6.4 Voltage Oscillation

To prevent voltage oscillations for trip of a Bendigo to Kerang 220 kV line the following limits are applied:

**Table 10** Voltage oscillation limits

Generator	MW Limit
Bannerton Solar Farm	$\leq 20$ MW
Broken Hill Solar Farm	$\leq 25$ MW
Coleambally Solar Farm	$\leq 60$ MW
Darlington Point Solar Farm	$\leq 110$ MW
Finley Solar Farm	$\leq 55$ MW
Gannawarra Solar Farm	$\leq 15$ MW
Karadoc Solar Farm	$\leq 20$ MW
Limondale 1 Solar Farm	$\leq 85$ MW
Limondale 2 Solar Farm	$\leq 15$ MW
Murra Warra 1+2 Wind Farm	$\leq 60$ MW
Murraylink (SA to Vic)	$\leq 150$ MW
Murraylink (Vic to SA)	$\leq 150$ MW
Silverton Wind Farm	$\leq 80$ MW
Sunraysia Solar Farm	$\leq 80$ MW
Waubra Wind Farm	$\leq 0$ MW and $\leq 0$ MVAR
Wemen Solar Farm	$\leq 20$ MW
Yatpool Solar Farm	$\leq 20$ MW

*Horsham SVC switched off or set to manual mode with a fixed Q setpoint*

# 7 Ballarat to Bendigo 220 kV line

The following limit equations are enabled during an outage of the Ballarat to Bendigo 220 kV line.

## 7.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

**Table 11** V::N BATS-BETS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-60
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	-60
Offset to system normal equation NILS_decel	-60

## 7.2 Voltage Stability – Murraylink

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Buronga to Balranald to Darlington point 220 kV line, apply the following prior outage limit equations. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 12** V^S [MRLK] BATS-BETS\_X5

Term	Coefficient
Intercept	497.4
RCTS Load	-1.003
KGTS Load	-2.599
HOTS Load	-1.978
BATS TX MW	-0.2051
BKNH TX MW	-0.5091
BHSS220 Load	-1.122
HOTS SVC Out of Service	-14.20
KGTS SVC Out of Service	-18.67
VIC to NSW	0.01021



Term	Coefficient
Confidence Level (95%) offset	-33

### 7.3 Voltage Oscillation

To prevent voltage oscillations for trip of Bendigo to Shepparton 220kV line the following limits applied:

**Table 13 Voltage oscillation limits**

Generator	MW Limit
Ararat wind farm	≤ 120 MW
Bannerton Solar Farm	≤ 25 MW
Bulgana Wind Farm	≤ 50 MW
Broken Hill Solar Farm	≤ 25 MW
Coleambally Solar Farm	≤ 40 MW
Crowlands Wind Farm	≤ 40 MW
Darlington Point Solar Farm	≤ 60 MW
Finley Solar Farm	≤ 40 MW
Gannawarra Solar Farm	≤ 25 MW
Karadoc Solar Farm	≤ 25 MW
Kiamal Solar Farm	≤ 50 MW
Limondale 1 Solar Farm	≤ 50 MW
Limondale 2 Solar Farm	≤ 10 MW
Murra Warra 1+2 Wind Farm	≤ 60 MW
Murraylink (SA to Vic)	≤ 150 MW
Murraylink (Vic to SA)	≤ 150 MW
Silverton Wind Farm	≤ 50 MW
Sunraysia Solar Farm	≤ 60 MW
Wemen Solar Farm	≤ 25 MW
Yatpool Solar Farm	≤ 25 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

***Kerang SVC switched off or set to manual mode with a fixed Q setpoint***

## 8 Bendigo to Kerang 220 kV line

The following limit equations are enabled during an outage of the Bendigo to Kerang 220 kV line.

### 8.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

Table 14 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-60
Offset to the system normal equation NIL_O	-60

### 8.2 Voltage Stability – Murraylink

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Ararat to Waubra to Ballarat 220 kV line, apply the following prior outage limit equations. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

Table 15 V^S [MRLK] BETS-KGTS

Term	Coefficient
Intercept	269.3
RCTS Load	-0.4457
WETS Load	-1.828
KGTS Load	-2.276
RCTS-MLK_MVAR	-0.7164
Q3-REDCLF 220	0.6137
Q2-BURNGA 220	0.5999
HOTS_TX1_TX2 MW	-0.5086
HOTS_TX1_TX2 MVAR	-0.2575
Confidence Level (95%) offset	-45

## 8.3 Islanding

Limitation to prevent islanding of local load following the trip of the Kerang to Wemen to Red Cliffs 220 kV line.

**Table 16** Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Cohuna Solar Farm	$\leq 0$ MW	0 and disconnected
Gannawarra Solar Farm	$\leq 0$ MW	0 and disconnected
Gannawarra Battery	$= 0$ MW	0 and disconnected

## 8.4 Voltage Oscillation

To prevent voltage oscillations for trip of Ararat to Waubra to Ballarat 220 kV line the following limits applied:

**Table 17** Voltage oscillation limits

Generator	MW Limit
Bannerton Solar Farm	$\leq 25$ MW
Broken Hill Solar Farm	$\leq 25$ MW
Coleambally Solar Farm	$\leq 45$ MW
Darlington Point Solar Farm	$\leq 80$ MW
Finley Solar Farm	$\leq 45$ MW
Karadoc Solar Farm	$\leq 25$ MW
Kiamal Solar Farm	$\leq 50$ MW
Kiata Wind Farm	$\leq 0$ MW (can be operated Blocked)
Limondale 1 Solar Farm	$\leq 60$ MW
Limondale 2 Solar Farm	$\leq 25$ MW
Murra Warra 1+2 Wind Farm	$\leq 0$ MW (can be operated Blocked)
Murraylink (SA to Vic)	$\leq 150$ MW
Murraylink (Vic to SA)	$\leq 150$ MW
Sunraysia Solar Farm	$\leq 60$ MW
Wemen Solar Farm	$\leq 25$ MW
Yatpool Solar Farm	$\leq 25$ MW

# 9 Bendigo to Shepparton 220 kV line

The following limit equations are enabled during an outage of the Bendigo to Shepparton 220 kV line.

## 9.1 Voltage Stability – Murraylink

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of Buronga to Balranald to Darlington point 220 kV line, apply the following prior outage limit equation. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid.

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 18** VAS [MRLK] BETS-SHTS\_X5

Term	Coefficient
Intercept	376.5
RCTS Load	-1.151
KGTS Load	-2.486
BHSS220 Load	-2.267
BKNH TX MW	-0.5398
BATS TX MW	-0.8298
HOTS SVC out of service	-19.85
KGTS SVC out of service	-20.73
Confidence Level (95%) offset	-29.78

## 9.2 Voltage Oscillation

To prevent voltage oscillations the following limits applied:

**Table 19** Voltage oscillation limits

Generator	MW Limit
Ararat Wind Farm	≤ 70 MW
Bannerton Solar Farm	≤ 25 MW
Broken Hill Solar Farm	≤ 25 MW
Bulgana Wind Farm	≤ 30 MW
Coleambally Solar Farm	≤ 90 MW
Crowlands Wind Farm	≤ 25 MW
Darlington Point Solar Farm	≤ 165 MW



Generator	MW Limit
Finley Solar Farm	≤ 90 MW
Gannawarra Solar Farm	≤ 15 MW
Karadoc Solar Farm	≤ 30 MW
Kiata Wind Farm	≤ 10 MW
Kiamal Solar Farm	≤ 60 MW
Limondale 1 Solar Farm	≤ 120 MW
Limondale 2 Solar Farm	≤ 15 MW
Murra Warra 1+2 Wind Farm	≤ 60 MW
Murraylink (SA to Vic)	≤ 150 MW
Silverton Wind Farm	≤ 100 MW
Sunraysia Solar Farm	≤ 120 MW
Wemen Solar Farm	≤ 25 MW
Yatpool Solar Farm	≤ 25 MW

# 10 Cranbourne to Hazelwood 500 kV line

The following limit equations are enabled during an outage of the Cranbourne to Hazelwood 500 kV line.

## 10.1 Transient stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 20 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-250
Offset to the system normal equation NIL_O	-250

# 11 Crowlands to Bulgana to Horsham 220 kV line

The following limit equations are enabled during an outage of the Crowlands to Bulgana, Bulgana to Horsham or Crowlands to Bulgana to Horsham 220 kV lines unless indicated.

## 11.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

**Table 21** V::N ARTS-HOTS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-80
Offset to system normal equation NILQ	-40
Offset to system normal equation NILS	-80
Offset to system normal equation NILS_decel	-80

## 11.2 Islanding

Limitation to prevent islanding of local load following the trip of the Kiamal to Red Cliffs 220 kV line.

**Table 22** Islanding limits

Generator	MW Limit	inverter
Kiata Wind Farm	$\leq 0 \text{ MW}$	
Kiamal Solar Farm	$\leq 0 \text{ MW}$	0 and disconnected

***Kiamal SynCon switched off***

For an outage of the Bulgana to Crowlands 220 kV line section the following islanding limit also applied:

**Table 23** Islanding limit

Generator	MW Limit
Bulgana Wind Farm	$\leq 0 \text{ MW}$

## 11.3 Voltage Oscillation

To prevent voltage oscillations for trip of a Bendigo to Kerang 220 kV line the following limits are applied:

**Table 24 Voltage oscillation limits**

Generator	MW Limit	Inverter / Turbine maximum
Bannerton Solar Farm	$\leq 45 \text{ MW}$	$\leq 22$ inverters connected, otherwise 0 MW
Broken Hill Solar Farm	$\leq 30 \text{ MW}$	$\leq 44$ inverters connected, otherwise 0 MW
Gannawarra Solar Farm	$\leq 30 \text{ MW}$	$\leq 12$ inverters connected, otherwise 0 MW
Karadoc Solar Farm	$\leq 45 \text{ MW}$	$\leq 21$ inverters connected, otherwise 0 MW
Murra Warra 1+2 Wind Farm	$\leq 15 \text{ MW}$	$\leq 30$ inverters connected, otherwise 0 MW
Wemen Solar Farm	$\leq 45 \text{ MW}$	$\leq 21$ inverters connected, otherwise 0 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

***Kerang SVC switched off or set to manual mode with a fixed Q setpoint***

For the outage of the Bulgana to Horsham 220 kV line the following limit is also applied:

**Table 25 Voltage oscillation limit**

Generator	MW Limit
Bulgana Wind Farm	$\leq 130 \text{ MW}$



## 12 Dederang to Mount Beauty 220 kV line

The current system normal limits are adequate to manage the prior-outage of one Dederang to Mount Beauty 220 kV line.

# 13 Dederang to Murray 330 kV line

The following limit equations are enabled during an outage of one Dederang to Murray 330 kV line.

Note: these limits are in addition to the limits provided by TransGrid for this outage.

## 13.1 Transient Stability – Vic to NSW

### 13.1.1 V::N DDTS-MSS-V

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Dederang to Murray 330 kV line (where Victoria accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$

Table 26 V::N DDTS-MSS-V coefficients

Term	Coefficient
Intercept	994.7
Basslink	0.1248
Vic. to SA (Heywood)	0.07176
Vic. to SA (Heywood)^2	-2.59e-4
Vic. to SA (Murraylink)	-0.5758
LV 500 Inertia	1.439
EPS Inertia	3.446
MOPS Inertia	2.061
KIEWA Inertia	6.499
SNOWY Inertia	1.392
Murray Gen	0.8731
LV 220 Gen	0.09512
VIC Metro Gen	0.1612
State Grid Load North	-0.4595
Vic Wind & Solar	0.06173
VIC Demand - State Grid Load North	-0.4486
220 kV_Caps	-0.1013
Num. ROTS SVC	13.52
Confidence Level (95%) offset	-64

### 13.1.2 V::N DDTS-MSS-S

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Dederang to Murray 330 kV line (where South Australia accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 27 V::N DDTS-MSS-S coefficients**

Term	Coefficient
Intercept	1036
Basslink	0.08914
Vic. to SA (Heywood)	-0.0383
Vic. to SA (Heywood)^2	-1.2e-4
Vic. to SA (Murraylink)	-0.5229
LV 500 Inertia	1.072
EPS Inertia	4.662
MOPS Inertia	1.288
LV 220 Inertia	-4.738
KIEWA Inertia	2.931
SNOWY Inertia	1.081
Murray Gen	0.8924
Kiewa Gen	0.206
LV 220 Gen	0.2181
VIC Metro Gen	0.149
State Grid Load North	-0.3608
APD Load	-0.07564
Vic Wind & Solar	0.07921
VIC Demand - State Grid Load North - APD Load	-0.04914
220 kV_Caps	-0.070
Num. ROTS SVC	15.68
Confidence Level (95%) offset	-67

## 13.2 Voltage Stability – NSW to Vic

### 13.2.1 Largest Vic generator or Basslink trip

To manage Victorian voltage stability import limit from NSW to Victoria for fault and trip of Basslink or the loss of the largest Victorian generator, apply the following limit equation. Studies monitor post-contingent voltages and reactive power margin in northern Victoria and southern NSW. The limit equation is of the form:

$$NSW\ to\ Victoria \leq -1 * Sum [Term\ Values * Coefficients]$$

**Table 28 VAN DDTS-MSS BLVG coefficients**

Term	Coefficient
Intercept	-1535
Contingent_MW	0.9062
SW_NSW	0.7723
NSWd-SW_NSW	0.02759
STH_NSW_GEN	-0.07476

Term	Coefficient
UTUM1SC+UTUM2SC	-20.47
LTUM3SC	-67.3
MSS2SC	-52.63
DD330Cap	-0.2519
WAGGACap	-0.2607
MSSReac	-0.3413
YASSReac	-0.1853
U_TUMUT_Gen	-0.4923
L_TUMUT_Gen	-0.3274
MURRAY_Gen	0.61
UQT Gen	-0.516
BKNH_GEN	-1.038
Num. MSS1 on	-19.27
Confidence Level (95%) offset	+65.0

### 13.2.2 Dederang to Murray 330 kV line trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of the remaining Dederang to Murray 330 kV line, apply the following limit equation. Studies monitor post-contingent voltages and reactive power margin in northern Victoria and southern NSW. The limit equation is of the form:

$$NSW\ to\ Victoria \leq -1 * Sum [Term\ Values * Coefficients]$$

Table 29 VAN DDTS-MSS DDMS coefficients

Term	Coefficient
Intercept	-886
SW_NSW	0.6468
UTUM1SC+UTUM2SC	-14.75
LTUM3SC	-32.13
MSS2SC	-19.60
WAGGACap	-0.1989
DLPTshnt	-0.4695
MSSReac	-0.1648
YASSReac	-0.09942
U_TUMUT_Gen	-0.1822
L_TUMUT_Gen	-0.04036
MURRAY_Gen	0.9568
UQT Gen	-0.4729
HUME VIC GEN	-1.819
BKNH GEN	-0.9831
Num. MSS1 on	-10.66
Confidence Level (95%) offset	+65





## 13.3 Voltage Stability – Vic to NSW

### 13.3.1 Trip of both APD Potlines or the trip of the remaining Dederang-Murray line

To manage the Vic to NSW voltage stability export limit from Victoria to NSW for loss of both APD Potlines or the trip of the remaining Dederang-Murray 330 kV line, apply the following prior outage offset to the system normal equation  $V^N_{2xAPD}$ . The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients] + Offset}$$

Table 30  $V^N_{2xAPD}$  offset

Term	Offset
Offset to system normal $V^N_{2xAPD}$	-170

# 14 Dederang to South Morang 330 kV line

The following limit equations are enabled during an outage of one Dederang to South Morang 330 kV line.

## 14.1 Transient Stability – Vic to NSW

### 14.1.1 V::N DDTS-SMTS-V

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Dederang to South Morang 330 kV line (where Victoria accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 31** V::N DDTS-SMTS-V coefficients

Term	Coefficient
Intercept	847.5
Basslink	0.1478
Vic. to SA (Heywood)	0.1098
Vic. to SA (Heywood)^2	-4.28e-4
Vic. to SA (Murraylink)	-0.901
LV 500 Inertia	1.95
EPS Inertia	16.34
MOPS Inertia	1.854
SNOWY Inertia	0.836
VIC Metro Gen Inertia	1.558
Murray Gen	0.8631
Kiewa Gen	1.057
LV 220 Gen	0.1268
VIC Metro Gen	0.1087
State Grid Load North	-0.8808
Vic Wind & Solar	0.1184
VIC Demand - State Grid Load North	-0.08903
Both TAIL- SESS Series Caps Out	17.552
Num. ROTS SVC	18.34
Confidence Level (95%) offset	-67

### 14.1.2 V::N DDTS-SMTS-S

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Dederang to South Morang 330 kV line (where South Australia accelerates ahead of the other states), apply the following limit equation

**Victoria to NSW  $\leq$  Sum [Term Values \* Coefficients]**

**Table 32 V::N DDTS-SMTS-S coefficients**

Term	Coefficient
Intercept	972.9
Basslink	0.1097
Vic. to SA (Heywood)^2	-2.74e-4
Vic. to SA (Murraylink)	-0.849
LV 500 Inertia	1.527
EPS Inertia	19.58
MOPS Inertia	2.563
KIEWA Inertia	2.001
SNOWY Inertia	0.5206
VIC Metro Gen Inertia	3.017
Murray Gen	0.9295
Kiewa Gen	0.9608
LV 220 Gen	0.09506
State Grid Load North	-0.8921
Vic Wind & Solar	0.1513
VIC Demand - State Grid Load North	-0.09823
Num. ROTS SVC	19.1
Confidence Level (95%) offset	-70

The above outage Vic-NSW transient stability limits are also applicable to the multiple outage combination of lines 62 + X5 + Dederang to South Morang 330 kV line.

## 14.2 Voltage Stability – NSW to Vic

### 14.2.1 Largest Vic generator or Basslink trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of Basslink or the loss of the largest Victorian generator, apply the following prior outage offset to the system normal equation NIL\_VI\_BLVG. The limit equation is of the form:

$$NSW\ to\ Victoria \leq [-1 * Sum [Term\ Values * System\ Normal\ Coefficients] ] + Offset$$

**Table 33 NIL\_VI\_BLVG offset**

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-100

### 14.2.2 The remaining Dederang to South Morang r 330 kV line trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of the remaining Dederang to South Morang 330 kV line, apply the following prior outage offset to the system normal equation NIL\_VI\_BLVG. The limit equation is of the form:

$$\text{NSW to Victoria} \leq [-1 * \text{Sum} [\text{Term Values} * \text{System Normal Coefficients}] ] + \text{Offset}$$

**Table 34 NIL\_VI\_BLVG offset**

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-150

The above outage NSW-Vic voltage stability limits are also applicable to the multiple outage combination of lines 62 + X5 + Dederang to South Morang 330 kV line.

## 14.3 Voltage Stability – Vic to NSW

To manage the Vic to NSW voltage stability export limit from Victoria to NSW for loss of both APD Potlines, apply the following prior outage offset to the system normal equation V^N\_2xAPD. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum} [\text{Term Values} * \text{Coefficients}] + \text{Offset}$$

**Table 35 V^N\_2xAPD offset**

Term	Offset
Offset to system normal V^N_2xAPD	-100



# 15 Dederang Substation No. 1 or No. 2 330 kV Bus

The following limit equation is enabled during an outage of a Dederang 330 kV bus.

## 15.1 Voltage Stability – NSW to Vic

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the fault and trip of Basslink or the loss of the largest Victorian generator or loss of a Dederang to South Morang 330 kV line and series capacitor and the subsequent offloading of a Dederang to Murray 330 kV line. Therefore, no additional offset is required.

# 16 Dederang to Wodonga 330 kV line

The following limit equations are enabled during an outage of the Dederang to Wodonga 330 kV line.

Note: these limits are in addition to the limits provided by Transgrid for this outage.

## 16.1 Transient stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 36 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-100
Offset to the system normal equation NIL_O	-90

## 16.2 Voltage Stability – NSW to Vic

### 16.2.1 Largest Vic generator or Basslink trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of Basslink or the loss of the largest Victorian generator, apply the following prior outage offset to the system normal equation NIL\_VI\_BLVG. Studies monitored post-contingent voltages and reactive power margin in northern Victoria and southern NSW. The limit equation is of the form:

$$\text{NSW to Victoria} \leq [-1 * \text{Sum [Term Values * System Normal Coefficients] } + \text{Offset}$$

Table 37 NIL\_VI\_BLVG offset

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-70

### 16.2.2 Dederang to Murray 330 kV line trip

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the loss of a Dederang to Murray 330 kV line. Therefore, no additional offset is required.

## 16.3 Voltage Oscillation

To prevent voltage oscillations for the trip of Ararat to Waubra to Ballarat or Bendigo to Kerang 220 kV line the following limits are applied:

**Table 38 Voltage oscillation limits**

Generator	MW Limit	Inverter / Turbine maximum
Ararat Wind Farm	≤ 0 MW (can be operated Blocked)	
Bannerton Solar Farm	≤ 45 MW	
Bulgana Wind Farm	≤ 0 MW (can be operated Blocked)	Turbines ≤ 0 MW (Blocked), Q-control mode, Q setpoint = zero MVAR
Bulgana Battery	= 0 MW	0 and disconnected
Crowlands Wind Farm	≤ 0 MW (can be operated Blocked)	
Gannawarra Solar Farm	≤ 30 MW	
Karadoc Solar Farm	≤ 25 MW	
Kiamal Solar Farm	≤ 50 MW	
Limondale 2 Solar Farm	≤ 0 MW	0 and disconnected
Murra Warra 1+2 Wind Farm	≤ 100 MW	
Murraylink (SA to Vic)	≤ 125 MW	
Wemen Solar Farm	≤ 45 MW	
Yatpool Solar Farm	≤ 25 MW	

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

***Kerang SVC switched off or set to manual mode with a fixed Q setpoint***



# 17 Eildon to Mount Beauty 220 kV line

The following limits are applied for the above outage.

## 17.1 Voltage Stability – NSW to Vic

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the fault and trip of Basslink or the loss of the largest Victorian generator or a Dederang to Murray 330 kV line. Therefore, no additional offset is required.



# 18 Eildon To Thomastown 220 kV line

The following limit equation is enabled during an outage of the Eildon to Thomastown 220 kV line.

## 18.1 Transient Stability – Vic to NSW

### 18.1.1 V::N EPS-TTS -V

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Dederang to South Morang 330 kV line where Victoria accelerates ahead of the other states, apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$

Table 39 V::N EPS-TTS -V coefficients

Term	Coefficient
Intercept	1239
Basslink	0.217
Vic. to SA (Heywood)^2	-5.05e-4
Vic. to SA (Murraylink)	-0.9143
LV 500 Inertia	3.003
EPS Inertia	16.9
MOPS Inertia	4.407
LV 220 Inertia	6.021
SNOWY Inertia	3.11
Murray Gen	0.7123
Kiewa Gen	0.9577
VIC Metro Gen	0.2778
State Grid Load North	-0.8903
Vic Wind & Solar	0.1359
VIC Demand - State Grid Load North	-0.1087
220 kV_Caps	-0.1669
Confidence Level (95%) offset	-84

### 18.1.2 V::N EPS-TTS -S

To manage the Victorian transient stability export limit from Victoria to fault and trip of a Dederang to South Morang 330 kV line (where South Australia accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$



**Table 40 V::N EPS-TTS-S coefficients**

Term	Coefficient
<b>Intercept</b>	1241
<b>Basslink</b>	0.207
<b>Vic. to SA (Heywood)</b>	-0.1075
<b>Vic. to SA (Heywood)^2</b>	-4.30e-4
<b>Vic. to SA (Murraylink)</b>	-0.9241
<b>LV 500 Inertia</b>	3.313
<b>EPS Inertia</b>	18.36
<b>MOPS Inertia</b>	4.039
<b>SNOWY Inertia</b>	1.55
<b>VIC Metro Gen Inertia</b>	4.291
<b>Murray Gen</b>	0.894
<b>Kiewa Gen</b>	1.095
<b>LV 220 Gen</b>	0.182
<b>State Grid Load North</b>	-0.777
<b>Vic Wind &amp; Solar</b>	0.1821
<b>VIC Demand - State Grid Load North</b>	-0.156
<b>220 kV_Caps</b>	-0.1031
<b>Num. ROTS SVC</b>	22.35
<b>Num. SESS SVC</b>	18.94
<b>Confidence Level (95%) offset</b>	-75

## 18.2 Voltage Stability – NSW to Vic

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the fault and trip of Basslink or the loss of the largest Victorian generator or a Dederang to South Morang 330 kV line. Therefore, no additional offset is required.

# 19 Hazelwood to Loy Yang 500 kV line

The following limit equation is enabled during an outage of the Hazelwood to Loy Yang 500 kV line.

## 19.1 System Strength

Electro Magnetic Transient (EMT) studies identified the requirement of minimum number of synchronous generators in Victoria to be available prior to this outage. This is to maintain sufficient system strength in Victoria network for the loss of all three Hazelwood to Loy Yang 500 kV lines. Verified combinations are listed below.

**Table 41 Hazelwood – Loy Yang outage system strength minimum generator combinations**

Combination	Bogong	Dartmouth	Jeeralang A+B	Mortlake	Murray (unit 1-10)	Murray (unit 11-14)	Newport	Yallourn
1			4			4		3
2						4	1	3
3				2		4		3
4			4	1		4		2
5		1	4	1		2		2
6	1	1	4	1	1	1		2

# 20 Hazelwood To South Morang 500 kV line

The following limit equations are enabled during an outage of one Hazelwood to South Morang 500 kV line.

## 20.1 Transient Stability – Vic to NSW

### 20.1.1 V::N HWTS-SMTS -V

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Hazelwood to South Morang 500 kV line (where Victoria accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 42** V::N HWTS-SMTS-V coefficients

Term	Coefficient
Intercept	1282
Basslink	0.4379
Vic. to SA (Heywood)	-0.3323
Vic. to SA (Heywood)^2	-9.229e-4
Vic. to SA (Murraylink)	-1.092
LV 500 Inertia	7.984
EPS Inertia	24.30
MOPS Inertia	8.864
LV 220 Inertia	6.883
Murray Gen	0.8310
Kiewa Gen	1.167
LV 220 Gen	0.3025
VIC Metro Gen	0.9260
State Grid Load North	-0.7591
APD Load	-1.176
Vic Wind & Solar	0.4519
VIC Demand - State Grid Load North - APD Load	-0.4406
Num. ROTS SVC	32.41
Num. SESS SVC	27.43
Confidence Level (95%) offset	-88

### 20.1.2 V::N HWTS-SMTS-Q

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Hazelwood to South Morang 500 kV line (where Queensland accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum} [\text{Term Values} * \text{Coefficients}]$$

**Table 43 V::N HWTS-SMTS-Q coefficients**

Term	Coefficient
Intercept	1748
Basslink	0.619
Vic. to SA (Heywood)	-1.275
Vic. to SA (Murraylink)	-0.6562
LV 500 Inertia	9.343
MOPS Inertia	16.42
Murray Gen	0.7247
Kiewa Gen	0.7898
LV 220 Gen	0.5231
Vic Wind & Solar	0.719
State Grid Load	-0.7987
VIC Demand - State Grid Load	-0.615
Confidence Level (95%) offset	-78

Note: this equation should only be applied when power transfers are above 900 MW from Queensland to New South Wales.

### 20.1.3 V::N HWTS-SMTS-S

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Hazelwood to South Morang 500 kV line (where South Australia accelerates ahead of the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum} [\text{Term Values} * \text{Coefficients}]$$

**Table 44 V::N HWTS-SMTS-S coefficients**

Term	Coefficient
Intercept	970.8
Basslink	0.5021
Vic. to SA (Heywood)	-0.5782
Vic. to SA (Heywood)^2	-5.973e-4
Vic. to SA (Murraylink)	-1.149
LV 500 Inertia	8.332
EPS Inertia	22.71
MOPS Inertia	10.68
LV 220 Inertia	17.10
KIEWA Inertia	4.865
VIC METRO Gen Inertia	7.135
Murray Gen	0.9213

Term	Coefficient
<b>Kiewa Gen</b>	0.7844
<b>VIC Metro Gen</b>	0.2938
<b>State Grid Load North</b>	-1.166
<b>APD Load</b>	-0.4342
<b>Vic Wind &amp; Solar</b>	0.5615
<b>VIC Demand - State Grid Load North - APD Load</b>	-0.4538
<b>220 kV_Caps</b>	-0.1530
<b>Num. ROTS SVC</b>	33.88
<b>Num. SESS SVC</b>	22.04
<b>Confidence Level (95%) offset</b>	-92

#### 20.1.4 V::N HWTS-SMETS-S\_decel

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Hazelwood to South Morang 500 kV line (where South Australia decelerates away from the other states), apply the following limit equation:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 45** V::N HWTS-SMETS-S\_decel coefficients

Term	Coefficient
<b>Intercept</b>	1211
<b>Basslink</b>	0.4028
<b>Vic. to SA (Heywood)</b>	-1.772
<b>Vic. to SA (Murraylink)</b>	-1.065
<b>LV 500 Inertia</b>	9.683
<b>MOPS Inertia</b>	11.69
<b>LV 220 Inertia</b>	18.59
<b>KIEWA Inertia</b>	18.86
<b>VIC METRO Gen Inertia</b>	7.38
<b>Murray Gen</b>	0.8217
<b>State Grid Load North</b>	-0.8141
<b>Vic Wind &amp; Solar</b>	0.565
<b>VIC Demand - State Grid Load North</b>	-0.4551
<b>Confidence Level (95%) offset</b>	-128

Note: this equation should only be applied when power transfers are above 500 MW from Victoria to South Australia.



## 20.2 Voltage Stability- VIC to NSW

To manage the Vic to NSW voltage stability export limit from Victoria to NSW for loss of both APD Potlines, apply the following prior outage offset to the system normal equation  $V^N_{2xAPD}$ . The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * Coefficients] +Offset}$$

**Table 46**  $V^N_{2xAPD}$  offset

Term	Offset
Offset to system normal equation $V^N_{2xAPD}$	-50

# 21 Heywood to South East 275 kV line

The following limit equations are enabled during an outage of one Heywood to South East 275 kV line.

## 21.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 47 V::N HYTS-SESS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-70
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	-27
Offset to system normal equation NILS_decel	N/A [VIC->SA transfer limited to 250MW]



# 22 Horsham SVC

## 22.1 Voltage Oscillation

To prevent voltage oscillations for trip of an Ararat to Waubra to Ballarat 220 kV line or Bendigo to Kerang 220 kV line the following limits applied:

**Table 48** Voltage oscillation limits

Generator	MW Limit
Ararat Wind Farm	≤ 145 MW
Bannerton Solar Farm	≤ 53 MW
Broken Hill Solar Farm	≤ 32 MW
Bulgana Wind Farm	≤ 111 MW
Cohuna Solar Farm	≤ 17 MW
Coleambally Solar Farm	≤ 105 MW
Crowlands Wind Farm	≤ 48 MW
Darlington Point Solar Farm	≤ 193 MW
Finley Solar Farm	≤ 93 MW
Gannawarra Solar Farm	≤ 30 MW
Karadoc Solar Farm	≤ 54 MW
Kiamal Solar Farm	≤ 120 MW
Kiata Wind Farm	≤ 18 MW
Limondale 1 Solar Farm	≤ 132 MW
Limondale 2 Solar Farm	≤ 18 MW
Murra Warra 1+2 Wind Farm	≤ 135 MW
Silverton Wind Farm	≤ 119 MW
Sunraysia Solar Farm	≤ 120 MW
Wemen Solar Farm	≤ 53 MW
Yatpool Solar Farm	≤ 49 MW

# 23 Horsham to Murra Warra to Kiamal 220 kV line

The following limit equations are enabled during an outage of the Horsham to Murra Warra, Murra Warra to Kiamal or Horsham to Murra Warra to Kiamal 220 kV lines unless indicated.

## 23.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

Table 49 V::N HOTS-RCTS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-60
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	-40
Offset to system normal equation NILS_decel	-50

## 23.2 Voltage Stability – Murraylink

### 23.2.1 Buronga to Balranald to Darlington Point (X5) trip

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Buronga to Balranald to Darlington point 220 kV line, apply the following prior outage limit equation. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

Table 50 V^S [MRLK] HOTS-RCTS\_X5

Term	Coefficient
Intercept	277.7
RCTS Load	-0.9364
KGTS Load	-1.225
BETS Load	-0.1876
WETS Load	-0.6805
BKNH TX MW	-0.7594

Term	Coefficient
VIC2NSW	0.01024
KGTS SVC out of service	-18.79
Confidence Level (95%) offset	-32

### 23.2.2 Bendigo to Kerang trip

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Bendigo to Kerang 220 kV line, apply the following prior outage limit equation. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

Table 51 VAS [MRLK] HOTS-RCTS\_BEKG

Term	Coefficient
Intercept	164.4
RCTS Load	-0.9846
KGTS Load	-0.6067
WETS Load	-0.89
BKNH TX MW	-1.071
BHSS220 Load	-0.7057
KGTS SVC out of service	-6.367
Confidence Level (95%) offset	-31

## 23.3 Islanding

Limitation to prevent islanding of local load following the trip of the Ararat to Waubra to Ballarat or Kiamal to Red Cliffs 220 kV lines.

Table 52 Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Kiata Wind Farm	$\leq 0$ MW	
Kiamal Solar Farm	$\leq 0$ MW	0 and disconnected

*Kiamal SynCon switched off*

## 23.4 Voltage Oscillation

To prevent voltage oscillations for trip of the Bendigo to Kerang 220 kV line the following limits are applied:

**Table 53 Voltage oscillation limits**

Generator	MW Limit	Inverter / Turbine maximum
Bannerton Solar Farm	≤ 45 MW	
Broken Hill Solar Farm	≤ 30 MW	
Gannawarra Solar Farm	≤ 0 MW	0 and disconnected
Gannawarra Battery	≤ 0 MW	
Karadoc Solar Farm	≤ 45 MW	
Kiamal Solar Farm	≤ 40 MW	
Wemen Solar Farm	≤ 45 MW	
Yatpool Solar Farm	≤ 40 MW	

For an outage of the Horsham to Murra Warra 220 kV line the following limits are also applied:

**Table 54 Voltage oscillation limit**

Generator	MW Limit
Murra Warra 1+2 Wind Farm	≤ 15 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

***Kerang SVC switched off or set to manual mode with a fixed Q setpoint***

For outage of Murra Warra to Kiamal 220 kV line the following limits are also applied:

**Table 55 Voltage oscillation limit**

Generator	MW Limit
Murra Warra 1+2 Wind Farm	≤ 15 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

# 24 Jindera to Wodonga (060) 330 kV line

The following limit equations are enabled during an outage of the Jindera to Wodonga 330 kV line.

Note: these limits are in addition to the limits provided by TransGrid for this outage.

Note 2: Balranald to Darlington Point (X5) line is also out of service for this outage and the limits for an X5 outage also apply (see Vic Transfer Limit Advice – Outages in Adjacent Regions).

## 24.1 Transient stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

Table 56 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-100
Offset to the system normal equation NIL_O	-90

## 24.2 Voltage Stability – NSW to Vic

### 24.2.1 Largest Vic generator or Basslink trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of Basslink or the loss of the largest Victorian generator, apply the following prior outage offset to the system normal equation NIL\_VI\_BLVG. Studies monitored post-contingent voltages and reactive power margin in northern Victoria and southern NSW. The limit equation is of the form:

$$\text{NSW to Victoria} \leq [-1 * \text{Sum [Term Values * System Normal Coefficients]}] + \text{Offset}$$

Table 57 V^N JIND-WOTS\_BLVG offset

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-60

### 24.2.2 Dederang to Murray 330 kV line trip

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the loss of a Dederang to Murray 330 kV line. Therefore, no additional offset is required.



## 24.3 Voltage Oscillation

To prevent voltage oscillations for the trip of Ararat to Waubra to Ballarat or Bendigo to Kerang 220 kV line the limits of Section 16.3 are applied.

# 25 Kerang SVC

The following limit equations are enabled during an outage of the Kerang SVC.

## 25.1 Voltage Oscillation

To prevent voltage oscillations for trip of an Ararat to Waubra to Ballarat 220 kV line or Bendigo to Kerang 220 kV line the following limits applied:

**Table 58 Voltage oscillation limits**

Generator	MW Limit
Bannerton Solar Farm	≤ 25 MW
Broken Hill Solar Farm	≤ 25 MW
Coleambally Solar Farm	≤ 30 MW
Darlington Point Solar Farm	≤ 80 MW
Finley Solar Farm	≤ 30 MW
Gannawarra Solar Farm	≤ 25 MW
Karadoc Solar Farm	≤ 25 MW
Kiamal Solar Farm	≤ 50 MW
Limondale 1 Solar Farm	≤ 50 MW
Limondale 2 Solar Farm	≤ 25 MW
Murra Warra 1+2 Wind Farm	≤ 90 MW
Murraylink (SA to Vic)	≤ 150 MW
Sunraysia Solar Farm	≤ 50 MW
Wemen Solar Farm	≤ 25 MW
Yatpool Solar Farm	≤ 25 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

# 26 Kerang to Wemen to Red Cliffs 220 kV line

The following limit equations are enabled during an outage of the Kerang to Wemen, Red Cliffs to Wemen or Kerang to Wemen to Red Cliffs 220 kV lines unless indicated.

Note: For the outage of Kerang to Wemen to Red Cliffs 220 kV line Bannerton solar farm and Wemen solar farm are disconnected as they are connected to Wemen.

## 26.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

Table 59 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-60
Offset to system normal equation NIL_O	-60

## 26.2 Voltage Stability – Murraylink

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Ararat to Horsham 220 kV line, apply the following prior outage limit equations. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$



**Table 60 VAS [MRLK] KGTS-WETS-RCTS**

Term	Coefficient
<b>Intercept</b>	188.3
<b>RCTS Load</b>	-0.8288
<b>KGTS Load</b>	-0.857
<b>WETS load</b>	-1.156
<b>BKNH TX MW</b>	-1.023
<b>BHSS220 Load</b>	-1.137
<b>Confidence Level (95%) offset</b>	-25.7

## 26.3 Islanding

Limitation to prevent islanding of local load:

**Table 61 Islanding limits**

Generator	MW Limit	Inverter / Turbine maximum
Cohuna Solar Farm	$\leq 0$ MW	0 and disconnected
Gannawarra Solar Farm	$\leq 0$ MW	0 and disconnected
Gannawarra Battery	$= 0$ MW	0 and disconnected
Wemen Solar Farm	$\leq 0$ MW	0 and disconnected
Bannerton Solar Farm	$\leq 0$ MW	0 and disconnected

## 26.4 Voltage Oscillation

To prevent voltage oscillations for trip of the Ararat to Waubra to Ballarat 220 kV line the following limits are applied:

**Table 62 Voltage oscillation limits**

Generator	MW Limit
Ararat Wind Farm	$\leq 160$ MW
Broken Hill Solar Farm	$\leq 30$ MW
Bulgana Wind Farm	$\leq 40$ MW
Crowlands Wind Farm	$\leq 55$ MW
Coleambally Solar Farm	$\leq 45$ MW
Darlington Point Solar Farm	$\leq 85$ MW
Finley Solar Farm	$\leq 45$ MW
Karadoc Solar Farm	$\leq 20$ MW

Generator	MW Limit
Kiamal Solar Farm	≤ 50 MW
Kiata Wind Farm	≤ 15 MW
Limondale 1 Solar Farm	≤ 60 MW
Limondale 2 Solar Farm	≤ 15 MW
Murra Warra 1+2 Wind Farm	≤ 80 MW
Murraylink (SA to Vic)	≤ 150 MW
Murraylink (Vic to SA)	≤ 150 MW
Silverton Wind Farm	≤ 100 MW
Sunraysia Solar Farm	≤ 60 MW
Yatpool Solar Farm	≤ 20 MW

***Horsham SVC switched off or set to manual mode with a fixed Q setpoint***

For the outage of the Kerang to Wemen or Kerang to Wemen to Red Cliffs 220 kV lines the following limits are also applied:

***Kerang SVC switched off or set to manual mode with a fixed Q setpoint***

# 27 Kiamal synchronous condenser

## 27.1 Voltage Oscillation

To prevent voltage oscillations for a contingency, the following limit is applied:

**Table 63** Voltage oscillation limits when Murrawarra 2 synchronous condenser is in service

Generator	MW Limit	Inverter / Turbine maximum
Kiamal Solar Farm	$\leq 135$ MW	

# 28 Kiamal to Red Cliffs 220 kV line

## 28.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

**Table 64** NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-70
Offset to system normal equation NIL_O	-70

## 28.2 Voltage Stability – Murraylink

### 28.2.1 Buronga to Balranald to Darlington Point (X5) trip

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Buronga to Balranald to Darlington point 220 kV line, apply the following prior outage limit equation. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 65** VAS [MRLK] HOTS-RCTS\_X5

Term	Coefficient
Intercept	277.7
RCTS Load	-0.9364
KGTS Load	-1.225
BETS Load	-0.1876
WETS Load	-0.6805
BKNH TX MW	-0.7594
VIC2NSW	0.01024
KGTS SVC out of service	-18.79
Confidence Level (95%) offset	-32

## 28.2.2 Bendigo to Kerang trip

To manage the Murraylink voltage stability export limit from Victoria to SA for fault and trip of the Bendigo to Kerang 220 kV line, apply the following prior outage limit equation. Studies assume the Red Cliffs Voltage source controller (VSC) is in voltage control mode with the Very Fast Runback (VFRB) scheme disabled. Studies monitored post-contingent voltages and reactive power margin in southern NSW and the Victorian state grid. The limit equation is of the form:

$$\text{Victoria to SA (Murraylink)} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 66** V<sup>AS</sup> [MRLK] HOTS-RCTS\_BEKG

Term	Coefficient
Intercept	164.4
RCTS Load	-0.9846
KGTS Load	-0.6067
WETS Load	-0.89
BKNH TX MW	-1.071
BHSS220 Load	-0.7057
KGTS SVC out of service	-6.367
Confidence Level (95%) offset	-31

## 28.3 Islanding

Limitation to prevent islanding of local load following the trip of the Ararat to Waubra to Ballarat 220 kV line.

**Table 67** Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Kiata Wind Farm	$\leq 0$ MW	
Kiamal Solar Farm	$\leq 0$ MW	0 and disconnected

## 28.4 Voltage Oscillation

To prevent voltage oscillations for trip of the Bendigo to Kerang 220 kV line the following limits are applied:

**Table 68** Voltage oscillation limits

Generator	MW Limit	Inverter / Turbine maximum
Bannerton Solar Farm	$\leq 45$ MW	
Broken Hill Solar Farm	$\leq 30$ MW	
Coleambally Solar Farm	$\leq 40$ MW	
Darlington Point Solar Farm	$\leq 65$ MW	
Finley Solar Farm	$\leq 40$ MW	

Generator	MW Limit	Inverter / Turbine maximum
Gannawarra Solar Farm	≤ 0 MW	0 and disconnected
Gannawarra Battery	= 0 MW	
Karadoc Solar Farm	≤ 45 MW	
Limondale 1 Solar Farm	≤ 50 MW	
Limondale 2 Solar Farm	≤ 10 MW	
Murra Warra 1+2 Wind Farm	≤ 15 MW	
Murraylink (SA to Vic)	≤ 150 MW	
Silverton Wind Farm	≤ 50 MW	
Sunraysia Solar Farm	≤ 60 MW	
Wemen Solar Farm	≤ 45 MW	
Yatpool Solar Farm	≤ 40 MW	

# 29 Cressy to Mortlake 500 kV line

The following limit equations are enabled during an outage of the Cressy to Mortlake 500 kV line.

## 29.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

**Table 69** NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-100
Offset to system normal equation NIL_O	-100

## 29.2 Voltage Unbalance

The following limit equations are enabled to manage the voltage unbalance at APD 500kV and Heywood 275kV buses. These equations are only for Heywood Link Vic to SA power transfer. If the flow in Heywood Link is from SA to Vic, including zero power transfer, no limitations are required.

$$6.5562 \times \text{APD Net Load} + \text{Mortlake} + \text{Dundonnell generation} - 34.965 \times \text{Macarthur generation} + 16.6738 \times \text{VIC to SA (Heywood)} \leq 10931$$

$$\text{APD Net Load} - 0.6605 \times (\text{Mortlake} + \text{Dundonnell generation}) - 2.6368 \times \text{Macarthur generation} + 1.9966 \times \text{VIC to SA (Heywood)} \leq 1015$$

## 29.3 Islanding

Limitation to prevent islanding of local load following the next credible contingency.

**Table 70** Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Macarthur Wind Farm	$\leq 0 \text{ MW}$	

# 30 Moorabool to Sydenham 500 kV line

The following limit equations are enabled during an outage of one Moorabool to Sydenham 500 kV line.

## 30.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

**Table 71** NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-80
Offset to system normal equation NIL_O	-80

Studies assume the Emergency Moorabool Transformer Tripping Scheme (EMTT) is disabled. The equation is also valid when the scheme is enabled but the post-contingent conditions do not result in scheme operation.

## 30.2 Voltage Stability – Vic to SA

To manage the Victorian voltage stability export limit from Victoria to SA for fault and trip of the remaining Moorabool to Sydenham 500 kV line, apply the following limit equation:

$$\text{Victoria to SA (Heywood)} \leq \text{Sum [Term Values * Coefficients]}$$

**Table 72** V<sup>AS</sup>[HEY]\_MLTS-SYTS coefficients

Term	Coefficient (dVs)	Coefficient
Intercept	930.6	1008
APD-HYTS_MW	0.4953	0.4813
APD-HYTS_MVAR	0.3203	0.5232
GTS_LOAD	-0.5702	-0.6298
MOPS_Gen	0.7568	0.5596
MCAR_Gen	0.7757	0.312
MLTS_220_Reactors	0	-10.04
MLTS_Line_Reactors	-42.64	-43.67
Confidence Level (95%) offset	-85.97	-78.21

Studies assume the Emergency Moorabool Transformer Tripping Scheme (EMTT) is disabled. The equation is also valid when the scheme is enabled but the post-contingent conditions do not result in scheme operation.



### 30.3 System Strength

Electro Magnetic Transient (EMT) studies identified the requirement of minimum number of synchronous generators in Victoria to be online prior to this outage. This is to prevent undamped oscillations in Victoria network following a credible contingency of the remaining Moorabool – Sydenham 500 kV line which results in offloading multiple 500 kV lines between Sydenham and South Morang. Verified combinations are listed below.

**Table 73 Moorabool – Sydenham outage system strength minimum generator combinations**

Combination	Bogong	Dartmouth	Jeeralang A or B	Loy Yang	Mortlake	Murray (unit 1-10)	Murray (unit 11-14)	Newport	Valley Power	Yallourn	Loy Yang + Yallourn
<b>New_1</b>											8
<b>New_2</b>							2				7
<b>New_3</b>			2								7
<b>New_4</b>			2				2				6
<b>New_5</b>			2			4					6
<b>New_6</b>					1			1			6
<b>New_7</b>					2						6
<b>New_8</b>		1						1			6

‘Loy Yang’ in Table 73 refers to generators in Loy Yang A or Loy Yang B power stations.

# 31 Cressy to Haunted Gully or Haunted Gully to Tarrone 500 kV line

The following limit equations are enabled during the above prior outage conditions.

## 31.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

**Table 74** V::N MLTS-TRTS\_V/Q/S/S\_decel offsets

Term	Offset
Offset to system normal equation NILV	-30
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	0
Offset to system normal equation NILS_decel	N/A [VIC->SA transfer limited to 250MW]

## 31.2 Voltage Unbalance

The following limit equations are enabled to manage the voltage unbalance at APD 500kV and Heywood 275kV buses:

$$4.73 \times \text{APD Net Load} + \text{Mortlake} + \text{Dundonnell generation} + 1.07 \times \text{Macarthur generation} + 2.4 \times \text{VIC to SA (Heywood)} \leq 4665$$

$$1.61 \times \text{APD Net Load} + 1.18 \times \text{Macarthur generation} + \text{VIC to SA (Heywood)} \leq 2146$$

## 31.3 Fault Levels

Limitation due to insufficient fault level for converter operation at Macarthur Wind Farm.

**Table 75** Fault level limit

Generator	MW Limit
Macarthur Wind Farm	$\leq 0 \text{ MW}$

# 32 Cressy to Moorabool 500 kV line 1 or 2

The following limit equations are enabled during the above outage condition.

## 32.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 76 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-100
Offset to system normal equation NIL_O	-100

## 32.2 Islanding

Limitation to prevent islanding of local load following the next credible contingency.

Table 77 Islanding limits

Generator	MW Limit	Inverter / Turbine maximum
Macarthur Wind Farm	$\leq 0 \text{ MW}$	
Mortlake power station	$\leq 0 \text{ MW}$	

# 33 Moorabool A1 or A2 Transformer

## 500/220 kV

The following limit equations are enabled during an outage of the Moorabool A1/A2 500 kV transformer.

### 33.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 78 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-60
Offset to system normal equation NIL_O	-60

# 34 Murraylink

## 34.1 Voltage Stability – Wemen to Kerang limit

To manage the Wemen to Kerang flow limit to prevent voltage collapse at Kerang or Wemen for the loss of the Crowlands to Bulgana to Horsham or Horsham to Murra Warra to Kiamal 220kV line apply the following prior outage offset to the system normal equation NIL\_KERANG when Murraylink VFRB disabled only. The limit equation is of the form:

Table 79 V^V MRLK\_KERANG offset

Term	Offset
Offset to system normal NIL_KERANG	-45

## 34.2 Voltage Stability – NSW to Vic

### 34.2.1 Largest Vic generator or Basslink trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of Basslink or the loss of the largest Victorian generator, apply the following prior outage offset to the system normal equation NIL\_VI\_BLVG. Studies monitored post-contingent voltages and reactive power margin in northern Victoria and southern NSW. The limit equation is of the form:

$$NSW\ to\ Victoria \leq [-1 * Sum [Term\ Values * System\ Normal\ Coefficients] ] + Offset$$

Table 80 V^N MRLK\_BLVG offset

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-100

### 34.2.2 Ballarat to Waubra to Ararat 220kV line trip

To manage the Victorian voltage stability import limit from NSW to Victoria for fault and trip of Ballarat to Waubra to Ararat 220kV line (this also trips Waubra, Ararat and Crowlands, Bulgana and Murra Warra WFs), apply the following prior outage offset to the system normal equation NIL\_VI\_ARWBBA. Studies monitored post-contingent voltages and reactive power margin in northern Victoria and southern NSW. The limit equation is of the form:

$$NSW\ to\ Victoria \leq [-1 * Sum [Term\ Values * System\ Normal\ Coefficients] ] + Offset$$

Table 81 V^N MRLK\_ARWBBA offset

Term	Offset
Offset to system normal equation NIL_VI_ARWBBA	-100

# 35 Rowville to Hazelwood 500 kV line

The following limit equations are enabled during the above prior outage.

## 35.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to the system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 82 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-230
Offset to system normal equation NIL_O	-230

# 36 Rowville to South Morang 500 kV line

The following limit equations are enabled during an outage of the Rowville to South Morang 500 kV line.

## 36.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to the system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

**Table 83** NIL\_V and NIL\_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-190
Offset to the system normal equation NIL_O	-190

# 37 South Morang Series Capacitor

The following limit equations are enabled during an outage of one South Morang series capacitor.

## 37.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 84 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-50
Offset to system normal equation NIL_O	-50

## 37.2 Voltage Stability – NSW to Vic

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the fault and trip of Basslink, the loss of the largest Victorian generator, the loss of a Dederang to Murray 330 kV line, the loss of a Dederang 330/220 kV transformer or the loss of the parallel Dederang to South Morang 330 kV line and series capacitor. Therefore, no additional offset is required.



# 38 South Morang Substation No. 2 330 kV bus

The following limit equation is enabled during an outage of the South Morang B2 330 kV bus.

## 38.1 Transient Stability – Vic to NSW

### 38.1.1 Hazelwood to South Morang trip

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to SMTS F2 prior outage equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * SMTS F2 Prior Outage Coefficients]} + \text{Offset}$$

**Table 85** V::N SMTS-B2\_V/Q/S/S\_decel offsets (HWTS-SMTS 500 kV fault)

Term	Offset
Offset to SMTS F2 prior outage equation NILV	-50
Offset to SMTS F2 prior outage equation NILQ	0
Offset to SMTS F2 prior outage equation NILS	-50
Offset to SMTS F2 prior outage equation NILS_decel	-50


### 38.1.2 South Morang to Thomastown trip

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the South Morang to Thomastown No 1 220 kV line, apply the following prior outage offsets to system normal equations NILV, NILQ, NILS and NILS decelerating. The limit equation is of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients]} + \text{Offset}$$

**Table 86** V::N SMTS-B2\_V/Q/S/S\_decel offsets (SMTS-TTS 220 kV fault)

Term	Offset
Offset to system normal equation NILV	-20
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	-20
Offset to system normal equation NILS_decel	0



# 39 South Morang H1 or H3 Transformer 330 / 220 kV

The following limit equations are enabled during an outage of the South Morang H1 or H3 330/220 kV transformer.

## 39.1 Voltage Stability – NSW to Vic

The system normal voltage stability equation NIL\_VI\_BLVG will manage voltage stability associated with the fault and trip of Basslink, the loss of the largest Victorian generator, the loss of a Dederang to Murray 330 kV line, the loss of a Dederang to South Morang 330 kV line, the loss of the parallel H3 or H1 transformer, the loss of the F2 transformer, or the loss of a Dederang transformer. Therefore, no additional offset is required.

# 40 South Morang to Sydenham 500 kV line

The following limit equations are enabled during an outage of the South Morang to Sydenham 500 kV line.

## 40.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to the system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 87 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-70
Offset to system normal equation NIL_O	-70

# 41 South Morang to Thomastown 220 kV line

The following limit equations are enabled during an outage of one South Morang to Thomastown 220 kV line.

## 41.1 Transient Stability – Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of a Hazelwood to South Morang 500 kV line, apply the following prior outage offsets to the system normal equations NIL\_V and NIL\_O. The limit equations are of the form:

$$\text{Victoria to NSW} \leq \text{Sum [Term Values * System Normal Coefficients] + Offset}$$

Table 88 NIL\_V and NIL\_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-50
Offset to system normal equation NIL_O	-50

# 42 Wemen B1 or B2 220/66 kV Transformers

The following limits are enabled during the above outage.

## 42.1 System Strength

To manage the low fault level during the above outage the following limits are applied:

**Table 89** System strength limits

Generator	MW Limit	Inverter / Turbine maximum
Bannerton Solar Farm	-	15
Wemen Solar Farm	-	15

# A1. Measures and Definitions

## A1.1 Units of Measure

Abbreviation	Unit of measure
<b>kV</b>	Kilovolt.
<b>MVA</b>	Megavolt amperes.
<b>MVAR</b>	Megavolt amperes reactive.
<b>MW</b>	A Megawatt (MW) is one million watts. A watt (W) is a measure of power and is defined as one joule per second and it measures the rate of energy conversion or transfer.
<b>MW.sec</b>	Megawatt seconds – a measure of the inertia of a generating unit.

## A1.2 Parameter Definitions


Abbreviation	Definition
<b>220 kV Caps</b>	MVAR output from capacitors connected at 220 kV busbars (i.e. Altona, Brooklyn, Dederang, Fishermans Bend, Keilor, Moorabool, Rowville, Ringwood, Templestowe and Thomastown).
<b>APD-HYTS_MVAR</b>	Alcoa Portland smelter (APD) reactive power export (measured at 500 kV feeders). A negative value indicates that APD is importing MVAR.
<b>APD-HYTS_MW</b>	APD real power export (measured at 500 kV feeders. A negative value indicates that APD is importing MW).
<b>APD Load</b>	APD MW load at 33 kV and 22 kV.
<b>APD Net Load</b>	Net load measured at APD 500kV bus (Actual APD load consumption – Portland wind farm generation).
<b>BANReac</b>	MVAR output of Bannaby reactors. Values associated with this term are negative.
<b>Basslink</b>	MW flow on the Basslink interconnector (measured at the receiving end).
<b>BATS TX MW</b>	MW flow through 220/66kV transformers at Ballarat (measured at HV side, positive value indicates load MW).
<b>BETS Load</b>	Bendigo (BETS) customer load (MW).
<b>BHSS220 Load</b>	Broken Hill 220 kV MW industrial (mine) load.
<b>BKNH GEN</b>	MW output from Broken Hill Generation.
<b>BRKNHLSF_SilvWF</b>	MW output from Broken Hill SF and Silverton WF.
<b>BKNH TX MW</b>	MW flow through 220/22kV transformers at Broken Hill (measured at HV side, positive value indicates load MW).
<b>BOPS+MKPS GEN</b>	MW output from Bogong and McKay Power Station [BOPS & MKPS].
<b>Both TAIL-SESS Series Caps Out</b>	Both Tailem Bend – South East series caps out of service (1= Both series caps are out of service).
<b>BRGAsht</b>	MVAR output of Buronga shunt devices. Values associated with this term can be positive or negative.
<b>CANCap</b>	MVAR output of Canberra 220 kV capacitor banks. Values associated with this term are positive.
<b>CMACap</b>	MVAR output of Cooma capacitor banks. Values associated with this term are positive.
<b>Constraint equation</b>	These are the mathematical representations that AEMO uses to model power system limitations and FCAS requirements in National Electricity Market Dispatch Engine (NEMDE).
<b>Contingent MW</b>	Maximum of:

Abbreviation	Definition
	<ul style="list-style-type: none"> <li>a) MW Transfer from Tas to Vic via Basslink (measured at Loy Yang). Values associated with this term are positive for flows from Tas to Vic.</li> <li>b) MW output of a single generating unit in Vic (MW associated with the contingency: Loss of the Largest Generator). Values associated with this term are positive.</li> </ul>
<b>CUECap</b>	MVAR output of Queanbeyan capacitor banks. Values associated with this term are positive.
<b>DARL_PT_3WTX_MW</b>	MW flow through 3 winding 330/220/33 transformers at Darlington point measured at 330kV transformer terminal with positive values indicate MW flow into transformers from 330kV side.
<b>DARL_PT_3WTX_MVAR</b>	MVAR flow through 3 winding 330/220/33 transformers at Darlington point measured at 330kV transformer terminal with positive values indicate MVAR flow into transformers from 330kV side.
<b>DD220Cap</b>	MVAR output of Dederang 220 kV capacitor banks. Values associated with this term are positive.
<b>DD330Cap</b>	MVAR output of Dederang 330 kV capacitor banks. Values associated with this term are positive.
<b>DLPTshunt</b>	MVAR output of Darlington Point shunt devices. Values associated with this term can be positive or negative.
<b>DPS GEN</b>	MW output from Dartmouth Power Station [DPS].
<b>EPS Inertia</b>	Inertia from Eildon Power Station (EPS). Inertia is on a 100 MVA base (MW.sec / 100 MVA) as per EMS.
<b>GEN EPS on</b>	Number of Eildon Power station (EPS) units online.
<b>GEN DPS on</b>	Number of Dartmouth Power station units online [DPS].
<b>GEN BOPS on</b>	Number of Bogong Power station units online [BOPS].
<b>Gen_Lower_NW_VIC_MW</b>	Sum of generation MW output from lower NorthWest Victoria wind farms including Ararat WF, Bulgana WF, Crowlands WF, Kiata WF, Murra Warra WF, Waubra WF.
<b>GEN MKPS on</b>	Number of Mckay Power station units online [MKPS].
<b>GEN WKPS on</b>	Number of West Kiewa Power station units online [WKPS].
<b>Gen_Upper_NW_VIC_MW</b>	Sum of generation MW output from upper NorthWest Victoria wind and solar farms including Bannerton SF, Cohuna SF, Gannawarra SF, Gannawarra Battery, Karadoc SF, Kiamal SF, Wemen SF, Yatpool SF.
<b>Guthega GEN</b>	MW output from Guthega Power Station [GGA].
<b>Guthega Inertia</b>	Inertia from Guthega Power Station [GGA]. Inertia is on a 100 MVA base (MW.sec / 100 MVA) as per EMS.
<b>HOTS Load</b>	Horsham (HOTS) customer load (MW).
<b>HOTS SVC out of service</b>	Horsham SVC out of service, This term is equal to 0 when the SVC is in service, and equal to 1 when the SVC is out of service.
<b>HOTS_TX1_TX2 MW</b>	Sum of MW flow on Horsham B2 and B3 220/66 kV transformers. Positive value indicates power flow from HV to LV side.
<b>HOTS_TX1_TX2 MVAR</b>	Sum of MVAR flow on Horsham B2 and B3 220/66 kV transformers. Positive value indicates power flow from HV to LV side.
<b>HOTS-66REC</b>	MVAR output from Horsham 66kV reactor. Values associated with this term are negative.
<b>HOTS-66CAP</b>	MVAR output from Horsham 66kV Capacitor. Values associated with this term are positive.
<b>HUME VIC GEN</b>	MW output from Hume Power station (Victorian connection).
<b>HYTS_CAP_Status</b>	Heywood capacitor status (1 = capacitor in service).
<b>JBE Pump</b>	MW at Jindabyne Power Station [JBE]. Values associated with this term are negative.
<b>KGTS Load</b>	Kerang (KGTS) customer load (MW).
<b>KGTS SVC MVAR</b>	MVAR flow through SVC installed at Kerang.
<b>KGTS SVC out of service</b>	Kerang SVC out of service, This term is equal to 0 when the SVC is in service, and equal to 1 when the SVC is out of service.
<b>Kiewa Gen</b>	MW output from Kiewa hydro scheme generators (Bogong, Clover, Dartmouth, Mckay and West Kiewa).
<b>Kiewa Inertia</b>	Inertia from Kiewa hydro scheme generators (Bogong, Clover, Dartmouth, McKay and West Kiewa). Inertia is on a 100 MVA base (MW.sec / 100 MVA).

Abbreviation	Definition
<b>L_TUMUT_Gen</b>	MW output from Lower Tumut 3 power station (LTSS). Values associated with this term can be positive or negative due to the ability of Lower Tumut units to operate in pumping mode.
<b>LTUM3SC</b>	Number of generator units operating as synchronous condensers at Lower Tumut.
<b>LV 220 Gen</b>	MW output from Latrobe Valley generation on the 220 kV network (Yallourn W2, 3, and 4, and Yallourn unit 1 when connected to the 220 kV network).
<b>LV 220 Inertia</b>	Inertia associated with Latrobe Valley generation on the 220 kV network (Yallourn W2, 3, and 4, and Yallourn unit 1 when connected to the 220 kV network).
<b>LV 500 Inertia</b>	Inertia associated with Latrobe Valley generation on the 500 kV network (Loy Yang (A, B, and Valley Power), Jeeralang, Bairnsdale, and Yallourn W unit 1 when connected to the 500 kV network).
<b>MCAR_Gen</b>	MW output from the Macarthur Wind Farm (MCAR).
<b>MLTS_220_Reactors</b>	Count of MLTS 220 kV reactors.
<b>MLTS_Line_Reactors</b>	Count of MLTS line reactors (2=both reactors in service).
<b>MMWF_Gen</b>	MW output from the Mount Mercer Wind Farm (MMWF).
<b>MOPS Inertia</b>	Inertia from Mortlake Power Station (MOPS). Inertia is on a 100 MVA base (MW.sec / 100 MVA) as per EMS.
<b>MSS2SC</b>	Number of generator units operating as synchronous condensers at Murray 2.
<b>MSSReac</b>	MVAR output of Murray reactors. Values associated with this term are negative.
<b>Murray Gen</b>	MW output from Murray Power Station (Murray 1 and Murray 2).
<b>Num. MSS1 on</b>	Number of generator units operating at Murray 1.
<b>Num. ROTS SVC</b>	Number of Static Var Compensators (SVCs) at Rowville in service.
<b>Num. SESS SVC</b>	Number of SVCs at South East in service.
<b>NSW_D</b>	New South Wales demand.
<b>NSWd- SW_NSW</b>	NSW demand (customer load + losses) minus the load in southern NSW.
<b>NSW_H</b>	Inertia of New South Wales generators excluding Murray, Lower Tumut and Upper Tumut (Eraring, Vales Point, Bayswater, Munmorah, Redbank, Mt Piper, Liddell, Bendeela, Kangaroo Valley, Colongra, Tallawarra, Uranquinty).
<b>Parallel System</b>	Victorian system operating in "Parallel" mode, This term is equal to 0 when operating in radial mode, and equal to 1 when operating in parallel mode.
<b>Portland WF</b>	Portland wind farm generation, MW.
<b>QLD_H</b>	Inertia of Queensland generators (Swanbank B, Gladstone, Tarong, Wivenhoe, Callide B, Stanwell, Callide C, Tarong North, Swanbank E, Barcaldine, Barron Gorge, Callide A, Collinsville, Invicta, Kareeya, Mackay, Mt Stuart, Townsville, Oakey, Millmerran, Braemar, Darling Downs, Condamine, Braemar 2, Kogan Creek).
<b>Q2-BURNGA 220</b>	MVAR output from the two line reactors on the X2 and X3 line at Buronga. Values associated with this term are negative.
<b>Q3-REDCLF 220</b>	MVAR output from Redcliff Capacitor at 220kV bus. Values associated with this term are positive.
<b>RCTS Load</b>	Red Cliffs (RCTS) customer load (MW).
<b>RCTS-MLK_MVAR</b>	MVAR flow from Redcliff to Murraylink 220kV line. Measured at Redcliff. Flow is positive from Redcliff to Murraylink.
<b>Rowville SVC1 or SVC2 out of service</b>	Rowville SVC out of service, This term is equal to 0 when the SVC is in service, and equal to 1 when one SVC is out of service.
<b>SNOWY Inertia</b>	Inertia from the Snowy area (Murray, Lower Tumut and Upper Tumut). Inertia is on a 100 MVA base (MW.sec / 100 MVA).
<b>SNOWY_GSC_H</b>	Inertia of Snowy generation (Murray, Guthega, Lower Tumut and Upper Tumut) minus the inertia of Lower Tumut machines running as pumps. Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA).
<b>State Grid Load</b>	Vic State Grid Load. This is the sum of the State Grid Load North (SGLN) and State Grid Load South (SGLS).



Abbreviation	Definition
<b>State Grid Load North</b>	Vic State Grid Load north is the sum of load at the following bulk supply points: Bendigo (BETS), Fosterville (FVTS), Glenrowan (GNTS), Kerang (KGTS), Mt Beauty (MBTS), Red Cliffs (RCTS), Shepparton (SHTS), Wemen (WETS), and Wodonga (WOTS).
<b>State Grid Load South</b>	Vic State Grid Load south is the sum of load at the following bulk supply points: Ararat (ARTS), Ballarat (BATS), Horsham (HOTS), Stawell (STA) and Terang (TGTS).
<b>SW_NSW</b>	Load in Southern NSW is the sum of customer load at the following bulk supply points: Broken Hill (BKH_S1-22 and BKH-220), Gadara (GAD-11), Jounama (JOU-66), Darlington Point (DLP-132), Morven (MOR-132), Albury (ALB-132), AMN-132, Coleambally (CLY-132), Marulan (MRN-132, GOU-132), Wagga (WAN-132, WAN-66, WAW-132), Murrumburrah (MRU-66), Deniliquin (DNQ-66), Yass (YAS-66), Balranald (BRD-22), Finley (FNY-132), Griffith (GRF-132), Mulwala (MUL-132), Corowa (COR-132), and Yanco (YNC-33).
<b>STH_NSW_GEN</b>	Generation in southern NSW. Values associated with this term are positive. Generation in this region are Gullen Range WF, Gullen SF, Capital WF, Cullerin Range WF, Coleambally SF, Gunning WF, Boco Rock WF, Taralga WF, Woodlawn WF, Burrinjuck Hydro, Blowering Hydro, Gadara, and Jounama Hydro Embedded generation.
<b>System normal</b>	The configuration of the power system where: <ul style="list-style-type: none"> <li>a) All transmission elements are in service, or</li> <li>b) The network is operating in its normal network configuration.</li> </ul>
<b>TNSP</b>	Transmission Network Service Provider.
<b>Tumut Pump</b>	MW of Lower Tumut machines in pumping mode (this MW value is negative).
<b>UQT Gen</b>	MW output from Uranquinty (UQT) Power Station.
<b>U_TUMUT_Gen</b>	MW output from Upper Tumut 1 and Upper Tumut 2 Power Station (UTSS).
<b>UTUM1SC+UTUM2SC</b>	Number of generator units operating as synchronous condensers at Upper Tumut 1 and Upper Tumut 2.
<b>V_MLTS5</b>	MLTS 500 kV voltage (typical values between 450 and 550 kV).
<b>V_MSS3330</b>	Voltage (kV) at the Murray Power Station 330 kV bus.
<b>VIC220_Gen</b>	MW output from Latrobe Valley generation on the 220 kV network (Yallourn W units 2, 3 and 4 and unit 1 when connected to 220 kV network).
<b>Vic Demand</b>	Vic MW demand (calculated as generation minus export).
<b>Vic to SA (Heywood)</b>	MW transfer from Vic to SA via Heywood (measured at South East end). The interconnector direction and lines it consists of follow the NEM standard.
<b>Vic to SA (Murraylink)</b>	MW transfer from Vic to SA via Murraylink (measured at Red Cliffs end).
<b>VIC to NSW</b>	MW transfer from Vic to NSW.
<b>Vic Demand - State Grid Load</b>	Vic Demand (MW) minus Vic State Grid Load (SGL).
<b>Vic Demand - State Grid Load North – APD Load</b>	Vic Demand (MW) minus Vic State Grid Load North (SGLN) minus APD Load.
<b>Vic Metro Gen</b>	MW output from Vic metropolitan generators (Newport, Somerton, and Laverton North).
<b>Vic Metro Gen Inertia</b>	Inertia from Vic metropolitan generators (Newport, Somerton and Laverton North). Inertia is on a 100 MVA base (MW.sec / 100 MVA) as per EMS.
<b>Vic Wind &amp; Solar</b>	MW Generation from all Vic windfarms and solar plant. This includes Ararat WF, Bald Hills WF, Ballarat Battery (Gen Component), Bannerton SF, Bulgana WF, Challcum Hills WF, Crowlands WF, Gannawarra Battery (Gen component), Gannawarra SF, Karadoc SF, Kiata WF, Macarthur WF, Moorabool WF, Mortons Lane WF, Mount Gellibrand WF, Mount Mercer WF, Murra Warra WF, Numurkah SF, Oaklands Hill WF, Portland WF, Salt Creek WF, Waubra WF, Wemen SF, Yaloak South WF, Yambuk WF, Yatpool SF and Yendon SF.
<b>WAGGACap</b>	MVAR output of Wagga Wagga capacitor banks. Values associated with this term are positive.
<b>WKPS GEN</b>	MW output from West Kiewa Power Station [WKPS].
<b>WETS Load</b>	Wemen (WETS) customer load (MW).



Abbreviation	Definition
<b>WOTSCap</b>	MVAR output of Wodonga capacitor banks. Values associated with this term are positive.
<b>YASSCap</b>	MVAR output of Yass capacitor banks. Values associated with this term are positive.
<b>YASSReac</b>	MVAR output of Yass reactors. Values associated with this term are negative.

# 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
<b>Constraint equation</b>	These are the mathematical representations that AEMO uses to model power system limitations and FCAS requirements in National Electricity Market Dispatch Engine (NEMDE).
<b>System normal</b>	The configuration of the power system where: <ul style="list-style-type: none"><li>• All transmission elements are in service, or</li><li>• The network is operating in its normal network configuration.</li></ul>
<b>TNSP</b>	Transmission Network Service Provider.