Victorian Transfer Limit Advice – Multiple Outages

April 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 and voltage oscillation or constraint equation performance and related issues, as at the date of publication.

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Version control

Version	Release date	Changes
5	24/04/2024	Updated outage limits associated with SA islanding conditions and few other multiple outage limits
4	10 April 2022	Updated to new AEMO template.
3	23/11/2018	New Template Applied.
2	23/07/2018	Updated voltage stability import limits.
1	01/08/2017	Initial version.

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Tables

1 Introduction

AEMO is responsible for calculating the maximum transient and voltage stability limits into and out of Victoria in accordance with the National Electricity Rules (NER) S5.1.2.3 and the Power System Stability Guidelines[1]. This document describes the values for these transfer limits for multiple prior outage conditions 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 system normal cases are described in a separate document, *Victorian Transfer Limit Advice – System Normal*. The limit equations for single prior outage conditions are described in *Victorian Transfer Limit Advice – Outages.* Both documents are available on the AEMO website[2].

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.

1.3 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.
2. Execute a binary search algorithm to search for limiting interconnector power transfer.
3. Linear regression and statistical limit determination.

[1] AEMO, *Power System Stability Guidelines*, Available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information.

[2] Available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information/Limits-advice.

1.4 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:

http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information.

2 Balranald to Buronga 220 kV Line & Dederang to Murray 330 kV Line

The following limit equations are enabled during a planned outage of the Balranald to Buronga 220 kV line and the Dederang to Murray 330 kV line.

2.1 V::N BALR-BSS_DDTS-MSS_V/Q/S/S_decel

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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 1 V::N BALR-BSS_DDTS-MSS_V/Q/S/S_decel offsets

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	-20

2.2 V::N BALR-BSS_DDTS-MSS_V/S

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the remaining Dederang to Murray 330 kV line, apply the following prior outage offsets to the DDTS-MSS prior outage limit equations V::N_DDTS-MSS_V/S. The limit equation is of the form:

Victoria to NSW ≤ Sum [Term Values * DDTS-MSS Prior Outage Coefficients] + Offset

Table 2 V::N BALR-BSS_DDTS-MSS_V/S offsets

Term	Offset
Offset to DDTS-MSS prior outage equation NILV	-50
Offset to DDTS-MSS prior outage equation NILS	-50

2.3 V^N BALR-BSS_DDTS-MSS_BLVG

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 ≤ [-1 * Sum [Term Values * System Normal Coefficients]] + Offset

Table 3 V::N BALR-BSS_DDTS-MSS_BLVG offset

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-270

3 Two Dederang to Mount Beauty 220 kV Lines

The following limit equations are enabled during a planned outage of both Dederang to Mount Beauty 220 kV lines.

3.1 V::N 2xDDTS-MBTS_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:

Victoria to NSW ≤ Sum [Term Values * Coefficients]

Table 4 V::N 2xDDTS-MBTS-V coefficients

Term	Coefficient
Intercept	1214
Basslink	0.1991
Vic to SA (Heywood)^2	-3.935e-4
Vic to SA (Murraylink)	0.9722
LV 500 _Inertia	3.063
EPS Inertia	8.350
MOPS Inertia	2.206
LV 220 Inertia	3.495
Kiewa Inertia	3.056
SNOWY Inertia	2.850
VIC METRO Gen Inertia	2.626
Murray Gen	0.8173
LV 220 Gen	0.09785
VIC Metro Gen	0.2162
State Grid Load North	-0.8338
Vic Wind & Solar	0.1362
VIC Demand - State Grid Load North	-0.1259
220 kV_Caps	-0.1334
Num. ROTS SVC	17.27
Confidence Level (95%) offset	-69

3.2 V::N 2xDDTS-MBTS_S

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 South Australia accelerates ahead of the other states), apply the following limit equation:

Victoria to NSW ≤ Sum [Term Values * Coefficients]

Table 5 V::N 2xDDTS-MBTS -S coefficients

Term	Coefficient
Intercept	1220
Basslink	0.2090
Vic to SA (Heywood)	-0.08414
Vic to SA (Heywood)^2	-3.888e-4
Vic to SA (Murraylink)	-0.8971
LV 500_ Inertia	3.307
EPS Inertia	9.665
MOPS Inertia	4.838
SNOWY Inertia	1.579
VIC METRO Gen Inertia	3.913
Murray Gen	0.9046
Kiewa Gen	0.2808
LV 220 Gen	0.1702
State Grid Load North	-0.7707
Vic Wind & Solar	0.1901
VIC Demand - State Grid Load North	-0.1441
220 kV_Caps	-0.09476
Num. ROTS SVC	19.50
Num. SESS SVC	13.23
Confidence Level (95%) offset	-72

3.3 V^N 2xDDTS-MBTS_BLVG

The system normal voltage stability equation NIL_VI_BLVG will manage voltage stability associated with the loss of Basslink or the largest Victorian generator. Therefore, no additional offset is required.

4 Two Dederang to South Morang 330 kV Lines

The following limit equations are enabled during a planned outage of both Dederang to Mount Beauty 220 kV lines.

4.1 V^N 2xDDTS-SMTS_BLVG

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 ≤ -1 * Sum [Term Values * Coefficients]

Table 6 V^N 2xDDTS-SMTS BLVG coefficients

Term	Coefficient
Intercept	-931.6
Contingent_MW	0.8019
SW_NSW	0.3344
NSWd-SW_NSW	0.011222
UTUM1SC+UTUM2SC	-21.52
LTUM3SC	-39.01
MSS2SC	-28.92
DLPTshunt	-0.2850
MSSReac	-0.1781
YASSReac	-0.07908
U_TUMUT_Gen	-0.3474
L_TUMUT_Gen	-0.08695
MURRAY_Gen	0.6716
UQT Gen	-0.2963
BKNH_GEN	-0.8475
Num. MSS1 on	-12.52
Confidence Level (95%) offset	+61.0

5 Two Dederang to South Morang 330 kV Lines with Buronga to Balranald out of Service

The following limit equations are enabled during a prior outage of both Dederang to South Morang 330 kV lines, with Buronga to Balranald out of service.

5.1 V^N 2xDDTS-SMTS_BSS-BALR_BLVG

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 prior outage equation V^N 2xDDTS-SMTS. 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 ≤ [-1 * Sum [Term Values * System Normal Coefficients]] + Offset

Table 7 V^N 2xDDTS-SMTS_BSS-BALR BLVG offset

Term	Offset
Offset to prior outage equation V^N 2xDDTS-SMTS	-100

6 One Dederang to Murray 330 kV Line & One Dederang to South Morang 330 kV Line

The following limit equations are enabled during a planned outage of a Dederang to Murray 330 kV line and a Dederang to South Morang 500 kV line.

6.1 V::N DDTS-MSS_DDTS-SMTS_V/Q/S/S_decel

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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 8 V::N DDTS-MSS_DDTS-SMTS _V/Q/S/S_decel offsets

Term	Offset
Offset to system normal equation NILV	-170
Offset to system normal equation NILQ	-20
Offset to system normal equation NILS	-170
Offset to system normal equation NILS_decel	-100

6.2 V::N DDTS-MSS_DDTS-SMTS_V/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, apply the following prior outage offsets to the DDTS-SMTS prior outage limit equations V::N_DDTS-SMTS_V/S. The limit equation is of the form:

Victoria to NSW ≤ Sum [Term Values * DDTS-SMTS Prior Outage Coefficients] + Offset

Table 9 V::N DDTS-MSS_DDTS-SMTS _V/S offsets

Term	Offset
Offset to DDTS-SMTS prior outage equation NILV	-20
Offset to DDTS-SMTS prior outage equation NILS	-20

7 Two Eildon to Mount Beauty 220 kV Lines

The following limit equations are enabled during a planned outage of both Eildon to Mount Beauty 220 kV lines.

7.1 V::N DDTS-MSS_DDTS-SMTS_V/Q/S/S_decel

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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 10 V::N 2xEPS-MBTS_V/Q/S/S_decel offsets

Term	Offset
Offset to system normal equation NILV	-80
Offset to system normal equation NILQ	0
Offset to system normal equation NILS	-80
Offset to system normal equation NILS_decel	-80

7.2 V^N 2xEPS-MBTS_BLVG

The system normal voltage stability equation NIL_VI_BLVG will manage voltage stability associated with the loss of Basslink or the largest Victorian generator. Therefore, no additional offset is required.

8 Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line

The following limit equations are enabled during a planned outage of a Hazelwood to South Morang 500 kV line and the Hazelwood to Rowville 500 kV line.

8.1 V::N HWTS-SMTS_HWTS-ROTS-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:

Victoria to NSW ≤ Sum [Term Values * Coefficients]

Table 11 V::N HWTS-SMTS_HWTS-ROTS-V coefficients

Term	Coefficient
Intercept	1328
Basslink	0.4424
Vic to SA (Heywood)	-0.5236
Vic to SA (Heywood)^2	-9.96e-4
Vic to SA (Murraylink)	-1.183
LV 500_ Inertia	6.56
EPS Inertia	16.45
MOPS Inertia	12.06
LV 220 Inertia	11.52
Murray Gen	0.7401
Kiewa Gen	1.082
LV 220 Gen	0.3693
VIC Metro Gen	1.025
State Grid Load North	-1.02
APD Load	-0.5355
Vic Wind & Solar	0.6794
VIC Demand - State Grid Load North - APD Load	-0.6293
Confidence Level (95%) offset	-97

8.2 V::N HWTS-SMTS_HWTS-ROTS-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:

Victoria to NSW ≤ Sum [Term Values * Coefficients]

Table 12 V::N HWTS-SMTS_HWTS-ROTS-Q coefficients

Term	Coefficient
Intercept	997
Basslink	0.5567
Vic to SA (Heywood)	-1.05
Vic to SA (Murraylink)	-0.8617
LV 500 Inertia	8.319
MOPS Inertia	11.88
Murray Gen	0.9048
Kiewa Gen	0.9
LV 220 Gen	0.448
State Grid Load	-0.734
Vic Wind & Solar	0.5185
VIC Demand - State Grid Load	-0.4871
Confidence Level (95%) offset	-98

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

8.3 V::N HWTS-SMTS_HWTS-ROTS-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:

Victoria to NSW ≤ Sum [Term Values * Coefficients]

Table 13 V::N HWTS-SMTS_HWTS-ROTS-Q coefficients

Term	Coefficient
Intercept	1112
Basslink	0.5166
Vic to SA (Heywood)	-0.7435
Vic to SA (Heywood)^2	-4.13e-4
Vic to SA (Murraylink)	-1.38
LV 500 Inertia	8.049
EPS Inertia	17.83
MOPS Inertia	13.05
Murray Gen	0.8779
Kiewa Gen	1.089
LV 220 Gen	0.9503
VIC Metro Gen	0.9778
State Grid Load North	-0.8316
APD Load	-0.6002
Vic Wind & Solar	0.7544

Term	Coefficient
VIC Demand - State Grid Load North - APD Load	-0.6835
220kV_Caps	-0.276
Confidence Level (95%) offset	-83

8.4 V::N HWTS-SMTS_HWTS-ROTS-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:

Victoria to NSW ≤ Sum [Term Values * Coefficients]

Table 14 V::N HWTS-SMTS_HWTS-ROTS-S_decel coefficients

Term	Coefficient
Intercept	1540
Basslink	0.4573
Vic to SA (Heywood)	-0.5008
Vic to SA (Heywood)^2	-0.00106
Vic to SA (Murraylink)	-1.161
LV 500 _Inertia	6.571
EPS Inertia	20.68
MOPS Inertia	13.38
LV 220 Inertia	11.95
Murray Gen	0.8176
Kiewa Gen	1.018
LV 220 Gen	0.3516
VIC Metro Gen	1.075
State Grid Load North	-1.175
APD Load	-0.7413
Vic Wind & Solar	0.7271
VIC Demand - State Grid Load North - APD Load	-0.6462
Confidence Level (95%) offset	-108

Note: this equation should only be applied when power transfers are above **0 MW** from Victoria to South Australia.

9 Both Hazelwood to South Morang 500 kV Lines

The following limit equations are enabled during a planned outage of both Hazelwood to South Morang 500 kV lines.

9.1 V::N 2x_HWTS-SMTS_V/Q/S/S_decel

To manage the Victorian transient stability export limit from Victoria to NSW for fault and trip of the Rowville to South Morang 500 kV line, apply offsets to the prior outage equations associated with a Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line outage, HWTS-SMTS_HWTS-ROTS_V/S/Q and S decelerating. The limit equation is of the form:

Victoria to NSW ≤ Sum [Term Values * HWTS-SMTS HWTS-ROTS Prior Outage Coefficients] + Offset

Table 15 V::N 2x_HWTS-SMTS _V/Q/S/S_decel offsets

Term	Offset
Offset to HWTS-SMTS_HWTS-ROTS prior outage equation NILV	-225
Offset to HWTS-SMTS HWTS-ROTS prior outage equation NILQ	-225
Offset to HWTS-SMTS HWTS-ROTS prior outage equation NILS	0
Offset to HWTS-SMTS HWTS-ROTS prior outage equation NILS_decel	0

10 Hazelwood to South Morang 500 kV line & Rowville to South Morang 500 kV line

The following limit equations are enabled during a planned outage of the Hazelwood to South Morang 500 kV line and the Rowville to South Morang 500 kV line.

10.1 V::N HWTS-SMTS_ROTS-SMTS _V/Q/S/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, apply offsets to the prior outage equations associated with a Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line outage, HWTS-SMTS_HWTS-ROTS_V/S/Q and S decelerating. The limit equation is of the form:

Victoria to NSW ≤ Sum [Term Values * HWTS-SMTS HWTS-ROTS Prior Outage Coefficients] + Offset

Table 16 V::N HWTS-SMTS_ROTS-SMTS_V/Q/S/S_decel offsets

Term	Offset
Offset to HWTS-SMTS_HWTS-ROTS prior outage equation NILV	-350
Offset to HWTS-SMTS HWTS-ROTS prior outage equation NILQ	-150
Offset to HWTS-SMTS HWTS-ROTS prior outage equation NILS	0
Offset to HWTS-SMTS HWTS-ROTS prior outage equation NILS_decel	0

11 Hazelwood to South Morang 500 kV Line & South Morang F2 500/330 kV Transformer

The following limit equations are enabled during a planned outage of a Hazelwood to South Morang 500 kV line and the South Morang 500/330 kV F2 Transformer.

11.1 V::N HWTS-SMTS_SMTS-F2_V/Q/S/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, apply the following offsets to prior outage equation HWTS-SMTS_V/S/Q and S decelerating. The limit equation is of the form:

Victoria to NSW ≤ Sum [Term Values * HWTS-SMTS Prior Outage Coefficients] + Offset

Table 17 V::N HWTS-SMTS_SMTS-F2_V/Q/S/S_decel offsets

Term	Offset
Offset to HWTS-SMTS prior outage equation NILV	-150
Offset to HWTS-SMTS prior outage equation NILQ	-100
Offset to HWTS-SMTS prior outage equation NILS	-200
Offset to HWTS-SMTS prior outage equation NILS_decel	-100

12 Hazelwood to South Morang 500 kV Line & Yallourn 220 kV Bus 1

The following limit equations are enabled during a planned outage of a Hazelwood to South Morang 500 kV line and the Yallourn B1 220 kV busbar. This limit is enabled when Yallourn Unit 1 is connected to the 500 kV network; under this connection arrangement, the outage of the YPS bus B1 will offload the following 220 kV lines:

- Hazelwood to Yallourn Power Station 220 kV line 1.
- Rowville to Yallourn Power Station 220 kV line 7.
- Hazelwood to Rowville 220 kV line 1.
- Hazelwood to Rowville 220 kV line 2.

12.1 V::N HWTS-SMTS_YPS-B1_V/Q/S/S_decel

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:

Victoria to NSW ≤ Sum [Term Values * HWTS-SMTS Prior Outage Coefficients] + Offset

Table 18 V::N HWTS-SMTS_YPB-B1_V/Q/S/S_decel offsets

Term	Offset
Offset to HWTS-SMTS prior outage equation NILV	-40
Offset to HWTS-SMTS prior outage equation NILQ	0
Offset to HWTS-SMTS prior outage equation NILS	-40
Offset to HWTS-SMTS prior outage equation NILS_decel	-40

13 Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line & Rowville A1 500/220 kV Transformer

The following limit equations are enabled during a planned outage of a Hazelwood to South Morang 500 kV line, a Hazelwood to Rowville 500 kV line and the Rowville A1 500/220 kV transformer.

13.1 V::N HWTS-SMSS_HWTS-ROTS_ROTS-A1_V/Q/S/S_decel

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 prior outage equations associated with a Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line outage, HWTS-SMTS_HWTS-ROTS _V/Q/S and S_decelerating, No offsets are required.

14 Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line & Yallourn 220 kV Bus 1

The prior outage equations HWTS-SMTS_HWTS_ROTS V/Q/S and S_decelerating are enabled during a planned outage of a Hazelwood to South Morang 500 kV line, a Hazelwood to Rowville 500 kV line and the Yallourn B1 220 kV busbar. When Yallourn Unit 1 is connected to the 500 kV network, the outage of the YPS bus B1 will offload the following 220 kV lines:

- Hazelwood to Yallourn Power Station 220 kV line 1.
- Rowville to Yallourn Power Station 220 kV line 7.
- Hazelwood to Rowville 220 kV line 1.
- Hazelwood to Rowville 220 kV line 2.

14.1 V::N HWTS-SMSS_HWTS-ROTS_YPS-B1_V/Q/S/S_decel

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 prior outage equations associated with a Hazelwood to South Morang 500 kV Line & Hazelwood to Rowville 500 kV Line outage, HWTS-SMTS_HWTS-ROTS _V/Q/S and S_decelerating, No offsets are required.

15 Heywood to South East both 275 kV lines (APD load is in service) SA Islanding condition

The following limit equations are enabled during the prior outage of both Heywood to South East 275 kV lines (APD load is in service) SA islanding condition.

15.1 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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 19 NIL_V and NIL_O Offsets

Term	Offset
Offset to system normal equation NIL_V	-270
Offset to system normal equation NIL_O	-270

16 Heywood to Tarrone and Heywood to Mortlake 500kV lines with APD load disconnected SA Islanding condition

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

16.1 Transient Stability Vic to NSW

To manage the Victorian transient stability export limit from Victoria to NSW for the 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:

Victoria to NSW ≤ 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

17 Both Kiamal and Murrawarra 2 synchronous condensers

The following limits are enabled during the above prior outage condition.

17.1 Voltage Oscillation

To prevent voltage oscillations for any contingency:

Table 21 Voltage oscillation limits

Generator	MW Limit
Kiamal Solar Farm	≤ 100 MW
Murrawarra 2 Wind Farm	≤ 100 MW

18 One Moorabool to Sydenham 500 kV Line & One South Morang to Sydenham 500 kV Line

The following limit equations are enabled during a planned outage of one Moorabool to Sydenham 500 kV line and one South Morang to Sydenham 500 kV line.

18.1 V::N MLTS-SYTS_SMTS-SYTS_V/Q/S/S_decel

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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 22 V::N MLTS-SYTS_SMTS-SYTS_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	-45
Offset to system normal equation NILS_decel	-100

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

19 Lower Tumut to Canberra and Dederang to South Morang 330 kV Line

19.1 Voltage Stability – NSW to Vic

Largest Vic generator or Basslink trip

To manage the Victorian voltage stability import limit from NSW to Victoria for the 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 ≤ ≤ [-1 * Sum [Term Values * System Normal Coefficients]] + Offset

Table 23 NIL_V1_BLVG offset

Term	Offset [MW]
Offset to the system normal equation	-160

19.2 Voltage Stability –Vic to NSW

Trip of both APD potlines

To manage the Vic to NSW voltage stability export limit from Victoria to NSW for the 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:

Victoria to NSW ≤ Sum [Term Values * Coefficients] +Offset

Table 24 V^N_2xAPD offset

Term	Offset [MW]
Offset to the system normal equation	-130

20 One Moorabool to Sydenham 500 kV Line & One South Morang to Sydenham 500 kV Line & the Keilor to Sydenham 500 kV Line

The following limit equations are enabled during a planned outage of one Moorabool to Sydenham 500 kV line, one South Morang to Sydenham 500 kV line and the Keilor to Sydenham 500 kV line.

20.1 V::N MLTS-SYTS_SMTS-SYTS_KTS-SYTS_V/Q/S/S_decel

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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 25 V::N MLTS-SYTS_SMTS-SYTS_KTS-SMTS_V/Q/S/S_decel offsets

Term	Offset
Offset to system normal equation NILV	-85
Offset to system normal equation NILQ	-5
Offset to system normal equation NILS	-45
Offset to system normal equation NILS_decel	-150

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

21 Ravine to Yass 330 kV line and South Morang F2 Transformer

21.1 Voltage Stability – NSW to Vic

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 ≤ ≤ [-1 * Sum [Term Values * System Normal Coefficients]] + Offset

Table 26 NIL_V1_BLVG offset

Term	Offset [MW]
Offset to the system normal equation	-160

21.2 Voltage Stability –Vic to NSW

Trip of both APD potlines

To manage the Vic to NSW voltage stability export limit from Victoria to NSW for the 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:

Victoria to NSW ≤ Sum [Term Values * Coefficients] +Offset

Table 27 V^N_2xAPD offset

Term	Offset [MW]
Offset to the system normal equation	-120

21.3 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 transient stability limit equations V::N SMTS-F2_V, V::N SMTS-F2_Q, V::N SMTS-F2_S and V::N SMTS-F2_S_decel for the prior outage of the South Morang F2 Transformer.

22 Tailem Bend to South East SA Islanding condition

The following limit equations are enabled during a Tailem Bend to South East SA islanding condition.

22.1 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:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 28 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

23 Tailem Bend-Tungkillo and Tailem Bend-Cherry Gardens 275kV lines out of service SA Islanding condition

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

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 NIL_V and NIL_O. The limit equation is of the form:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 29 NIL_V and NIL_O Offsets

Term	Offset
Offset to the system normal equation NIL_V	-170
Offset to the system normal equation NIL_O	-170

24Two South Morang Series Capacitors

The following limit equations are enabled during a planned outage of both South Morang series capacitors.

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 equation is of the form:

Victoria to NSW ≤ Sum [Term Values * System Normal Coefficients] + Offset

Table 30 NIL_V and NIL_O Offsets

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

24.2 V^N 2xSMTS-CAP_BLVG

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 ≤ [-1 * Sum [Term Values * System Normal Coefficients]] + Offset

Table 31 V^N 2xSMTS-CAP_BLVG offset

Term	Offset
Offset to system normal equation NIL_VI_BLVG	-100

A1. Measures and Definitions

A1.1 Units of Measure

Abbreviation	Unit of measure
MW	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.

A1.2 Parameter Definitions

Abbreviation	Definition
220 kV Caps	MVAR output from capacitors connected at 220 kV busbars (i.e. Altona, Brooklyn, Dederang, Fishermans Bend, Keilor, Moorabool, Rowville, Ringwood, Templestowe and Thomastown).
APD–HYTS_MVAR	Alcoa Portland smelter (APD) reactive power export (measured at 500 kV feeders). A negative value indicates that APD is importing MVAr.
APD–HYTS_MW	APD real power export (measured at 500 kV feeders. A negative value indicates that APD is importing MW).
APD Load	APD MW load at 33kV and 22kV.
Basslink	MW flow on the Basslink interconnector (measured at the receiving end).
BATS TX MW	MW flow through 220/66kV transformers at Ballarat (measured at HV side, positive value indicates load MW).
BETS Load	Bendigo (BETS) customer load (MW).
BHSS220 Load	Broken Hill 220 kV MW industrial (mine) load.
BKNH GEN	MW output from Broken Hill Generation.
BOPS+MKPS GEN	MW output from Bogong and McKay Power Station [BOPS & MKPS].
BKNH TX MW	MW flow through 220/22kV transformers at Broken Hill (measured at HV side, positive value indicates load MW).
Both TAIL-SESS Series Caps Out	Both Tailem Bend – South East series caps out of service (1= Both series caps are out of service).
BRGAshnt	MVAR output of Buronga shunt devices. Values associated with this term can be positive or negative.
CANCap	MVAR output of Canberra 220 kV capacitor banks. Values associated with this term are positive.
CMACap	MVAR output of Cooma capacitor banks. Values associated with this term are positive.
Constraint equation	These are the mathematical representations that AEMO uses to model power system limitations and FCAS requirements in National Electricity Market Dispatch Engine (NEMDE).
Contingent MW	Maximum of: 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. 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.
CUECap	MVAR output of Queanbeyan capacitor banks. Values associated with this term are positive.
DD220Cap	MVAR output of Dederang 220 kV capacitor banks. Values associated with this term are positive.
DD330Cap	MVAR output of Dederang 330 kV capacitor banks. Values associated with this term are positive.
DLPTshunt	MVAR output of Darlington Point shunt devices. Values associated with this term can be positive or negative.
DPS GEN	MW output from Dartmouth Power Station [DPS].
EPS Inertia	Inertia from Eildon Power Station (EPS). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA) as per EMS.
Geelong Load (GTS LOAD)	Real Power (MW) component of load at Geelong (Sum of MW load at 66 kV, 22 kV and 11 kV busbars).
GEN EPS on	Number of Eildon Power station (EPS) units online.
GEN DPS on	Number of Dartmouth Power station units online [DPS].
GEN BOPS on	Number of Bogong Power station units online [BOPS].
GEN MKPS on	Number of Mckay Power station units online [MKPS].
GEN WKPS on	Number of West Kiewa Power station units online [WKPS].

Abbreviation	Definition
Guthega GEN	MW output from Guthega Power Station [GGA].
Guthega Inertia	Inertia from Guthega Power Station [GGA]. Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA) as per EMS.
HOTS SVC out of service	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.
HUME VIC GEN	MW output from Hume Power station (Victorian connection).
HYTS_CAP_Status	Heywood capacitor status (1 = capacitor in service).
JBE Pump	MW at Jindabyne Power Station [JBE]. Values associated with this term are negative.
KGTS Load	Kerang (KGTS) customer load (MW).
KGTS SVC out of service	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.
Kiewa Gen	MW output from Kiewa hydro scheme generators (Bogong, Clover, Dartmouth, Mckay and West Kiewa).
Kiewa Inertia	Inertia from Kiewa hydro scheme generators (Bogong, Clover, Dartmouth, Mckay and West Kiewa). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA).
L_TUMUT_Gen	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.
LTUM3SC	Number of generator units operating as synchronous condensers at Lower Tumut.
LV 220 Gen	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).
LV 500 Inertia	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).
MCAR_Gen	MW output from the Macarthur Wind Farm (MCAR).
MLTS_Line_Reactors	Count of MLTS line reactors (2=both reactors in service).
MMWF_Gen	MW output from the Mount Mercer Wind Farm (MMWF).
MOPS Inertia	Inertia from Mortlake Power Station (MOPS). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA) as per EMS.
MSS2SC	Number of generator units operating as synchronous condensers at Murray 2.
MSSReac	MVAR output of Murray reactors. Values associated with this term are negative.
Murray Gen	MW output from Murray Power Station (Murray 1 and Murray 2).
Num. ROTS SVC	Number of Static Var Compensators (SVCs) at Rowville in service.
Num. SESS SVC	Number of SVCs at South East in service.
NSW to Queensland (QNI only)	MW Transfer from NSW to Qld via QNI. The interconnector direction and lines it consists of follow the NEM standard.
NSW_D	New South Wales demand.
NSWd- SW_NSW	NSW demand (customer load + losses) minus the load in southern NSW.
NSW_H	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).
Parallel System	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.
QLD_H	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).
RCTS Load	Red Cliffs (RCTS) customer load (MW).

Abbreviation	Definition
Rowville SVC1 or SVC2 out of service	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.
SA_H	Inertia of SA generators (Northern, Playford, Pelican Point, Torrens Island, Mintaro, Quarantine, Osborne, Dry Creek, Ladbroke Grove and Snuggery). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA).
South East SVC1 or SVC2 out of service	South East 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.
SGL-HUME	Victorian State Grid Load (SGL) minus Hume MW output.
SNOWY Inertia	Inertia from the Snowy area (Murray, Lower Tumut and Upper Tumut). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA).
SNOWY_GSC_H	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).
State Grid Load	Vic State Grid Load. This is the sum of the State Grid Load North (SGLN) and State Grid Load South (SGLS).
State Grid Load North	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).
State Grid Load South	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).
SW_NSW	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).
STH_NSW_GEN	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, Gunning WF, Boco Rock WF, Taralga WF, Woodlawn WF, Burrinjuck Hydro, Blowering Hydro, Gadara, and Jounama Hydro Embedded generation.
System normal	The configuration of the power system where: • All transmission elements are in service, or • The network is operating in its normal network configuration.
TNSP	Transmission Network Service Provider.
Tumut Pump	MW of Lower Tumut machines in pumping mode (this MW value is negative).
UQT_Gen	MW output from Uranquinty (UQT) power station.
U_TUMUT_Gen	MW output from Upper Tumut 1 and Upper Tumut 2 power station (UTSS).
UTUM1SC+UTUM2SC	Number of generator units operating as synchronous condensers at Upper Tumut 1 and Upper Tumut 2.
V_MLTS5	MLTS 500 kV voltage (typical values between 450 and 550 kV).
V_MSS3330	Voltage (kV) at the Murray Power Station 330 kV bus.
VIC220_Gen	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).
Vic Demand	Vic MW demand (calculated as generation minus export).
Vic. to SA (Heywood)	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.
Vic. to SA (Murraylink)	MW transfer from Vic to SA via Murraylink (measured at Red Cliffs end).
Vic Demand - State Grid Load	Vic Demand (MW) minus Vic State Grid Load (SGL).
VIC Demand - State Grid Load North – APD Load	Vic Demand (MW) minus Vic State Grid Load North (SGLN).minus APD Load.

Abbreviation	Definition
Vic Metro Gen	MW output from Vic metropolitan generators (Newport, Somerton and Laverton North).
Vic Metro Gen Inertia	Inertia from Vic metropolitan generators (Newport, Somerton and Laverton North). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA) as per EMS.
Vic Wind & Solar	MW Generation from Vic windfarms and solar plant (Ararat WF, Bald Hill WF, Ballarat Battery (Gen Component), Bannerton SF, Challcum Hills WF, Crowlands WF, Gannawarra Battery (Gen component), Gannawarra SF, Karadoc SF, Kiata WF, Macarthur WF, Mortons Lane WF, Mount Gellibrand WF, Mount Mercer WF, Oaklands Hill WF, Portland WF, Salt Creek WF, Waubra WF, Wemen SF, Yaloak South WF and Yambuk WF).
WAGGACap	MVAR output of Wagga Wagga capacitor banks. Values associated with this term are positive.
WKPS GEN	MW output from West Kiewa Power Station [WKPS].
WETS Load	Wemen (WETS) customer load (MW).
WOTSCap	MVAR output of Wodonga capacitor banks. Values associated with this term are positive.
YASSCap	MVAR output of Yass capacitor banks. Values associated with this term are positive.
YASSReac	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
Constraint equation	These are the mathematical representations that AEMO uses to model power system limitations and FCAS requirements in National Electricity Market Dispatch Engine (NEMDE).
System normal	The configuration of the power system where: • All transmission elements are in service, or • The network is operating in its normal network configuration.
TNSP	Transmission Network Service Provider.