# Victorian Transfer Limit Advice – Multiple Outages

November 2018

For the National Electricity Market

# Important notice

## PURPOSE

AEMO has prepared this document to provide information about voltage and transient stability limits for flows to and from Victoria, as at the date of publication.

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## VERSION CONTROL

| Version | Release date | Changes |
|---|---|---|
| 3 | 23/11/2018 | New Template Applied |
| 2 | 23/07/2018 | Updated voltage stability import limits |
| 1 | 01/08/2017 | Initial version |

# Contents

# 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 of these documents are available on the AEMO website[2].

## 1.1 Other AEMO publications

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

## 15.1 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 19 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.

# 16. 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.

## 16.1 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 20 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.

# 17. Two South Morang Series Capacitors

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

## 17.1 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 21 V::N 2xSMTS-CAP_V/Q/S/S_decel offsets**

| Term | Offset |
|---|---|
| **Offset to system normal equation NILV** | -70 |
| **Offset to system normal equation NILQ** | -90 |
| **Offset to system normal equation NILS** | -80 |
| **Offset to system normal equation NILS_decel** | -70 |

## 17.2 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 22 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. |

| Abbreviation | 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). |
| **Contingent MW** | Maximum of:<br>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.<br>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]. |
| **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. |

| Abbreviation | Definition |
|---|---|
| **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) |
| **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). |

| Abbreviation | Definition |
|---|---|
| **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:<br>• All transmission elements are in service, or<br>• 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 |
| **Vic Metro Gen** | MW output from Vic metropolitan generators (Newport, Sommerton and Laverton North). |
| **Vic Metro Gen Inertia** | Inertia from Vic metropolitan generators (Newport, Sommerton and Laverton North). Inertia is on a 100 MVA base (i.e. MW.sec / 100 MVA) as per EMS. |

| Abbreviation | Definition |
| --- | --- |
| **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 Gelibrand 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:<br>• All transmission elements are in service, or<br>• The network is operating in its normal network configuration |
| **TNSP** | Transmission Network Service Provider |