THE CONSTRAINT REPORT 2009

PREPARED BY: Ben Blake

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Contents

1 Definitions

ABBREVIATION	DEFINITION
Constraint Equation	These are the mathematical representations that AEMO uses to model power system limitations and FCAS requirements in NEMDE.
Constraint Function	A group of RHS terms that can be referenced by one or more Constraint Equation RHSs. These are used where a common calculation is required multiple times (such as a complex stability limit or a calculation for a sub-regional demand). These have been referred to as generic equations, base equations or shared expressions in the past.
Constraint Set	A grouping of Constraint Equations that apply under the same set of power system conditions, either for system normal or plant outage(s). AEMO uses Constraint Sets to efficiently activate / deactivate Constraint Equations.
CVP	Constraint Violation Penalty Factor
DNSP	Distribution Network Service Provider
FCAS	Frequency Control Ancillary Service
LHS	Left Hand Side of a Constraint Equation. This consists of the variables that can be optimised by NEMDE. These terms include scheduled or semi-scheduled generators, scheduled loads, regulated Interconnectors, MNSPs or regional FCAS requirements.
Limit Equation	A mathematical expression describing a limitation on a part of the transmission or distribution network. These are provided to AEMO by both TNSPs and DNSPs.
Mainland	The NEM regions: Queensland, New South Wales, Victoria and South Australia
MNSP	Market Network Service Provider
MPC	Market Price Cap (previously called VOLL)
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
PASA	Projected Assessment of System Adequacy
RHS	Right Hand Side of a Constraint Equation. The RHS is calculated and presented to the solver as a constant; these terms cannot be optimised by NEMDE.
SCADA	Supervisory Control And Data Acquisition. Information such as line flows and generator outputs are delivered via SCADA.
System Normal	The configuration of the power system where the status of all major transmission elements is normal (this usually means all major transmission elements are in service).
TNSP	Transmission Network Service Provider

2 References

- SO_OP3709 – Generic Constraints due to Network Limitations
- Constraint Naming Guidelines: http://www.aemo.com.au/electricityops/200-0141.html
- Constraint Violation Penalty Factors: http://www.aemo.com.au/electricityops/140-0011.html
- Reliability Panel Frequency Operating Standards: http://www.aemc.gov.au/Market-Reviews/Completed/Review-of-Mainland-Frequency-Operating-Standards-during-Periods-of-Supply-Scarcity.html
- MMS Data Model: http://www.aemo.com.au/data/320-0024.pdf
- Congestion Information Resource: http://www.aemo.com.au/electricityops/congestion.html

3 Introduction

Constraint Equations are used by AEMO to model the power system limitations in the dispatch engines NEMDE and PASA. This report details constraint equation performance and transmission congestion related issues for the calendar year 2009. It includes the drivers on Constraint Equation changes in 2009, analysis of binding and violating Constraint Equations, Interconnector limit setters, duration of outages and information on other constraint related issues.

This report has been developed for both internal AEMO requirements and in response to a submission to the Congestion Information Resource (CIR) consultation[1] which was seeking more information and commentary on binding/violating Constraint Equations as well as timing of major outages. AEMO intends to publish this document annually for the preceding calendar year and include it as a part of the CIR.

AEMO welcomes comments and suggestions on the content of this report from both internal AEMO staff and participants.

4 Current Statistics

This section details the current totals of the Constraint Sets, Equations and Functions.

As of 31st December 2009 there were:

- 3431 Constraint Sets. This is a minor increase over 2008's total of 3369.
- 8275 Constraint Equations, which compares to 7697 in 2008.
- 347 Constraint Functions. Due to the way the archiving works it is not possible to obtain the number of Constraint Functions historically.

Excluded from these totals are any Sets, Equations or Functions that were archived and any that are for Outage Ramping. The Outage Ramping Constraint Sets and Constraint Equations are not built by the Constraint Builders but are single use entities generated by an application used by AEMO's control room staff.

Outage Ramping (which would swamp the results) and the Constraint Automation built Constraint Equations are also excluded from the following graphs which show the breakup of Constraint Equation by Regions, FCAS and a few other types (Figure 1) and by Limit Type (Figure 2).

[1] http://www.aemo.com.au/electricityops/0178-0001.html

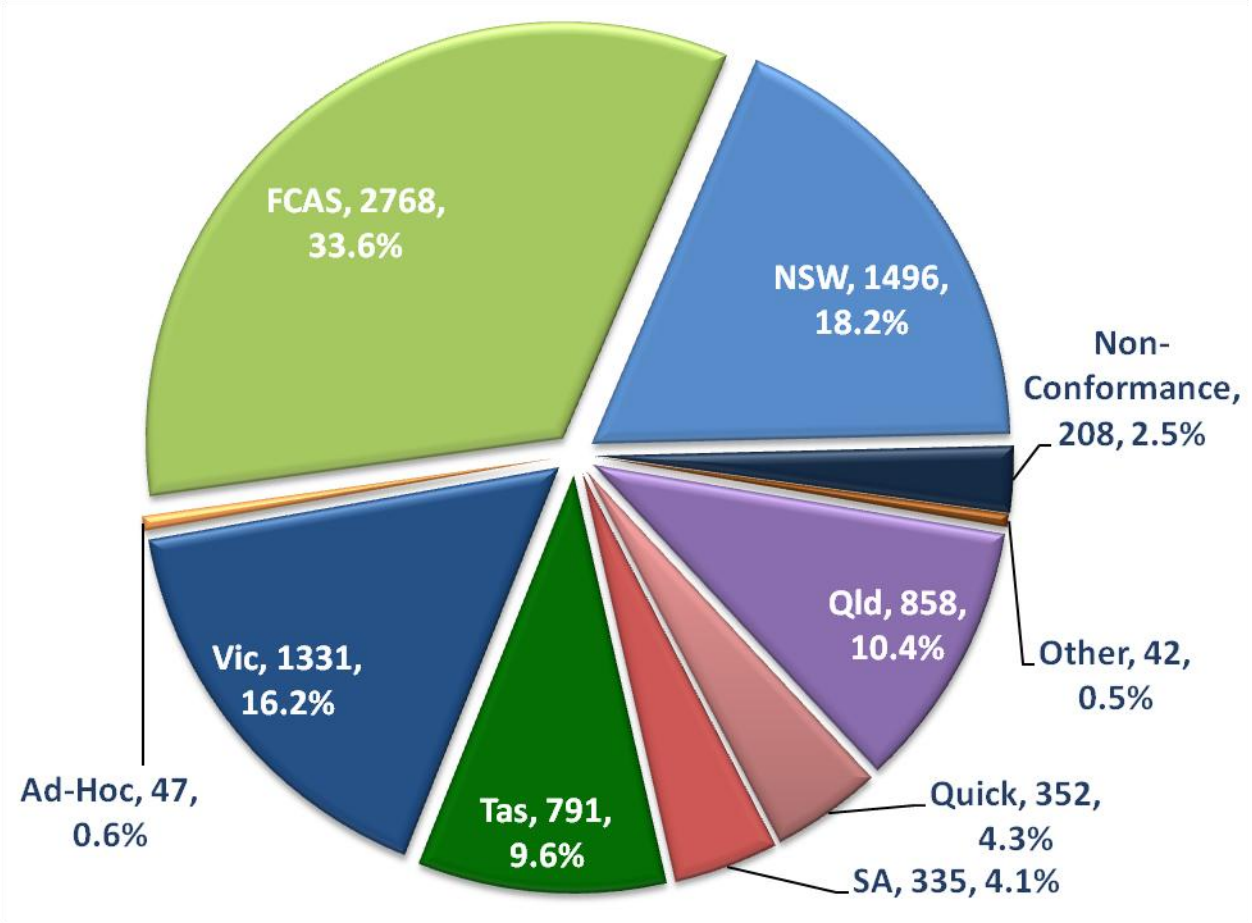


Figure 1: Constraint Equations by Region/FCAS

As can be seen in the graphs the majority of the Constraint Equations are for FCAS and NSW and this is borne out in the number of Constraint Equation changes (see 5.4). Additionally the main types of Constraint Equations are for FCAS (28.8%) and thermal overloads (25.5%) (see Figure 2 below).

The percentage breakup for the Constraint Equations, whether for the limit type or the regional basis, has not changed much from the 2008 results. The exception is FCAS which has increased its share by 2.6%. It is not expected these results will change in the next couple of years.

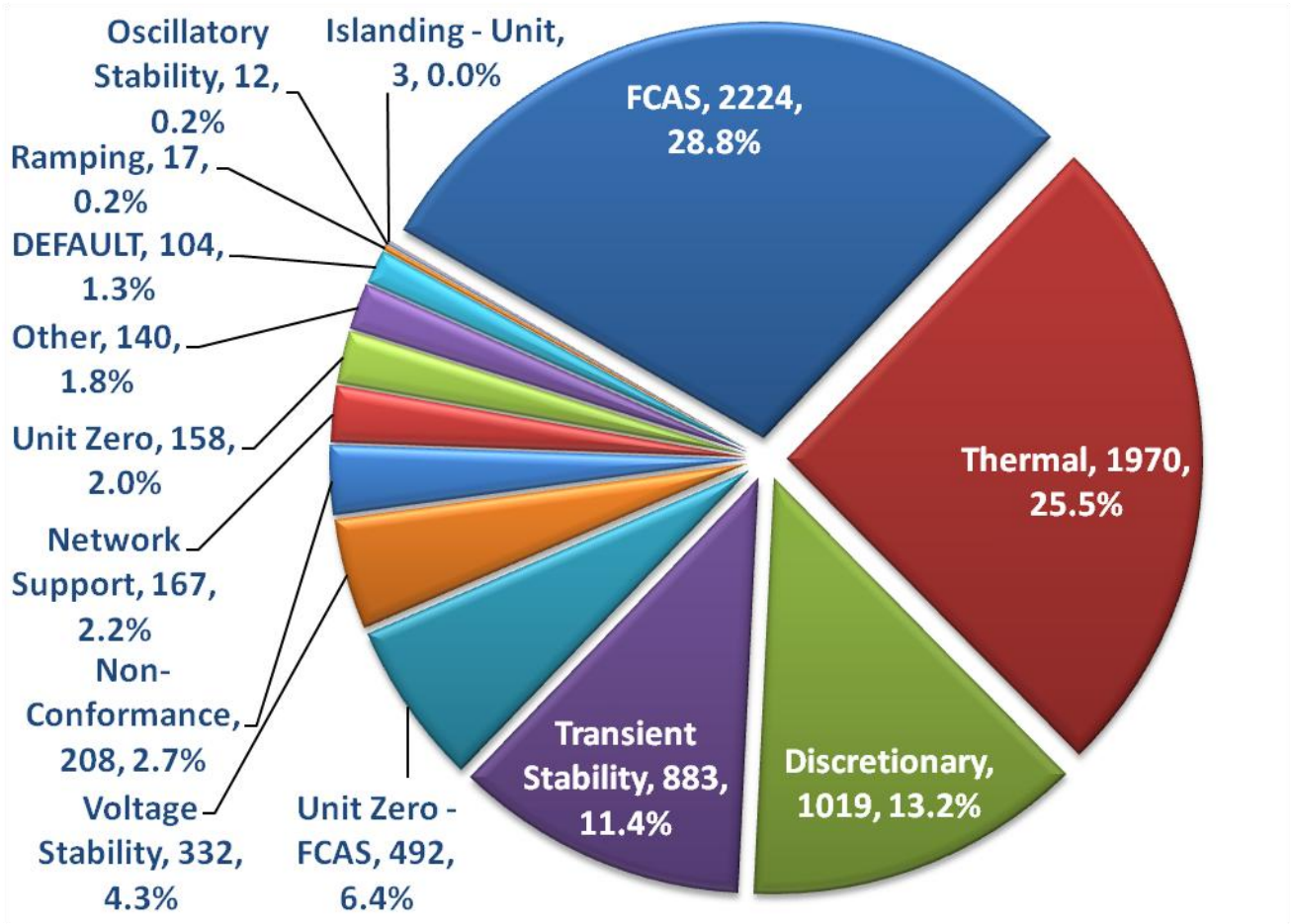


Figure 2: Constraint Equations by Limit Type

5 Constraint changes

One of the main drivers for changes to Constraint Equations (for other drivers see Appendix 1) is from power system change, whether this is the addition or removal of plant (either generation or transmission). In 2009 there were a significant number of new generators commissioned and this was spread across all regions. There were also a number of major transmission changes particularly in NSW and Queensland. Finally, there were 2 major changes to the FCAS Constraint Equations. All these changes led to 2009 having the most number of Constraint Equation changes (8592) in the history of the NEM. As this number is larger than the total number of Constraint Equations it indicates that some Constraint Equations were modified multiple times (some of the NSW thermals were modified 5 times during 2009).

This section only lists the power system changes that directly caused changes to the Constraint Equations.

It is worth noting that the addition of a single generator can cause multiple Constraint Equation changes. Currently AEMO's constraint builders can only add generator(s) to the Constraint Equations once the generator(s) are registered in AEMO's market systems. As transmission network modifications (where the generator substation is cut into existing lines) and the generator registration usually occur at different times there are usually multiple Constraint Equation changes. Where this has been the case the substation work and generator registration are listed separately.

5.1 Generators

The following list includes all scheduled and semi-scheduled generators that were added or removed in 2009. Additionally where non-scheduled wind-farms were of a significant size and caused constraint changes these are listed also.

There were a large number of new generator registrations in 2009 with the majority concentrated in the first 6 months.

Table 1: Generator changes in 2009

GENERATOR	REGISTRATION DATE	REGION	NOTES
Callide A2 & A4	1 Feb 2009	Queensland	Units recommissioned
Waubra wind farm	27 Feb 2009	Victoria	Non-scheduled
Braemar 2	27 March 2009	Queensland	
Tamar Valley 4	31 March 2009	Tasmania	
Clements Gap wind farm	17 April 2009	South Australia	
Hallett 2 wind farm	11 May 2009	South Australia	Connected to Mokota substation
Colongra	20 May 2009	NSW	
Condamine	2 June 2009	Queensland	
Tamar Valley CCGT	15 June 2009	Tasmania	
Capital wind farm	30 June 2009	NSW	Non-scheduled
Bogong	22 September 2009	Victoria	Aggregate unit with existing McKay Creek. McKay Creek was originally 2 aggregates in the Market Systems. They were also aggregated into 1 dispatchable unit.
Mt Stuart 3	15 October 2009	Queensland	
Darling Downs	16 November 2009	Queensland	

5.2 Transmission

In 2009 there were transmission changes each month except January with Queensland and New South Wales having the majority of projects in the year (which is reflected in the number of Constraint changes in those regions). This pace of transmission work is not expected to slow in 2010.

Table 2: Transmission changes in 2009

PROJECT	DATE	REGION	NOTES
3 South East Qld SVCs	February 2009	Queensland	These increased the Tarong and Central – South limits
Armidale Phase Shifting Transformer	February 2009	NSW	Removed the “965” Constraint Equation (N>>N-NIL_DF_DS) from the NSW system normal.
Waubra 220kV	February 2009	Victoria	For Waubra wind farm. Cut into the existing Ballarat to Horsham 220kV line
Innisfail to Tully 132kV line	13 February 2009	Queensland	This changed the definition of the Far North Qld cut set and increased the limit
Mokota switching station	March 2009	South Australia	For Hallett 2 wind farm. Cut into the Davenport to Robertstown 275kV line
NSW 500kV - 73 converted to 5A3	March 2009	NSW	See 5.2.2

PROJECT	DATE	REGION	NOTES
NSW 500kV – Bayswater unit 4 moved to 500kV bus	May 2009	NSW	See 5.2.2
Decommissioning of Lindisfarne – Waddamana 110kV line	May 2009	Tasmania	Removal of this line is the first part of the 220kV line from Lindisfarne to Waddamana
Broadsound to Nebo 275kV lines	1 May 2009	Queensland	See 5.2.1
Capital 330kV substation	June 2009	NSW	For Capital wind farm. Cut into the existing Canberra and Kangaroo Valley (6) 330kV line
Raleigh 132kV substation	July 2009	NSW	Cut into existing Coffs Harbour to Nambucca (9W3) 132kV line. Part of a larger project to commission a 2nd 132kV circuit between Coffs Harbour and Kempsey
Tarong, Greenbank and Mt England cap banks	August 2009	Queensland	These increased the Tarong, Central – South and Gold Coast limits
Tully to Woree 132kV line	13 August 2009	Queensland	This changed the definition of the Far North Qld cut set and increased the limit
NSW 500kV - 74 converted to 5A4	14 August 2009	NSW	74 line consisted of 500kV construction line between Bayswater and Mt Piper and a 330kV section between Mt Piper and Wallerawang. Also see 5.2.2
Macarthur 330kV substation	21 August 2009	NSW	Cut into existing Avon to Kemps Creek (37) 330kV line
Nebo to Strathmore 275kV	24 August 2009	Queensland	See 5.2.1
NSW 500kV – remaining part of 74 converted to 70	7 September 2009	NSW	See 5.2.2
Somerton PS reconnected to South Morang from Thomastown	October 2009	Victoria	
Larcom Creek 275kV substation	October 2009	Queensland	Cut into existing Gladstone to Bouldercombe (811) 275kV line
Davenport to Playford 132kV line	November 2009	South Australia	Part of the Playford 132kV relocation to Davenport project.
Clare South replaced Clare 132kV	December 2009	Queensland	Changed the new North Qld thermal Constraint Equations

5.2.1 Qld Central to North augmentation

Powerlink is constructing new transmission lines, in three stages, to increase the transmission capacity from Central Queensland to North Queensland (CQ-NQ). Each stage involves the construction of a new double-circuit 275kV line and then pairing of the existing 275kV lines. The first stage was completed in May 2009 with the second stage in August 2009. The effect of this has been to remove the transient stability limit between CQ-NQ and increase the previous voltage collapse limits to the point where thermal overloads are now more likely to be the limiting factor (on the trip of one Ross to Strathmore 275kV line) on the 275kV or 132kV lines in the area.

The third stage of this project, the Ross to Strathmore 275kV lines, should be completed in late 2010 and is expected to relieve the thermal limits between Ross and Strathmore[2].

5.2.2 NSW Western 500kV

2009 saw the most significant changes to the NSW main transmission system in over a decade. The last major line construction in NSW was in the late 1980s / early 1990s. These lines, the Bayswater to Mt Piper (73 & 74) and Mt Piper to Marulan (35 & 36), were originally designed to operate at 500kV but were initially run at 330kV. In 2009 Transgrid progressively re-commissioned both Bayswater to Mt Piper lines to operate at their design voltage of 500kV. Additionally Bayswater unit 4 was transferred to the new 500kV bus at Bayswater.

Each stage required updates to most of the NSW system normal thermal overload Constraint Equations.

This work will continue in early 2010 when the Mt Piper to Marulan lines will be upgraded to 500kV, commissioning of the new Bannaby substation and finally moving Bayswater unit 3 to the 500kV bus.

5.3 FCAS changes

There were 2 major changes to the FCAS Constraint Equations in 2009.

The first change was the co-optimisation of the 5 minute and regulation services. These Constraint Equations were made active on 1st January 2009, however all the work for this was completed and loaded into the AEMO's Market Systems in late 2008.

The second major change was the implementation of new frequency operating standards in Tasmania on 28th October 2009. The largest number of changes was made to the Raise/Lower 6 and 60 second Constraint Equations; the standards for Raise/Lower 5 min did not change so the corresponding Constraint Equations did not change. However, most of the work for the new standards was in recalculating the Basslink trip Constraint Equations. This was done using regression analysis over thousands of cases. This methodology was also applied to the Predispatch RHSs of the remaining Tasmanian FCAS Constraint Equations, which had the added advantage of improving their accuracy.

5.4 Comparison of Constraint Equation changes

The following 2 graphs compare the yearly and monthly Constraint Equation changes. They do not include changes to the Constraint Sets or Constraint Functions or any archiving. The number of times a Constraint Equation changes is not a fair indication of the amount of work involved in changing it (some changes are to fix a description, some changes require many days of work). Also these results measure when the changes occurred and not when they became active, so the FCAS change that was made active on 1st Jan 2009 that was loaded into the database in late 2008 is included in the 2008 results and not the 2009 results.

[2] http://www.powerlink.com.au/asp/index.asp?sid=5056&page=Projects/northern&cid=5274&gid=407

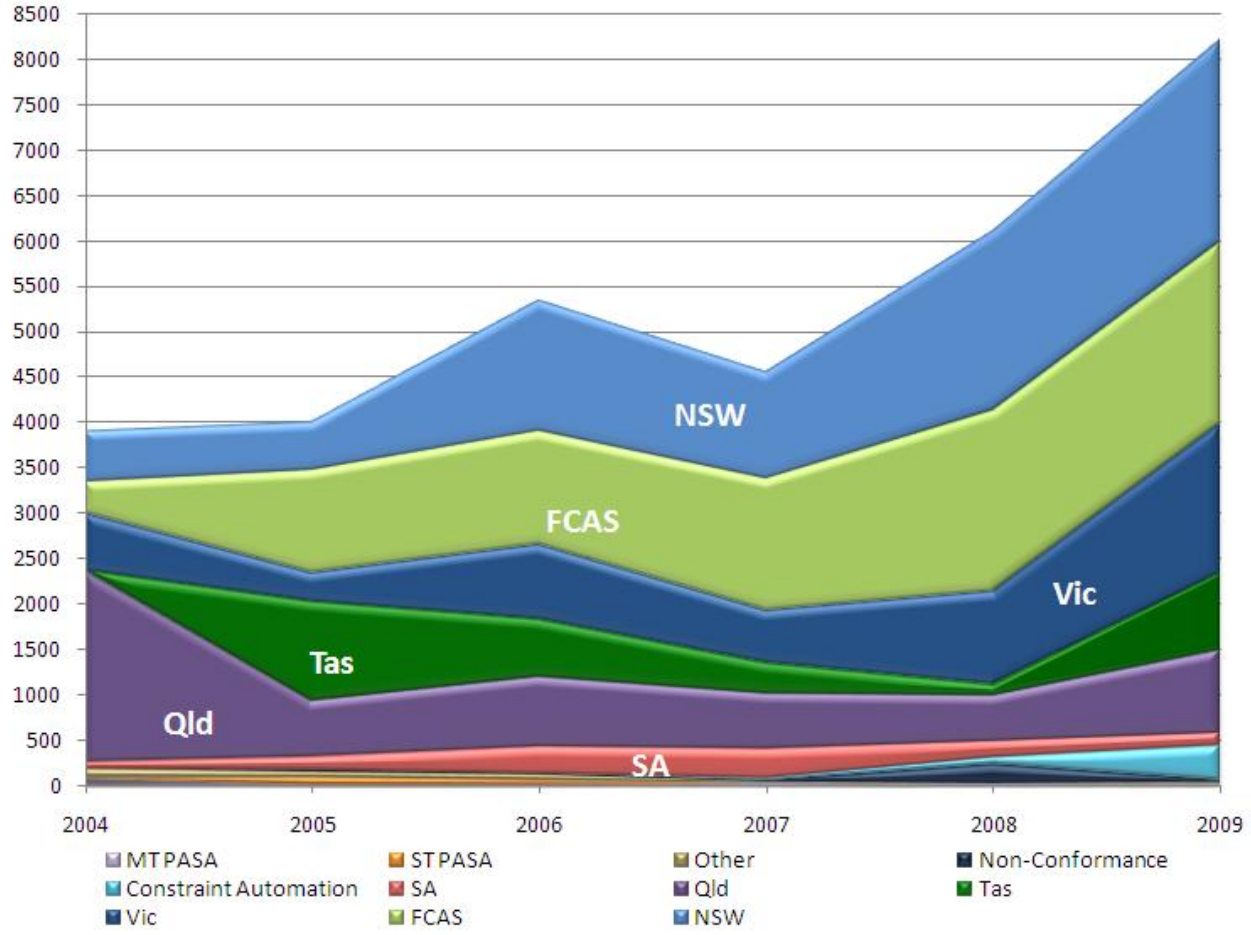


Figure 3: Constraint Equation changes per calendar year

As can be seen from Figure 3 the number of constraint changes has steadily increased between 2007 and 2009. The 2008 results include all the changes associated with the Snowy region abolition and the spike in 2006 is due to the program to convert Constraint Equations to "fully co-optimised". The number of changes in 2010 is not expected to be as high as 2009 as some of the changes (such as FCAS and description updates – see below) were for specific projects. However, with the number of transmission and generation projects planned for 2010 it is expected that the 2010 value will be similar to 2008.

Figure 4 shows the Constraint Equation changes per month in 2009 and with the exception of NSW most regions had bursts of activity. The major groups of constraint changes (apart from those that are due to the generation and transmission changes in Table 1 & Table 2) can be attributed to the following:

- In April and May a number of constraint equations had their descriptions updated. The majority of these were for setting generators to zero, FCAS has a high count as there are many more of these "zero" constraint equations to account for up to 8 services for each unit.
- FCAS in October was due to the revised Tasmanian frequency standards (see 5.3)
- In June a number of the Victorian transient stability constraint equations were modified to include Laverton North on the LHS.
- In October and November there were many changes in Queensland due to updated limit advice for the Tarong, Central – North and Gold Coast limits. Many of the other Queensland Constraint Equations were also changed due to the registration of Mt Stuart 3 and Darling Downs GTs.

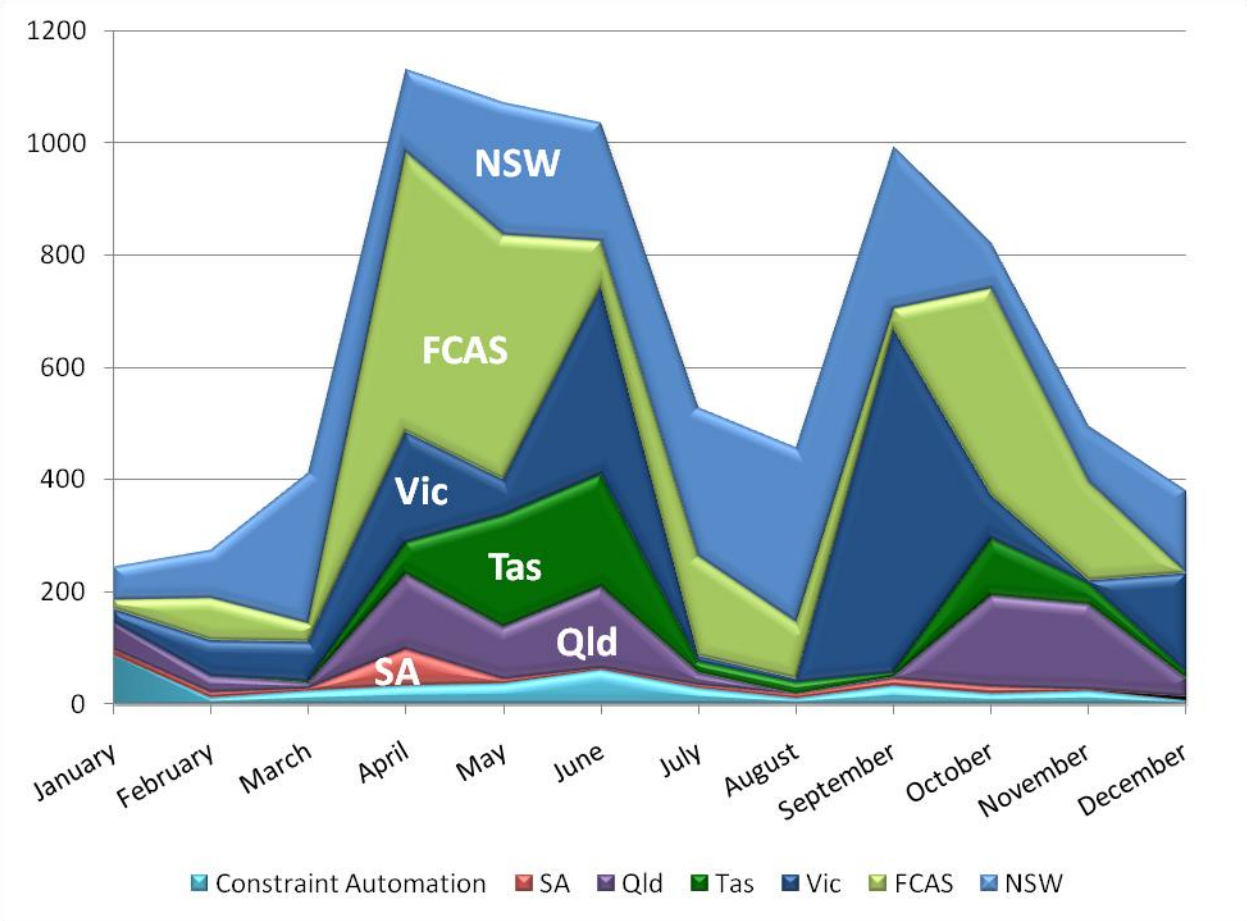


Figure 4: Constraint Equation Changes per month in 2009

6 Binding and Violating

In this section of the report the top 20 binding and violating Constraint Equations are examined. In the tables a brief description of the Constraint Equation is given (in *italics*) along with any comments. If the full description, LHS or RHS is required then this can be obtained from either the Plain English converter (see 9.4) on the MMS Web Portal or via the MMS Data Model[3].

6.1 Binding Constraint Equations

When a Constraint Equation is binding it is either on its limit or setting the FCAS requirements. Since there is at least one Constraint Equation setting the FCAS requirement for each service there are many more hours of binding for FCAS Constraint Equations and these would dominate the top 20. Due to this the FCAS and Network binding results have been separated into two tables (see Table 3 and Table 4 below). Some Constraint Equations only bind at certain times of the year (such as winter or summer) and Figure 5 shows this for the top 10 binding network Constraint Equations.

In several cases the binding results for several Constraint Equation IDs have been combined. The first reason for this is some Constraint Equations are split into several parts to either allow more terms to appear on the LHS (such as the Vic to NSW transient stability limit or the NSW to Qld voltage stability limit) or for managing the same limit under different network configurations (e.g. Yallourn W1 on the 500kV or 220kV). Secondly a few Constraint Equations had their ID changed during 2009.

[3] http://www.aemo.com.au/data/320-0024.pdf

Out of the top 20 binding results (see Table 3 and Table 4 below) the majority are system normal Constraint Equations and not those for outage cases. The 2008 results are listed in Appendix 2.

Table 3: Top 20 Binding Network Constraint Equations

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V_T_NIL_FCSPS	3967	*Basslink limit from Vic to Tas for load enabled for the Basslink Frequency Control Special Protection Scheme (FCSPS)* This constraint equation binds when there is high import to Tasmania or a low amount of load is enabled for tripping. It is expected this will bind for a similar amount in 2010.
V^^S_NIL_NPS_SE_OFF & V^^S_NIL_NPS_SE_ON & V^^S_TBCP_NPS_SE_OFF & V^^S_TBCP_NPS_SE_ON & V::S_NIL	669	*Out = Nil, Vic to SA Long Term Voltage Stability limit for loss of one Northern unit, South East Cap bank on / off, Tailem Bend Cap bank on/off* The ID for this Constraint Equation ID was changed in mid 2009 to better reflect its limit type and that it had been split into two parts (South East Cap bank on and off). In October 2009 the Tailem Bend outage Constraint Equations were added to the SA System Normal as this cap bank was switched in and out on a daily basis. It is expected this group of Constraint Equations will bind for a similar amount in 2010.
T>>T_NIL_BL_220_6B & T>T_NIL_BL_220_6	509	*Out = Nil, avoid overloading the Palmerston to Sheffield 220kV line (flow to South) for loss of a Sheffield to Georgetown 220kV line* The Constraint Equation ID for this was changed in mid 2009 as a part of re-orienting the Tasmanian Constraint Equations to the RRN at George Town. This Constraint Equation only bound during the winter months (the normal time of high demand in Tasmania). It is expected this will bind for a similar amount in winter 2010.
V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P	498	*Out = Nil, avoid pre-contingent overloading the South Morang 500/330kV (F2) transformer, for Radial/Parallel modes and Yallourn W1 on the 500 or 220kV* It is expected that the combination of these 3 Constraint Equations will bind for a similar amount in 2010.
V::N_SMCSVxxx & V::N_SMCSQxxx	459	*Out = South Morang 330kV series capacitor, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV, Radial* There are 12 Constraint Equations that make up the transient stability export limit from Victoria and all the results have been combined. The series capacitor was out of service for a number of months after the Victorian bushfires in Feb 2009. It is expected that in 2010 many of the hours that these Constraint Equations bound for the system normal Constraint Equations would bind instead.
Q>>NIL_855_871	334	*Out = Nil, avoid overload on Calvale to Wurdong 275kV fdr 871 on trip of Calvale to Stanwell (855)* This Constraint Equation now uses a dynamically calculated rating supplied by Powerlink which ramps up and down over several dispatch intervals. This will reduce the sudden shifts in RHS value. However, it is expected to bind for a similar amount in 2010 and for the next several years until Powerlink constructs double circuit 275kV lines between Calvale and Stanwell in 2012/13.
T_TAMARCCGT_GCS	294	*Limit output of Tamar CCGT based on load available for shedding by Tamar Valley 220 kV CCGT Generation Control Scheme (GCS)* This was only introduced in August 2009 and as Tamar Valley CCGT

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		output is dependent on the GCS it is expected that this Constraint Equation will bind for many more hours in 2010.
NC_S_LKBONNY2	276	*Non Conformance Constraint for Lake Bonney 2 Windfarm* This Constraint Equation binds as a consequence of the way Lake Bonney bids (it is actually registered as a scheduled generator and not semi-scheduled) as such it is expected it will bind with similar frequency in 2010.
#NPS1_E	231	*Quick Constraint Equation applied to Northern unit 2 at various levels* Invoked at various levels for the commissioning of the Northern unit 1 control system upgrade and compliance with performance standards. As such it is expected to bind for very few, if any, intervals in 2010.
V::N_NILVxxx & V::N_NILQxxx	223	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* There are 24 Constraint Equations that make up the transient stability export limit from Victoria for both radial and parallel modes and all the results have been combined. It is expected that these constraint equations will bind for more intervals in 2010 as these Constraint Equations would have bound in many of the intervals where the South Morang series cap banks were out.
N^^V_SM_SCAP_R & N^^V_SM_SCAP_P	214	*Out = South Morang 330kV series capacitor, avoid voltage collapse for trip of the largest Vic generating unit* The series capacitor was out of service for a number of months after the Victorian bushfires in Feb 2009. These are not expected to bind for the same number of hours in 2010.
N>N-KKLS_TE_1	209	*Out= Koolkhan to Lismore (967), avoid O/L Tenterfield to Lismore (96L) on trip of Coffs Harbour to Lismore (89)* The 967 line was out for a total of 14.1 days in 2009. The 96L 132kV line is the weakest of the 3 lines to Lismore and support is usually required from the interconnector. It is expected that for future outages of this line it would bind for a reasonable portion of the outage time.
S>V_NIL_NIL_RBNW	202	*Out=Nil, avoid overloading North West Bend to Robertstown 132kV line on no line trips* It is expected this will bind for a similar amount in 2010.
N>N-NIL_LSDU	147	*Out=Nil, avoid Lismore - Dunoon 132kV line (9U6 or 9U7) O/L on trip of the other Lismore - Dunoon 132kV line (9U7 or 9U6)* It is expected this will bind for a similar amount in 2010.
N_X_MBTE_3 & N_X_MBTE_3A & N_X_MBTE_3B	140	*Out= all three Directlink cables* There are 3 constraint equations reported as it was split into 2 constraint equations in 2009. Unless there is similar number of outages of the 3 cables it is not expected these will bind for as many hours in 2010.
NC_V_APS	138	*Non Conformance Constraint for Angelsea Power Station*
N_MBTE1_B	128	*Out= one Directlink cable, Qld to NSW limit*
N^^Q_NIL_B1, 2, 3, 4, 5, 6 & N^Q_NIL_B	114	*Out= Nil, avoid Voltage Collapse on loss of the largest Queensland unit*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		This voltage collapse limit is split into 7 Constraint Equations to be able to co-optimise with each of the 6 largest units in Queensland. Overall N^^Q_NIL_B1 (which is for trip of Kogan Creek) binds for the most number of intervals. It is expected these Constraint Equations will bind for a similar amount in 2010.
S_V_NIL-300	103	*Out= Nil, limit SA to Vic to reduce time and amount exceeding 300 MW due to non-conformance or FCAS raise regulation flows* With the expected increase in the SA to Vic limit to 460 MW in 2010 it is expected this Constraint Equation will be removed and its equivalent at 460MW will not bind as much as it will be undercut by thermal limits in the south east of SA.
NSA_Q_GSTONE34_310	100	*Gladstone 3 + 4 >= 310 for Network Support Agreement*

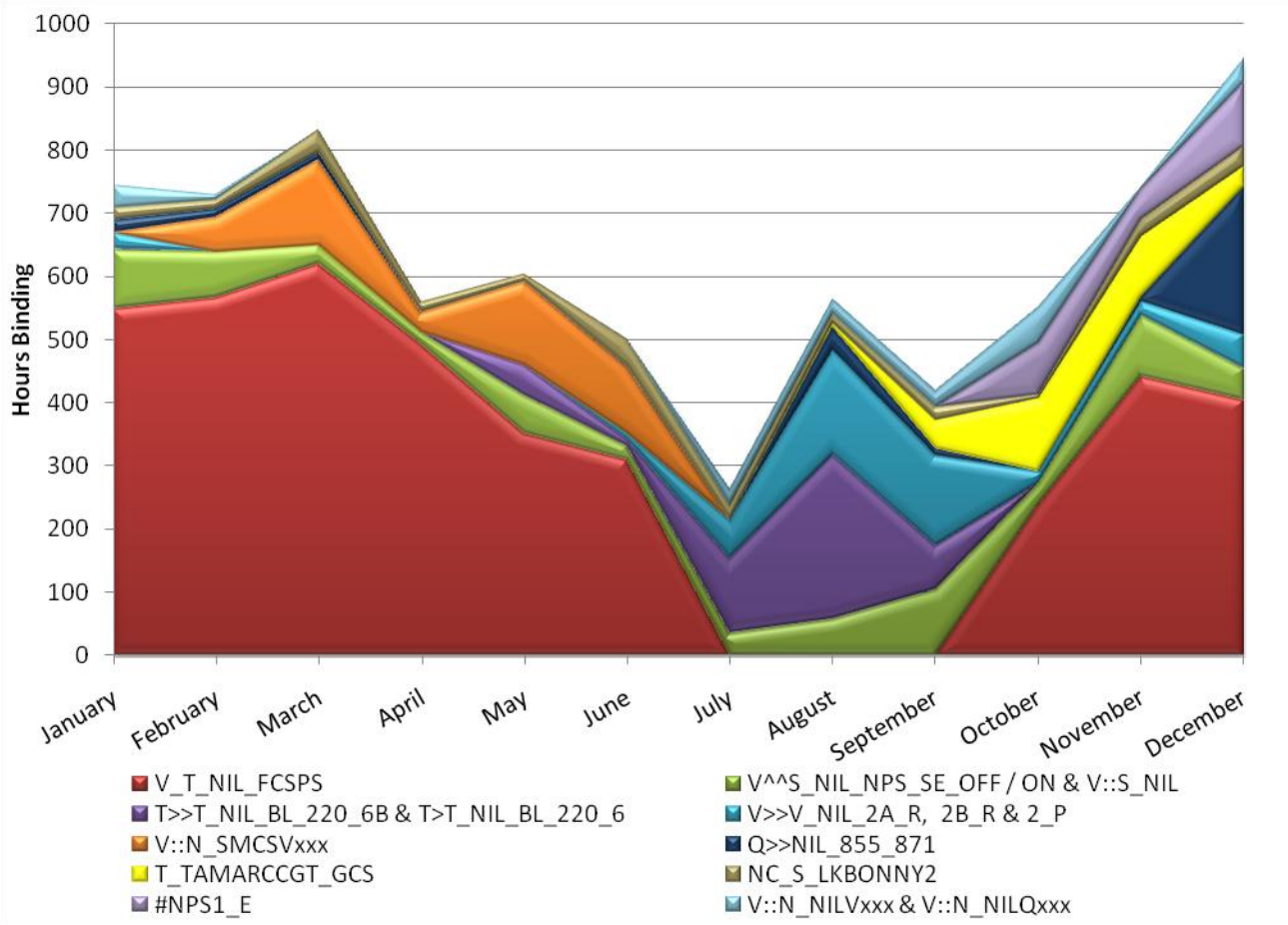


Figure 5: Top 10 Binding Constraint Equations per month

Table 4: Top 20 Binding FCAS Constraint Equations

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
F_I+NIL_MG_R6	7738	*Out = Nil, Raise 6 sec requirement for a NEM Generation Event* The largest unit is usually Kogan Creek or one of the NSW 660MW units.
F_I+NIL_MG_R5	7707	*Out = Nil, Raise 5 min requirement for a NEM Generation Event*
F_I+NIL_DYN_LREG	7535	*NEM Lower Regulation Requirement*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
F_I+NIL_MG_R60	7444	*Out = Nil, Raise 60 sec requirement for a NEM Generation Event*
F_I+ML_L5_0400 & F_I+ML_L5_0370	6099	*Out = Nil, Lower 5 min requirement for a NEM Load Event* The largest load in the NEM is at Boyne Island in Queensland. In February 2009 the value for Boyne Island was changed from 370 to 400 MW.
F_T+NIL_BL_R6 & F_T+NIL_BL_R6_1	5249	*Tasmania Raise 6 second Requirement for loss of Basslink, FCSPS available* These were changed from a single Constraint Equation into 4 Constraint Equations due to the regression analysis done as part of the 2009 Tasmanian Frequency Operating Standards change.
F_T+NIL_BL_R60 & F_T+NIL_BL_R60_1	4844	*Tasmania Raise 60 second Requirement for loss of Basslink, FCSPS available* See note for F_T+NIL_BL_R6 & F_T+NIL_BL_R6_1
F_I+ML_L6_0400 & F_I+ML_L6_0370	4714	*Out = Nil, Lower 6 sec requirement for a NEM Load Event, ML = 400* See note on F_I+ML_L5_0400
F_T+NIL_BL_R5	4530	*Tasmania Raise 5 min Requirement for loss of Basslink, FCSPS available*
F_MAIN++NIL_BL_L60	3335	*Mainland Lower 60 second Requirement for loss of Basslink, Basslink flow into Tas*
F_T+NIL_BL_L60	2024	*Tasmania Lower 60 second Requirement for loss of Basslink, FCSPS available* This Constraint Equation (and the others for trip of Basslink for export from Tasmania) was removed due to changes to the Basslink FCSPS as part of the 2009 Tasmanian Frequency Operating Standards change.
F_T+NIL_BL_L5	2010	*Tasmania Lower 5 min Requirement for loss of Basslink, FCSPS available* See note for F_T+NIL_BL_L60
F_T+NIL_BL_L6	1806	*Tasmania Lower 6 second Requirement for loss of Basslink FCSPS available* See note for F_T+NIL_BL_L60
F_MAIN++ML_L5_0400	1517	*Out = Nil, Lower 5 min requirement for a Mainland Load Event, ML = 400, Basslink able transfer FCAS*
F_I+NIL_DYN_RREG	1397	*NEM Raise Regulation Requirement*
F_T++NIL_TL_L60	1137	*Out=Nil, Tasmania Lower 60 sec requirement for loss of 2 Comalco potlines, Basslink able to transfer FCAS*
F_I+ML_L60_0400 & F_I+ML_L60_0370	1110	*Out = Nil, Lower 60 sec requirement for a NEM Load Event, ML = 400* See note on F_I+ML_L5_0400
F_T++NIL_TL_L5	819	*Out=Nil, Tasmania Lower 5 min requirement for loss of 2 Comalco potlines, Basslink able to transfer FCAS*
F_MAIN++NIL_MG_R60	789	*Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS*
F_T++RREG_0050	742	*Tasmania Raise Regulation Requirement greater than 50 MW, Basslink able transfer FCAS*

6.2 Violating Constraint Equations

A Constraint Equation is violating when NEMDE is unable to dispatch the entities on the LHS so they are less than or greater than the RHS (depending on the mathematical operator selected for the Constraint Equation). Many of the violating hours in the table below were due to the hot weather in January 2009 and the Victorian bushfires in February 2009.

Table 5: Top 20 Violating Constraint Equations

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
S>NIL_DVPF_WYCL	10.67	*Out = Nil; avoid OL Whyalla Terminal to Cultana 132 kV line on trip Playford - Davenport 275 kV line.* The issues around the violation of this Constraint Equation were covered in an incident report[4] published in 2009. In summary this was due to increased non-scheduled wind farm generation at Mt Millar and Cathedral Rocks and Playford B not following dispatch targets. This Constraint Equation was removed from the SA system normal Constraint Set in late 2009 as part of the relocation of the Playford 132kV bus to Davenport (which is expected to be completed in mid 2010).
V>SML_NIL_8	9.58	*Out = Nil, avoid overloading Ballarat to Bendigo 220 kV line for loss of Shepparton to Bendigo 220 kV line* This only violated during the high demand days in Victoria in late January and early February 2009[5].
#NPS2_P_E	5.75	*Quick Constraint Equation applied to Northern unit 2 at various levels* This was a direction on Northern unit 2 during the very hot weather on the 30th January 2009.
NC_S_LKBONNY2	5.08	*Non Conformance Constraint for Lake Bonney 2 Windfarm*
Q>CLBCN_RUNBACK_OFF	3.75	*Out= Ergon Runback Scheme, Ergon limit on T13 Chinchilla to T194 Columboola 132kV lines, Ergon Run Back Scheme off.* This Constraint Equation violated due to SCADA issues in the Ergon system that have since been resolved. Additionally the runback scheme was commissioned in late 2009.
V>>SML_NIL_1	3.42	*Out = Nil, avoid overloading Ballarat to Moorabool No.1 220 kV line for loss of Ballarat to Moorabool No.2 220 kV line* This only violated during the high demand days in Victoria in late January and early February 2009[5].
S_HL2WF_CONF	2.92	*Out= Nil; Limit Hallett 2 WF generation based on DVAR availability.* This Constraint Equation violated for a number of intervals in June 2009 which resulted in an incident report[6]. It has also violated a number of times since, but only for a few intervals and infrequently.
V>>SML_NIL_4	2.75	*Out = Nil, avoid overloading Ballarat to Moorabool No.2 220 kV line for loss of Ballarat to Moorabool No.1 220 kV line* This only violated during the high demand days in Victoria in late January and early February 2009[5].

[4] http://www.aemo.com.au/reports/232-0132.html
[5] http://www.aemo.com.au/reports/232-0127.html, http://www.aemo.com.au/reports/232-0128.html, http://www.aemo.com.au/reports/232-0129.html, http://www.aemo.com.au/reports/232-0130.html
[6] http://www.aemo.com.au/reports/0232-0011.html

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
T_TAMARCCGT_GCS	2.25	*Limit output of Tamar CCGT based on load available for shedding by Tamar Valley 220 kV CCGT Generation Control Scheme (GCS)* This Constraint Equation violated for a number of events in the second half of 2009 and the reason is typically for rapid changes in the load blocks armed for the GCS. It is worth noting that this Constraint Equation is binding very frequently.
V>V_NIL_4	1.83	*Out = Nil, limit Hazelwood units 3,4,5 to avoid overload on Hazelwood 500/220kV No.1 transformer, Hazelwood in radial mode.* This only violated during the high demand days in Victoria in late January 2009[5].
V::V_1900	1.83	*Out=Nil, upper limit into Vic of 1900 MW* This only violated during the high demand days in Victoria in late January 2009[5].
NC_N_CG1	1.83	*Non Conformance Constraint for Colongra 1 Power Station*
NC_V_BDL02	1.75	*Non Conformance Constraint for Bairnsdale 2 Power Station*
T^T_NIL_BL_5_DS	1.58	*Out = Nil, Palmerston 110kV bus not split, avoid voltage instability for loss of a Liapootah to Cluny Tee to Chapel St 220 kV line* This Constraint Equation violated for a number of different events and the main reason for the violation was fast load increases and the cap bank switching not keeping up.
#V-S-MNSP1_I_E	1.50	*Quick Constraint Equation applied to Murraylink at various levels* This violated during the Victorian bushfires in February 2009[5].
F_T+NIL_BL_R6_1	1.42	*Tasmania Raise 6 second Requirement for loss of Basslink, Segment 1, FCSPS available* F_T+NIL_BL_R6_1 violated for a number of intervals on 3 November and 31 December. In both cases this was co-incident with a reclassification of the loss of both Chapel St – Gordon 220kV lines as credible. For this reclassification Gordon is unable to supply R6 as it will be disconnected on the contingency. AEMO is investigating ways that Gordon can supply the Basslink trip requirement but not for the loss of Gordon FCAS requirement.
NSA_V_BDL02_20	1.42	*Bairnsdale Unit 2 >= 20 MW for Network Support Agreement*
T>T_NIL_POAT220	1.42	*Out = Nil, avoid overloading a Poatina to Palmerston 220 kV line* This Constraint Equation violating during the very hot weather in Tasmania in late January 2009.
Q_RS_230	1.33	*Upper limit on Ross cut set of 230MW* This Constraint Equation violated during the North Qld black system in January 2009[7] and during an unplanned outage of the Strathmore – Ross 275kV line. In both cases the violations were due to units being limited by their ramp rates or fast start profiles.
N>N-NIL_TE_E2	1.33	*Out= Nil, avoid Koolkhan to Lismore (967) O/L on Coffs Harbour - Lismore (89) trip*

[7] http://www.aemo.com.au/reports/232-0123.html

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		The violations on this Constraint Equation occurred in December 2009 and it has been subsequently modified and will not violate under similar conditions again.

7 Constraint Equations setting Interconnector Limits

This section details the binding Constraint Equations that most often set the Interconnector Limits. The binding hours indicated in the tables may differ from the hours indicated in the previous section. Only 1 Constraint Equation can set an Import or Export Limit for an Interconnector and the following results link the binding Constraint Equation results with the Constraint Equation setting the Import/Export limit in the Interconnector result tables. Where two (or more) Constraint Equations with the same Interconnector on the LHS can set the Interconnector limit, AEMO's market systems software chooses the Constraint Equation based on the following priority order: Single interconnector on the LHS, multiple Interconnectors and generators (energy) on the LHS and multiple Interconnectors, FCAS requirements and generators (FCAS) on the LHS.

The graphs in this section show the binding hours per month for each direction on each Interconnector. The results exclude the Outage Ramping Constraint Equations. The export binding hours are indicated as positive numbers and import with negative values. Each month is further categorized into 5 types:

- System Normal
- Outage
- FCAS: This includes all Constraint Equations that start with "F" even those which are in the FCAS system normal set
- Constraint Automation: All the Constraint Equations created by the Constraint Automation application
- Quick: Constraint Equations created by AEMO's control room staff. These all start with "#" and exclude the Outage Ramping Constraint Equations.

So for example in Figure 6 it can be seen that during the winter months the Terranora Interconnector is mainly limited by outage Constraint Equations and system normal in summer. However, Basslink (Figure 8) is mainly limited by system normal Constraint Equations and some FCAS, except in July to September where import into Tasmania is limited by FCAS.

7.1 Terranora Interconnector (N-Q-MNSP1)

The Terranora Interconnector comprises the two 110kV lines from Terranora in NSW to Mudgeeraba in Queensland. However, the controllable element is a 180 MW DC link between Terranora and Mullumbimby known as Directlink, which consists of 3 separate DC lines. Normally flows on this interconnector are into NSW and so both the import and export values are negative (unlike the other interconnectors in the NEM). Normally it is constrained by thermal limits in northern NSW or rate of change. However, since it can appear on the LHS with QNI it can be constrained in conjunction with QNI.

A number of the thermal Constraint Equations (e.g. N>N-KKLS_TE_1 and N>N-GITN_TE_C1) would be relieved with Transgrid's constructing the Dumaresq to Lismore 330kV line in 2012[8].

[8] http://www.transgrid.com.au/projects/projects/dumaresq_lismore/Pages/default.aspx

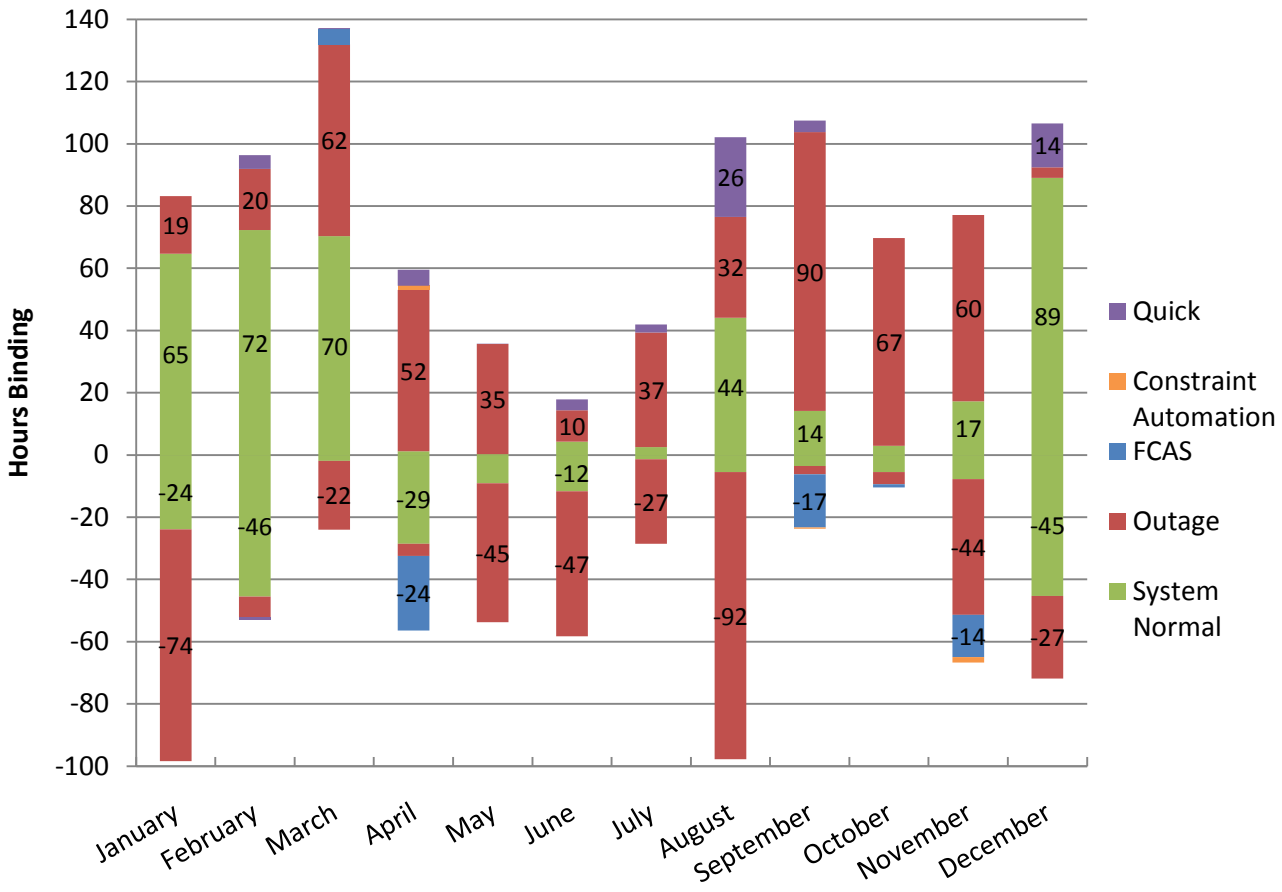


Figure 6: Categorized Binding Intervals per month for N-Q-MNSP1

Table 6: Binding Constraint Equations setting the NSW to Qld limit on N-Q-MNSP1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
N>N-KKLS_TE_1	207.0	*Out= Koolkhan to Lismore (967), avoid O/L Tenterfield to Lismore (96L) on trip of Coffs Harbour to Lismore (89)* See Table 3 for comments
Q>>NIL_855_871	174.4	*Out = Nil, avoid overload on Calvale to Wurdong 275kV fdr 871 on trip of Calvale to Stanwell (855)* See Table 3 for comments. Additionally a study in December 2009 with the latest network model determined that the factor of N-Q-MNSP1 had become too small to appear on the LHS. As such this Constraint Equation will no longer bind for N-Q-MNSP1
N_X_MBTE_3 & N_X_MBTE_3A	114.8	*Out= all three Directlink cables* See Table 3 for comments. Also the binding hours are very different from the previous section as the original Constraint Equation "N_X_MBTE_3" had a mathematical operator of "=" and could set both the Import and Export limits.
N>N-NIL_LSDU	96.3	*Out=nil, Avoid Lismore - Dunoon 132kV line (9U6 or 9U7) O/L on trip of the other Lismore - Dunoon 132kV line (9U7 or 9U6), Feedback* See Table 3 for comments
N^^Q_NIL_B1, 2, 3, 4, 5, 6 & N^Q_NIL_B	64.1	*Out= Nil, avoid Voltage Collapse on loss of the largest Queensland unit*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		See Table 3 for comments
#N-Q-MNSP1_I_E	33.8	*Quick Constraint Equation applied to Terranora at various levels* This Quick Constraint Equation was invoked a number of times during 2009 to manage power system security or dispatch oscillations.
NQTE_ROC	22.2	*Out=Nil, Rate of Change (NSW to Qld) constraint (80 MW / 5 Min) for Terranora Interconnector*
N>N-GITN_TE_C1	18.1	*Out= Glen Innes to Tenterfield (96R), avoid O/L Koolkhan to Lismore (967) on trip of Coffs Harbour to Lismore (89)*
N^N-967_LS_SVC	16.3	*Out= Koolkhan to Lismore (967) and Lismore SVC, avoid Voltage collapse on Coffs Harbour to Lismore (89) trip*
N>N-CHLS_TE_A1	15.1	*Out= Coffs Harbour to Lismore (89), avoid O/L Tenterfield to Lismore (96L) on trip of Koolkhan to Lismore (967)*

Table 7: Binding Constraint Equations setting the Qld to NSW limit on N-Q-MNSP1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
N_MBTE1_B	125.1	*Out= one Directlink cable*
N>>N-MNMP_ONE_1	73.7	*Out= Mt Piper to Marulan (35 or 36 line), avoid Mt Piper to Wallerawang (70) O/L on Mt Piper to Wallerawang (71) trip* Both 35 and 36 lines were out for a long period (see Table 18) due to the NSW 500kV.
N_X_MBTE2_B	70.4	*Out= two Directlink cables*
N>N-NIL_MBDU	60.0	*Out=Nil, avoid Mullumbimby - Dunoon 132kV line (9U6 or 9U7) O/L on trip of the other Mullumbimby - Dunoon 132kV line (9U7 or 9U6)*
N>>N-NIL_DF_DS	43.1	*Out= Nil, avoid Armidale - Kempsey (965) OL on Coffs Harbour - Nambucca (9W3) trip* This Constraint Equation was removed from the NSW system normal in February 2009 with the commissioning of the Armidale Phase Shifting Transformer.
N>>N-NIL__S	36.3	*Out= Nil, avoid Mt Piper to Wallerawang (70) O/L on Mt Piper to Wallerawang (71) trip* This Constraint Equation bound heavily in late 2009 due to the outage of a Wallerawang unit. It was only introduced in August 2009 with the commissioning of 70 line and it replaced N>>N-NIL__E.
N_X_MBTE_3 & N_X_MBTE_3B	20.6	*Out= all three Directlink cables* See Table 3 for comments. Also the binding hours are very different from the previous section as the original Constraint Equation “N_X_MBTE_3” had a mathematical operator of “=” and could set both the Import and Export limits.
F_Q++LDMU_L6	20.3	*Out = Liddell to Muswellbrook (83) line, Qld Lower 6 sec Requirement*
Q_CS_1100	18.8	*Qld Central to Qld South upper transfer limit of 1100MW (discretionary)* This appears as it is in the Constraint Set for the reclassification for loss of both Calvale to Tarong 275kV lines, Q-CLTR_N-2. These lines were reclassified over 50 times in 2009.
QNTE_ROC	17.8	*Out=Nil, Rate of Change (Qld to NSW) constraint (80 MW / 5 Min) for*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		Terranora Interconnector

7.2 Qld to NSW Interconnector (NSW1-QLD1)

The Queensland to NSW (QNI) interconnector is the AC interconnection between Dumaresq in NSW and Bulli Creek in Queensland. It was constructed in the early years of the NEM as a pair of 330kV lines between Armidale and Braemar and a pair of 275kV lines between Braemar and Tarong. The flow is normally from Qld into NSW, but at times of high demand in NSW the flow may reverse. Due to the close electrical proximity on the NSW side it normally appears on the LHS of Constraint Equations with Directlink.

Transfer from NSW to Qld is mainly limited by the system normal Constraint Equations for thermal limits on 871 in Qld and 86 line in NSW as well as the voltage collapse on loss of the largest Queensland unit (this is dependent on Kogan Creek generation).

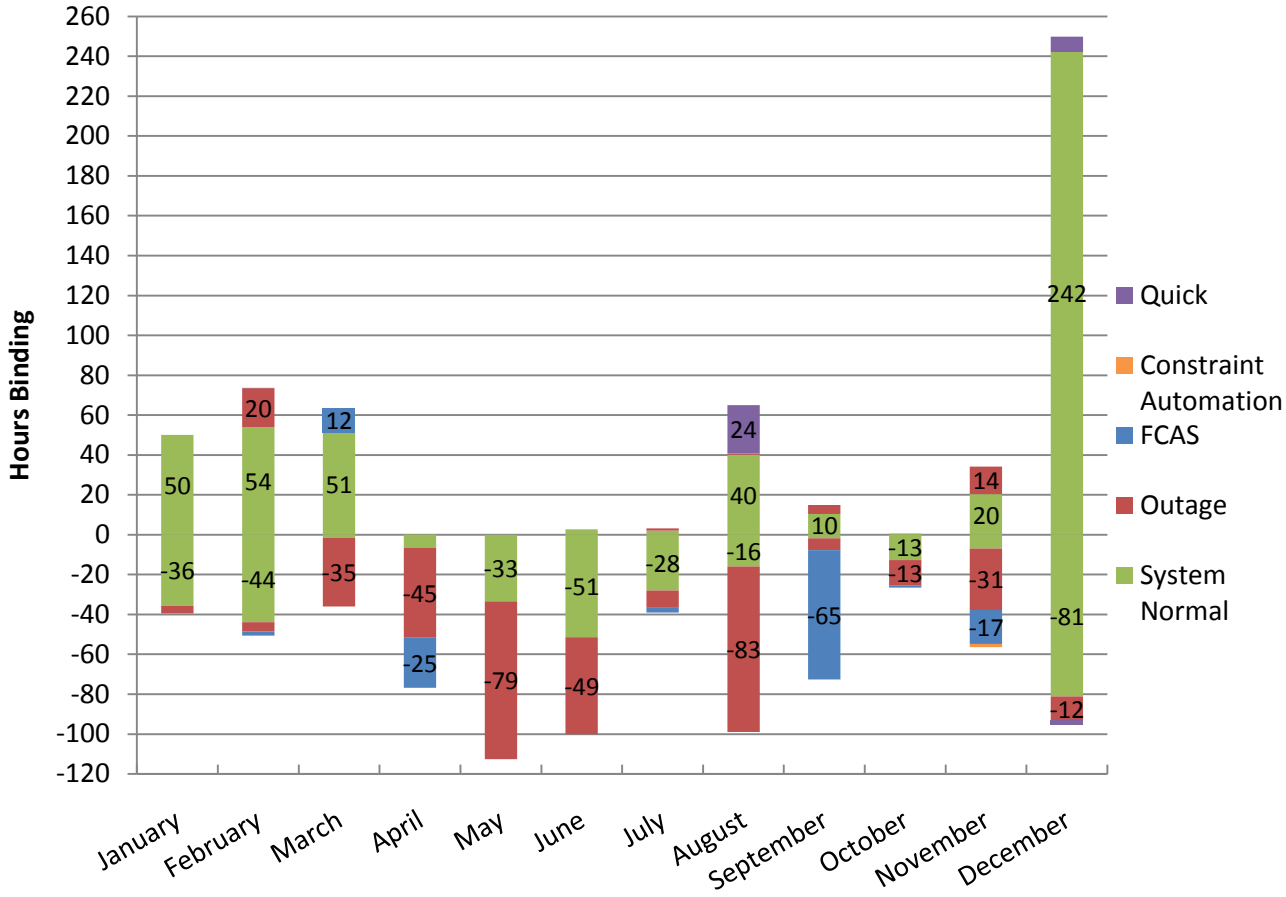


Figure 7: Categorized Binding Intervals per month for NSW1-QLD1

Table 8: Binding Constraint Equations setting the NSW to Qld limit on NSW1-QLD1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
Q>>NIL_855_871	327.3	*Out = Nil, avoid overload on Calvale to Wurdong 275kV fdr 871 on trip of Calvale to Stanwell (855)* See Table 3 for comments
N^^Q_NIL_B1, 2, 3, 4, 5, 6 & N^Q_NIL_B	109.2	*Out= Nil, avoid Voltage Collapse on loss of the largest Queensland unit* See Table 3 for comments

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
N^^Q_AR_VC_B1, 2, 3, 4, 5, 6 & N^Q_AR_VCB	17.7	*Out= Armidale SVC, avoid Voltage Collapse on loss of the largest Queensland unit* Similar to N^^Q_NIL_Bx the results of the 7 Constraint Equations have been combined. If the Armidale SVC is out and NSW is transferring into Qld it is expected that this Constraint Equation would bind.
N>N-NIL_F7_15M	16.8	*Out=Nil, avoid O/L (15 min rating) of Tamworth to Armidale (86) on trip of other Tamworth to Armidale (85) line*
#QLD1_E_20090819	10.4	*Quick Constraint Equation for multiple LHS terms in Queensland* This Quick Constraint Equation was created to manage negative residues between NSW and Qld.
N>>N-NIL_1A	9.4	*Out=Nil, avoid Bayswater to Liddell (33 or 34) O/L on loss of other Bayswater to Liddell (34 or 33)*
N::Q_NIL_Bx & N:Q_NIL_Bx	7.3	*Out= Nil, NSW to Qld Transient Stability Limit for Fault on Liddell to Newcastle (81) or Liddell to Tomago (82) lines* There are 9 Constraint Equations that make up the transient stability export limit from NSW to Qld and all the results have been combined.
Q>>BCGL1_BCGL2_CLWU	7.1	*Out= Bouldercombe to Gladstone (812 or 811) avoid O/L Calvale to Wurdong (871) on trip of Bouldercombe to Gladstone (811 or 812)* This bound due to either of these lines being out for over 20 days in 2009 (see Table 18).
N::Q_ARTW_Bx & N:Q_ARTW_Bx	6.8	*Out = Armidale to Tamworth (85 or 86), NSW to Qld Transient Stability Limit for Fault on Liddell to Newcastle (81) or Liddell to Tomago (82) lines* Similarly to N::Q_NIL_Bx the results of the 7 Constraint Equations have been combined.
#QLD1_E_20091208	5.8	*Quick Constraint Equation for multiple LHS terms in Queensland* This Quick Constraint Equation was created to manage negative residue between NSW and Qld.

Table 9: Binding Constraint Equations setting the Qld to NSW limit on NSW1-QLD1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V::N_SMCSVxxx & V::N_SMCSQxxx	108.6	*Out = South Morang 330kV series capacitor, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV, Radial* See Table 3 for comments
V::N_NILVxxx & V::N_NILQxxx	79.7	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* See Table 3 for comments
N>>N-MNMP_ONE_1	76.4	*Out= Mt Piper to Marulan (35 or 36 line), avoid Mt Piper to Wallerawang (70) O/L on Mt Piper to Wallerawang (71) trip* See Table 7 for comments
Q:N_NIL_BCK2L-G	72.8	*Out=Nil, avoid transient instability on 2L-G fault at Bulli Creek*
F_Q++ARDM_L6	47.8	*Out = one Armidale to Bulli Creek (8C, 8E, 8L or 8M) line, Qld Lower 6 sec Requirement*
N>>N-NIL_DF_DS	42.2	*Out= Nil, avoid Armidale - Kempsey (965) OL on Coffs Harbour - Nambucca (9W3) trip* See Table 7 for comments

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
Q:N_NIL_BI_POT	37.8	*Out=Nil, avoid transient instability on trip of a Boyne Island potline (400 MW)*
N>>N-NIL__S	35.9	*Out= Nil, avoid Mt Piper to Wallerawang (70) O/L on Mt Piper to Wallerawang (71) trip* See Table 7 for comments
Q:N_DM_CB	27.8	*Out = one Dumaresq 330kV CB O/S, avoid transient instability for a fault on either the Armidale to Dumaresq (8C or 8E) or Bulli Creek to Dumaresq (8L or 8M) 330kV lines* This Constraint Equation will restrict flow from Qld to NSW to either 666 or 526 MW depending on the number of Millmerran units in service. It is expected that before the next planned outage of these CBs the limit advice will be revised (as the advice dates back to 2004).
F_Q++LDMU_L6	19.9	*Out = Liddell to Muswellbrook (83) line, Qld Lower 6 sec Requirement*

7.3 Basslink (T-V-MNSP1)

Basslink is a DC interconnection between George Town in Tasmania and Loy Yang in Victoria. Unlike the other DC lines in the NEM, Basslink has a frequency controller and is able to transfer FCAS. Basslink is mainly limited by FCAS or the FCSPS Constraint Equations.

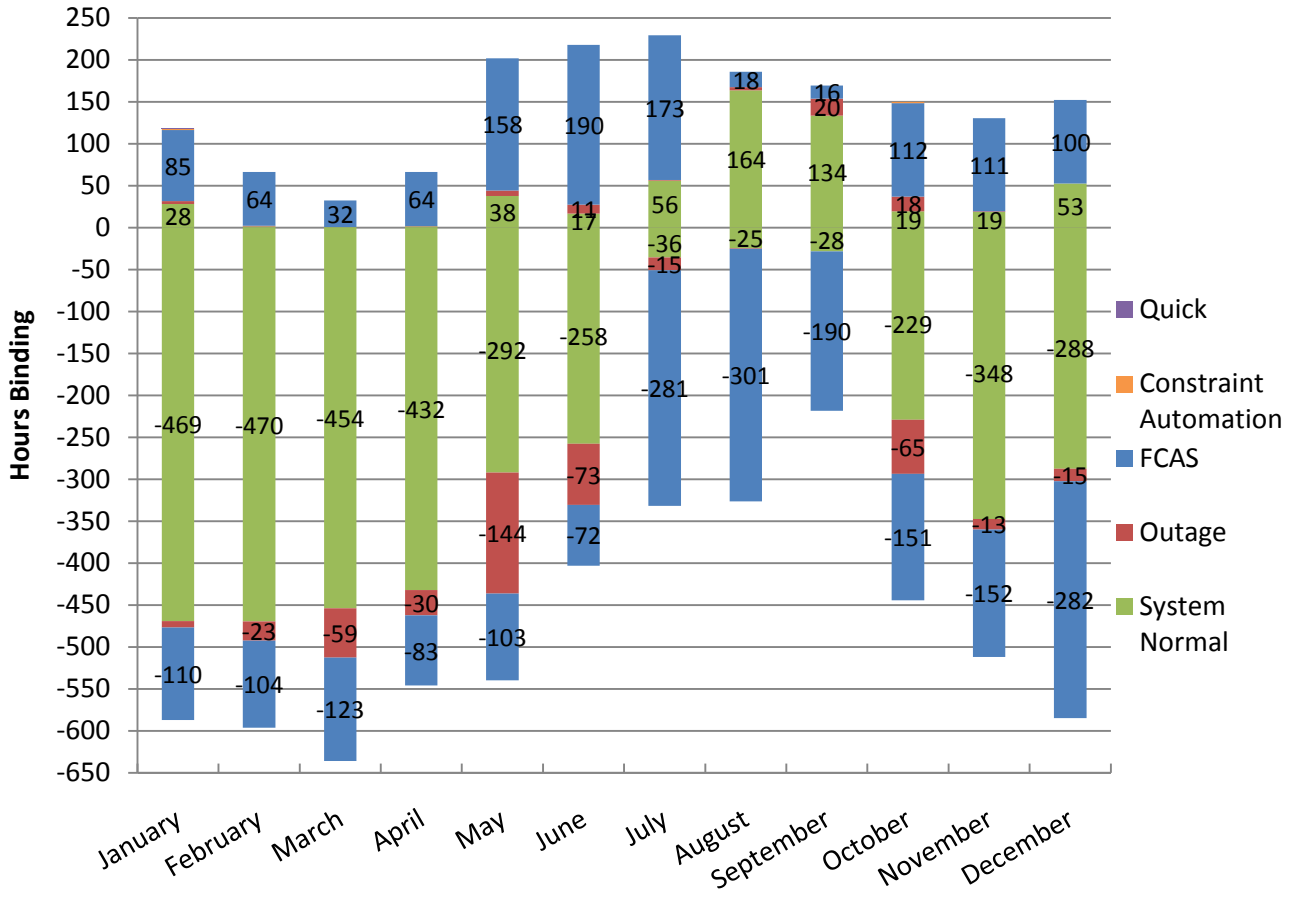


Figure 8: Categorized Binding Intervals per month for T-V-MNSP1

Table 10: Binding Constraint Equations setting the Tas to Vic limit on T-V-MNSP1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P	460.3	*Out = Nil, avoid pre-contingent overloading the South Morang 500/330kV (F2) transformer, for Radial/Parallel modes and Yallourn W1 on the 500 or 220kV* See Table 3 for comments
F_T++NIL_TL_L60	304.7	*Out=Nil, Tasmania Lower 60 sec requirement for loss of 2 Comalco potlines, Basslink able to transfer FCAS*
F_MAIN++NIL_MG_R5	194.5	*Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS*
F_T++NIL_TL_L5	193.3	*Out=Nil, Tasmania Lower 5 min requirement for loss of 2 Comalco potlines, Basslink able to transfer FCAS*
F_MAIN++NIL_MG_R60	174.8	*Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS*
F_MAIN++NIL_MG_R6	130.8	*Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS*
F_T++NIL_TL_L6	54.0	*Out=Nil, Tasmania Lower 6 sec requirement for loss of 2 Comalco potlines, Basslink able to transfer FCAS*
F_T++NIL_ML_L6	51.0	*Out = Nil, Lower 6 sec requirement for a Tasmania Load Event, Basslink able to transfer FCAS*
T>>T_NIL_BL_220_6B	41.3	*Out = Nil, avoid overloading the Palmerston to Sheffield 220kV line (flow to South) for loss of a Sheffield to Georgetown 220kV line* See Table 3 for comments. With the re-orientation of this Constraint Equation Basslink no longer appears on the LHS so it will no longer appear as a limit setter for Basslink.
T>>T_GTSH_220_1	17.4	*Out = Georgetown to Sheffield 220kV line, avoid O/L the Sheffield to Palmerston line for loss of the other Georgetown to Sheffield line* This Constraint Equation was re-orientated to George Town in October 2009 so Basslink no longer appears on the LHS.

Table 11: Binding Constraint Equations setting the Vic to Tas limit on T-V-MNSP1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V_T_NIL_FCSPS	3136.3	*Basslink limit from Vic to Tas for load enabled for FCSPS* See Table 3 for comments.
F_MAIN++ML_L5_0400	640.3	*Out = Nil, Lower 5 min requirement for a Mainland Load Event, ML = 400, Basslink able transfer FCAS*
F_MAIN++NIL_BL_L60	511.9	*Mainland Lower 60 second Requirement for loss of Basslink, Basslink flow into Tas*
V::N_SMCSVxxx & V::N_SMCSQxxx	236.6	*Out = South Morang 330kV series capacitor, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV, Radial* See Table 3 for comments.
V::N_NILVxxx & V::N_NILQxxx	135.2	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* See Table 3 for comments.

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
F_MAIN++APHY_L5	111.7	*Out=Heywood to Alcoa Portland 500kV line, Lower 5 min Service Requirement for the loss of the remaining 500kV line, Basslink able to transfer FCAS*
F_T++NIL_MG_R5	83.5	*Out = Nil, Raise 5 min requirement for a Tasmania Generation Event, Basslink able to transfer FCAS*
F_MAIN++ML_L60_0400	75.4	*Out = Nil, Lower 60 sec requirement for a Mainland Load Event, ML = 400, Basslink able transfer FCAS*
F_QNV++HYML_L5	71.8	*Out = one Heywood to Moorabool (HYTS-MLTS) line or one Moorabool to Sydenham (MLTS-SYTS) line Qld, NSW and Vic Lower 5 min Requirement, Basslink able to transfer FCAS*
F_QNV++HYML_L60	51.2	*Out = one Heywood to Moorabool (HYTS-MLTS) line or one Moorabool to Sydenham (MLTS-SYTS) line Qld, NSW and Vic Lower 60 sec Requirement, Basslink able to transfer FCAS*

7.4 Victoria to NSW (VIC1-NSW1)

The Victoria to NSW interconnector comprises the 330kV lines between Murray and Upper Tumut (65), Murray and Lower Tumut (66), Jindera and Wodonga (060) 330kV lines and the 220kV line between Buronga and Red Cliffs (0X1). This interconnector was formed on 1 July 2008 as a part of the Snowy abolition and replaced the previous “SNOWY1” and “V-SN” interconnectors. Many of the existing stability limits are still defined for these interconnectors and AEMO has translated these to work with the “new” interconnector.

VIC1-NSW1 can bind in either direction for high demand in NSW or Victoria. The binding results in 2009 were heavily influenced by the hot weather and bushfires in Victoria in January and February.

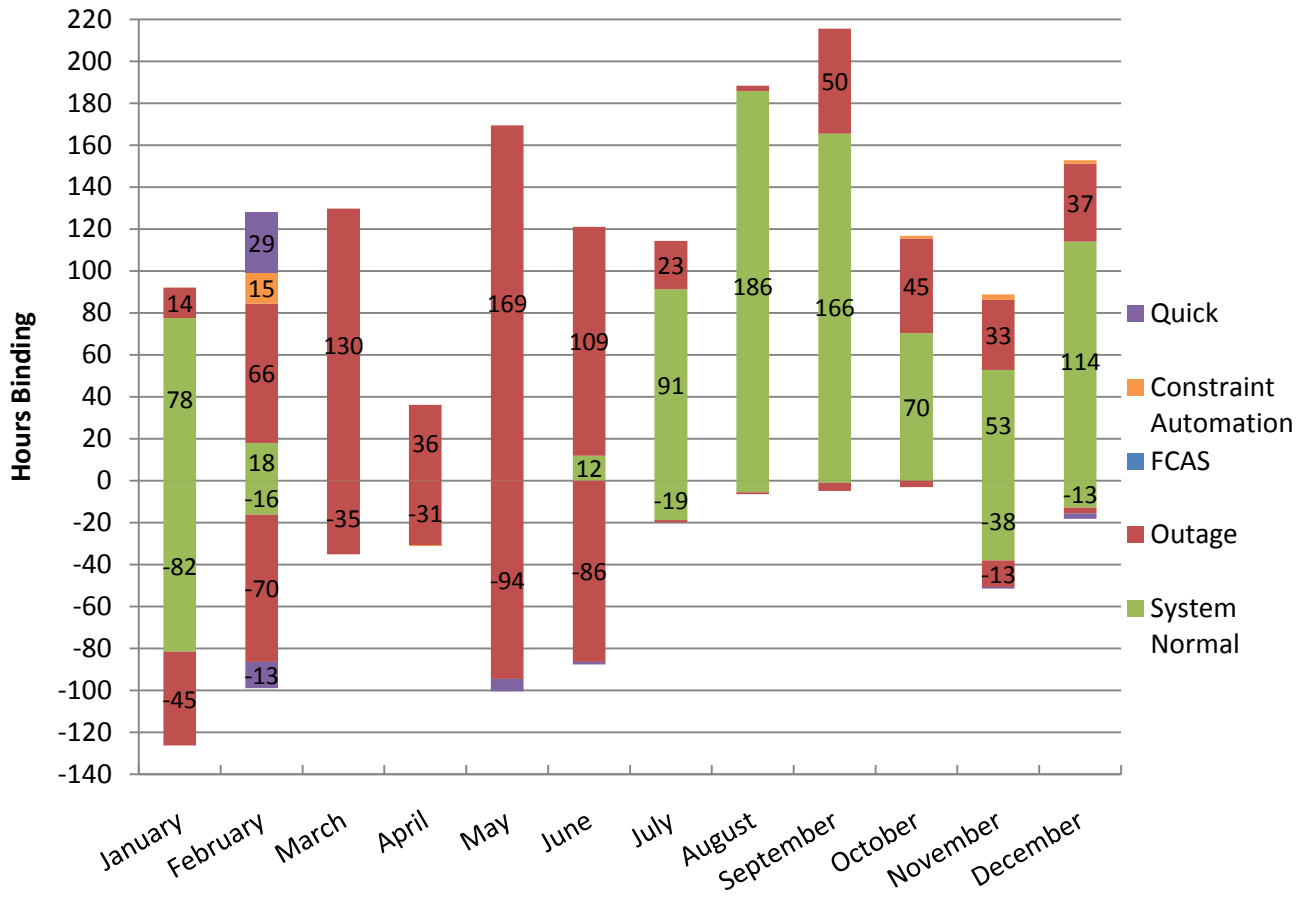


Figure 9: Categorized Binding Intervals per month for VIC1-NSW1

Table 12: Binding Constraint Equations setting the Vic to NSW limit on VIC1-NSW1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P	480.4	*Out = Nil, avoid pre-contingent overloading the South Morang 500/330kV (F2) transformer, for Radial/Parallel modes and Yallourn W1 on the 500 or 220kV* See Table 3 for comments.
V::N_SMCSVxxx & V::N_SMCSQxxx	412.0	*Out = South Morang 330kV series capacitor, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV, Radial* See Table 3 for comments.
V::N_NILVxxx & V::N_NILQxxx	204.9	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* See Table 3 for comments.
V::N_MSUTxxx	54.6	*Out = Upper Tumut to Murray 330kV line, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line* There are 12 Constraint Equations that make up the transient stability export limit from Victoria for this outage and all the results have been combined.
V::N_HWSMxxx	54.0	*Out = Hazelwood to South Morang 500 kV line, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line* There are 12 Constraint Equations that make up the transient stability export limit from Victoria for this outage and all the results have been combined.

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V>>N-NIL_HA	34.2	*Out= Nil, avoid Murray to Upper Tumut (65) O/L on Murray - Lower Tumut (66) trip*
#VIC1-NSW1_I_E	28.8	*Quick Constraint Equation applied to VIC1-NSW1 at various levels* This quick Constraint Equation was invoked during the multiple line outages following the Victorian bushfires in February 2009. It was in place to manage power system security[5].
N>>N-NIL__S	28.3	*Out= Nil, avoid Mt Piper to Wallerawang (70) O/L on Mt Piper to Wallerawang (71) trip* See Table 7 for comments
V::V_DDSM	23.5	*Out = Dederang to South Morang 330kV line, avoid transient instability for fault and trip of a Dederang to South Morang 330kV line*
V>>N_SMTXF2A	16.3	*Out = South Morang 500/330kV (F2) transformer, avoid overload of South Morang H2 transformer for trip of the H1 transformer*

Table 13: Binding Constraint Equations setting the NSW to Vic limit on VIC1-NSW1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
N^^V_SM_SCAP_R & N^^V_SM_SCAP_P	210.1	*Out = South Morang 330kV series capacitor, avoid voltage collapse for trip of the largest Vic generating unit* See Table 3 for comments.
N^^V_NIL_1	62.7	*Out = Nil, limit NSW to VIC, VIC and NSW generation to avoid voltage collapse for loss of the largest Vic generating unit*
N>>V-NIL_O	51.5	*Out= Nil, avoid Upper Tumut to Murray (65) O/L on Lower Tumut-Wagga (051) + 970,990,99M (out of Yass) line trips* This Constraint Equation models a control scheme for the 132kV lines between Wagga and Yass. These 132kV lines are successively tripped if they overload on trip of 051 line. The Wagga 132 to Yass (990) 132kV line has been out since May 2008 and will be until mid 2011 and this increases the likelihood of this scheme operating so it is expected to bind with a similar frequency in 2011 (unless Wagga to Yass 132kV is radicalised under high import into NSW from Victoria).
N^^V_LTUT	31.0	*Out = Lower Tumut to Upper Tumut 330kV line, avoid voltage collapse for trip of the largest Vic generating unit*
N>>V_SMSCP	27.3	*Out = South Morang 330kV series capacitor, avoid overloading Dederang No.1 330/220kV transformer for loss of Dederang No.2 or No.3 330/220kV transformer* The series capacitor was out of service for a number of months after the Victorian bushfires in Feb 2009[5].
N::V_KC_VC2	26.3	*Out= both Kemps Creek SVCs, NSW to Snowy Transient Limit*
N^^V_X_DDSM_TWO	18.7	*Out = Both Dederang to South Morang 330kV lines, avoid voltage collapse for loss of the largest Vic generating unit* This Constraint Equation was invoked following the Victorian bushfires in February 2009[5].
N::V_MSUT	14.1	*Out= Murray - Upper Tumut (65) line, NSW to Snowy Transient Limit*
#VIC1_E_20090209	12.6	*Quick Constraint Equation for multiple LHS terms in Victoria* This quick Constraint Equation was invoked during the multiple line outages following the Victorian bushfires in February 2009[5]. It was in place to manage power system security.
V>>V_NIL_1B	12.4	*Out = Nil, avoid overloading Dederang to Murray No.2 330kV line for loss of the parallel No.1 line, 15 min line ratings*

7.5 Heywood Interconnector (V-SA)

The Vic – SA (or Heywood) interconnector is an AC interconnector between Heywood in Victoria and South East in South Australia. It was originally constructed in the late 1980s as a connection from the western 500kV in Victoria to the nearest 275kV substation in South Australia, Para. It also has a number of connections to the 132kV network in south eastern SA. Up until recently the vast majority of the time it flowed from Victoria to SA. With an increasing number of wind farms in SA the flow now often is from SA to Victoria.

Victoria to SA flow is most often restricted by the voltage collapse limit in south east SA. V-SA appears in many of the Victorian Constraint Equations and these can limit both directions of flow on this interconnector. Export from SA is also restricted by the thermal limits on the South East substation 275/132kV transformers as well as the current upper limit of 300 MW. It is expected that this limit of 300 MW will be raised to 460 MW in early 2010. When this occurs other thermal limits in the 132kV network in the south east which would normally be above the 300 MW limit will start to limit SA to Victoria flows.

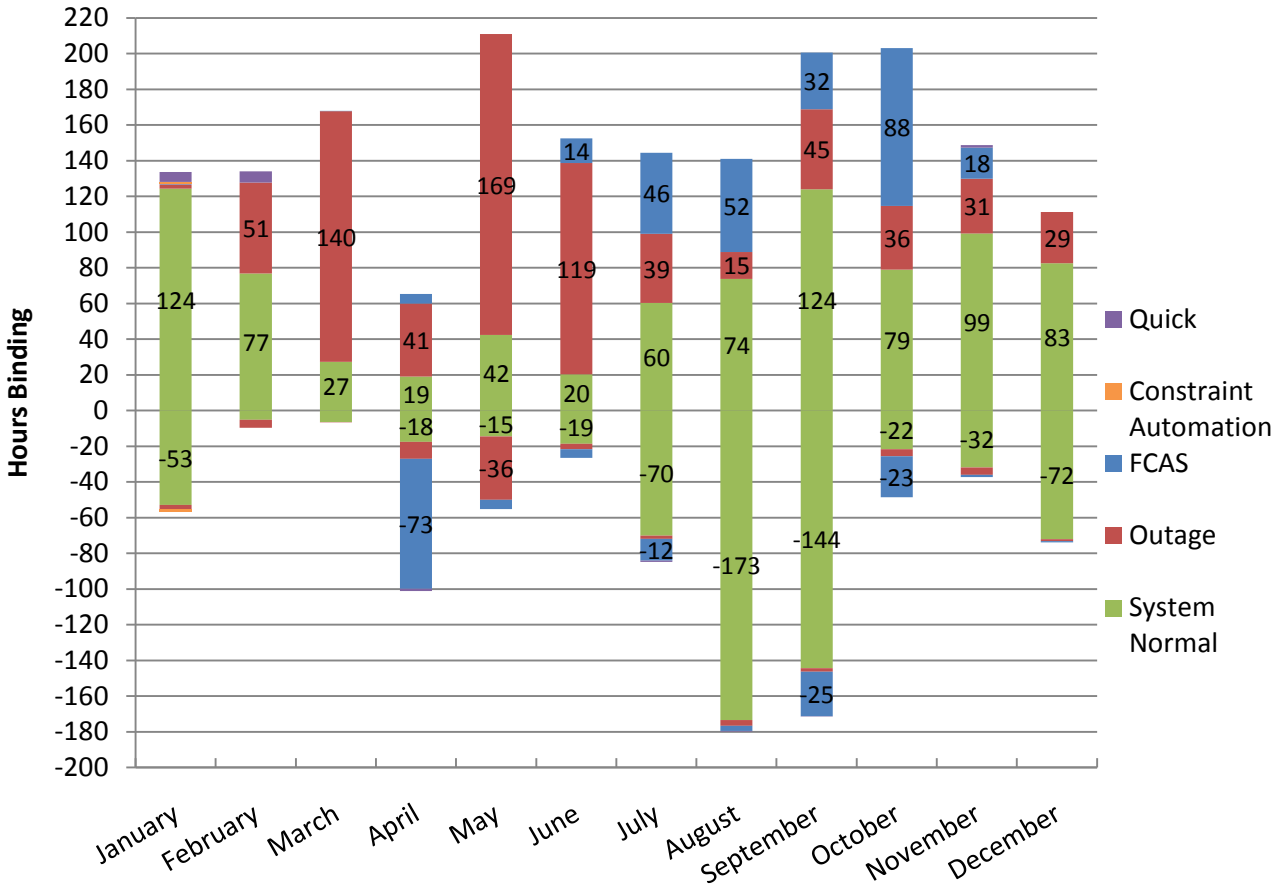


Figure 10: Categorized Binding Intervals per month for V-SA

Table 14: Binding Constraint Equations setting the Vic to SA limit on V-SA

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V^^S_NIL_NPS_SE_OFF & V^^S_NIL_NPS_SE_ON & V^^S_TBCP_NPS_SE_OFF & V^^S_TBCP_NPS_SE_ON & V::S_NIL	624.4	*Out = Nil, Vic to SA Long Term Voltage Stability limit for loss of one Northern unit, South East Cap bank on / off, Tailem Bend Cap bank on/off* See Table 3 for comments.
V::N_SMCSVxxx & V::N_SMCSQxxx	395.5	*Out = South Morang 330kV series capacitor, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV, Radial*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		See Table 3 for comments.
V::N_NILVxxx & V::N_NILQxxx	190.1	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* See Table 3 for comments.
F_QNV++HYML_L60	76.1	*Out = one Heywood to Moorabool (HYTS-MLTS) line or one Moorabool to Sydenham (MLTS-SYTS) line Qld, NSW, Snowy and Vic Lower 60 sec Requirement, Basslink able to transfer FCAS*
VS_250	67.9	*Victoria to SA on Vic-SA upper transfer limit of 250 MW* This Constraint Equation appears in a number of outages in both Victoria and South Australia.
F_ESTN++HYML_L60	55.3	*Out = one Heywood to Moorabool (HYTS-MLTS) line or one Moorabool to Sydenham (MLTS-SYTS) line Eastern Lower 60 sec Requirement*
F_QNV++HYML_L5	54.9	*Out = one Heywood to Moorabool (HYTS-MLTS) line or one Moorabool to Sydenham (MLTS-SYTS) line Qld, NSW, Snowy and Vic Lower 5 min Requirement, Basslink able to transfer FCAS*
V::N_HWSMxxx	54.6	Out = Hazelwood to South Morang 500 kV line, *avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line* See comment on Table 12
V::N_MSUTxxx	50.5	*Out = Upper Tumut to Murray 330kV line, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line* See comment on Table 12
F_ESTN++HYML_L5	40.8	*Out = one Heywood to Moorabool (HYTS-MLTS) line or one Moorabool to Sydenham (MLTS-SYTS) line Eastern Lower 5 min Requirement*

Table 15: Binding Constraint Equations setting the SA to Vic limit on V-SA

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P	493.0	*Out = Nil, avoid pre-contingent overloading the South Morang 500/330kV (F2) transformer, for Radial/Parallel modes and Yallourn W1 on the 500 or 220kV* See Table 3 for comments.
S>>V_NIL_SETX_SETX	67.7	*Out= Nil, avoid O/L the remaining South East 275/132 kV transformer on trip of one South East 275/132 kV transformer, Feedback* This Constraint Equation binds when there is export from South Australia to Victoria and high generation at the wind farms and GTs in the south east of South Australia.
F_S++HYSE_L60	57.2	*Out = one Heywood to South East (HYTS-SESS) or one Heywood (HYTS) 500/275kV (M1 or M2) transformer, SA Lower 60 sec Requirement*
SV_300	35.2	*SA to Victoria on Vic-SA upper transfer limit of 300 MW* This Constraint Equation is used in System Normal for the upper limit on export from SA to Victoria on the Heywood AC link. It is expected this will be raised to 460 MW in early 2010 and that the new limit will be undercut by thermal limitations.
F_S++HYML_L60	29.7	*Out = one Heywood to Moorabool (HYTS-MLTS) 500kV line or one Moorabool to Sydenham (MLTS-SYTS) 500kV line, SA Lower 60 sec Requirement*
N::V_KC_VC2	27.8	*Out= both Kemps Creek SVCs, NSW to Snowy Transient Limit*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
S_V_NIL-300	18.7	*Out= Nil, limit SA to Vic to reduce time and amount exceeding 300 MW due to non-conformance or FCAS raise regulation flows* See Table 3 for comments.
F_S++HYSE_L5	18.4	*Out = one Heywood to South East (HYTS-SESS) or one Heywood (HYTS) 500/275kV (M1 or M2) transformer, SA Lower 5 min Requirement*
F_S++HYML_L6	16.4	*Out = one Heywood to Moorabool (HYTS-MLTS) 500kV line or one Moorabool to Sydenham (MLTS-SYTS) 500kV line, SA Lower 6 sec Requirement*
N::V_MSUT	13.8	*Out= Murray - Upper Tumut (65) line, NSW to Snowy Transient Limit*

7.6 Murraylink (V-S-MNSP1)

Murraylink is a 220MW DC link between Red Cliffs in Victoria and Monash in South Australia. Transfers from Victoria to South Australia are mainly limited by Constraint Equations which affect the export from Victoria as a whole, such as the F2 transformer overload or the transient stability limit for exports from Victoria. Many of the thermal issues closer to Murraylink are dealt with by the Murraylink runback scheme. Transfers from SA to Victoria are limited by the 132kV network from Robertstown to Monash and Robertstown to Waterloo.

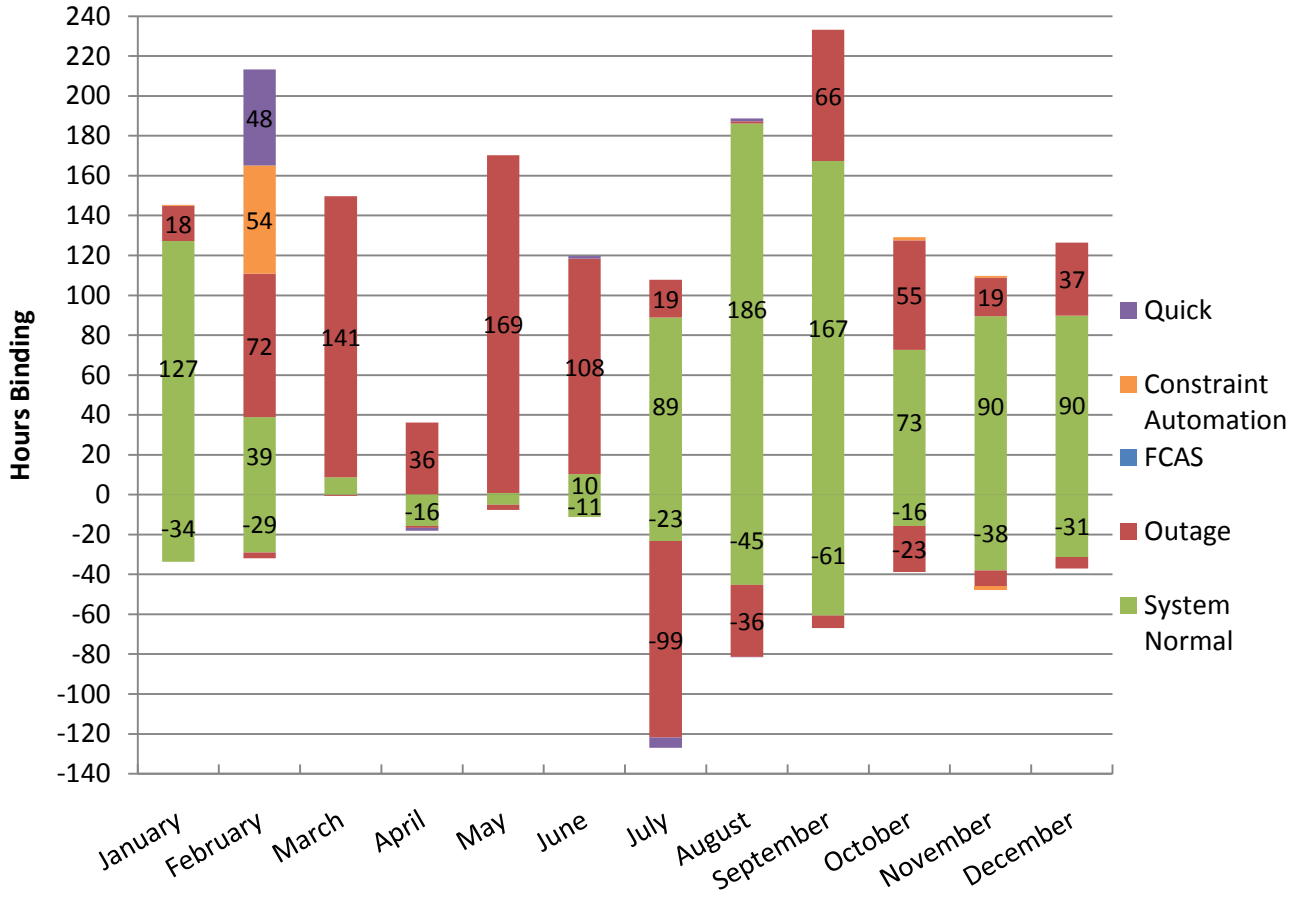


Figure 11: Categorized Binding Intervals per month for V-S-MNSP1

Table 16: Binding Constraint Equations setting the Vic to SA limit on V-S-MNSP1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P	488.2	*Out = Nil, avoid pre-contingent overloading the South Morang 500/330kV (F2) transformer, for Radial/Parallel modes and Yallourn W1 on the 500 or 220kV* See Table 3 for comments.
V::N_SMCSVxxx & V::N_SMCSQxxx	407.4	*Out = South Morang 330kV series capacitor, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV, Radial* See Table 3 for comments.
V::N_NILVxxx & V::N_NILQxxx	204.1	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* See Table 3 for comments.
V^SML_NSWRB_2	56.3	*Out = NSW Murraylink runback scheme, limit Vic to SA on Murraylink to avoid voltage collapse for loss of Darlington Pt to Buronga (X5) 220kV line*
V::N_HWSMxxx	54.6	*Out = Hazelwood to South Morang 500 kV line, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line* See comment on Table 12
V::N_MSUTxxx	53.8	*Out = Upper Tumut to Murray 330kV line, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line* See comment on Table 12
#V-S-MNSP1_I_E	49.8	*Quick Constraint Equation applied to Murraylink at various levels* For the majority of intervals that this quick Constraint Equation bound was for managing power system security for the multiple line outages following the Victorian bushfires in February 2009[5]. It was also invoked to manage negative residues and oscillations on Murraylink at other times during 2009.
CA_SPS_38B0D2AB_01	40.7	*Constraint Automation, avoid overloading 0X1 (Buronga – Red Cliffs) on trip of Bendigo - Kerang 220kV line.* The Constraint Automation was used during the outage of Ballarat Horsham on the 20th February. AEMO has added a new outage Constraint Equation V>SMLBAHO4
V>>N-NIL_HA	34.4	*Out= Nil, avoid Murray to Upper Tumut (65) O/L on Murray - Lower Tumut (66) trip*
VSML_000	31.3	*Vic to SA on ML upper transfer limit of 0 MW*

Table 17: Binding Constraint Equations setting the SA to Vic limit on V-S-MNSP1

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
S>V_NIL_NIL_RBNW	200.3	*Out=Nil, avoid overloading North West Bend to Robertstown 132kV line on no line trips* See Table 3 for comments.
S>>V_NIL_RBTX_WTMW4	53.3	*Out=Nil, avoid overloading Waterloo - MWP4 line for trip of one Robertstown Transformer*
S>VML_NWCB6023_TX2	50.9	*Out= North West Bend CB6023, avoid North West Bend transformer #2 overload on trip North West Bend - Robertstown line.*
SVML_000	45.4	*SA to Vic on ML upper transfer limit of 0 MW*
SVS_420	35.3	*SA to Vic on Vic-SA + ML upper transfer limit of 420 MW*

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
		It is expected that this Constraint Equation will be replaced with a higher value Constraint Equation in early 2010 after the completion of oscillatory stability studies by AEMO. It is expected this new limit will bind for fewer hours in 2010 and instead thermal Constraint Equations in SA will be binding.
S>>V_RBTX_RBTX_WTMW 4	35.1	*Out=One Robertstown 275/132 kV transformer, avoid overloading Waterloo - MWP4 line for trip of one Robertstown Transformer*
S>VML_NWCB6033_TX2	30.4	*Out= North West Bend CB6033, avoid North West Bend transformer#2 overload on trip North West Bend - Monash #2 line.*
V>>V_NIL_1B	16.2	*Out = Nil, avoid overloading Dederang to Murray No.2 330kV line for loss of the parallel No.1 line, 15 min line ratings*
S>VML_NWCB6024+25	6.3	*Out= North West Bend CBs 6024 and 6025, avoid North West Bend transformer #3 overload on trip North West Bend - Monash #1 line.*
#V-S-MNSP1_E_E	4.8	*Quick Constraint Equation applied to Murraylink at various levels* This Constraint Equation was invoked to manage power system security on 14 July 2009 and oscillations on Murraylink on 24 & 25 August 2009.

8 Major outages

The following table shows the duration of the outages in 2009 that used any of the binding Constraint Equations included in the tables in sections 6 and 7. This list excludes the "#" Constraint Equations as these are generally not associated with a particular outage.

The outage times were calculated from the times that the Constraint Sets were invoked.

Table 18: Top 40 outages associated with binding Constraint Equations

CONSTRAINT SET ID	DAYS	*OUTAGE* / NOTES
N-KC_VC_2	149.0	*Both Kemps Creek SVCs*
N-MBTE_1	142.6	*One Directlink cable*
V-SMSC & V-SMCS_R & V-SMCS_P	136.5	*one or both South Morang 330kV series capacitors* The series capacitor was out of service for a number of months after the Victorian bushfires in Feb 2009[5].
N-LTUT_64_15M & N-LTUT_64	32.1	*Lower to Upper Tumut (64) 330kV line*
Q-BCGL_812	19.3	*Bouldercombe to Gladstone (812) 275kV line*
N-MNMP_ONE	19.3	*Marulan to Mt. Piper (35 or 36) 330kV line* Outages due to work for cut into the Bannaby substation and conversion to 500kV
Q-BCGL_811	17.6	*Bouldercombe to Gladstone (811) 275kV line* This was mainly out for the commissioning of the Larcom Creek substation
F-V-HYML & V-HYML	17.0	*Heywood to Moorabool 500kV line* Outage mainly for OPGW installation
F-V-APHY_ONE	16.9	*Heywood to Alcoa Portland 500kV line*
I-MSUT	16.8	*Murray to Upper Tumut (65) 330kV line*
N-KKLS_967	14.1	*Koolkhan to Lismore (967) 132kV line*
N-X_MBTE_2	11.4	*Two Directlink cables*
F-V-HY_TX & V-HYTX	10.7	*One Heywood 500/275kV (M1 or M2) transformer*

CONSTRAINT SET ID	DAYS	*OUTAGE* / NOTES
Q-CLTR_N-2	9.0	*Reclassification Calvale to Tarong (8810 and 8811) 275kV lines as a credible contingency*
V-SMTXF2	6.0	*South Morang 500/330kV (F2) transformer*
N-AR_VC1	5.9	*Armidale SVC*
N-X_MBTE_3	5.7	*All three Directlink cables*
N-GITN_96R	4.8	*Glen Innes to Tenterfield (96R) 132kV line*
S-RB_TX1	4.1	*One Robertstown 275/132kV Transformer*
N-CHLS_89	3.9	*Coffs Harbour to Lismore (89) 330kV line*
V-HWSM_RADIAL	3.7	*Hazelwood to South Morang 500kV line, Radial*
V-DDSM	3.6	*One Dederang to South Morang 330 kV line* 1.9 days of this outage was following the Victorian bushfires in Feb 2009[5].
I-ML_ZERO	3.6	*Limit Murraylink to zero in either direction*
V-X_DDSM_TWO	3.5	*Both Dederang to South Morang (DDTS-SMTS) 330kV lines* These lines were out following the Victorian bushfires in Feb 2009[5].
F-N-ARDM_ONE	2.9	*One Armidale to Dumaresq (8C or 8E) 330kV line*
T-GTSH_BL	2.7	*One George Town to Sheffield 220kV line*
F-T-N-ARTW_85 & N-ARTW_85	2.4	*Armidale to Tamworth (85 or 86) 330kV line*
S-NW_CB6023	2.2	*North West Bend CB6023*
V-HWSM_C	1.7	*Hazelwood to South Morang 500kV line, 3/5 Parallel*
N-DM_CB	1.5	*One Dumaresq 330kV CB (5312, 5322, 5332, 5342) O/S*
S-NW_CB6024+25	1.3	*North West Bend CBs 6024 and 6025*
F-N-LDMU_83 & N-LDMU_83	1.0	*Liddell to Muswellbrook (83) 330kV line*
N-X_967_LS_SVC	1.0	*Koolkhan to Lismore (967) 132kV line and Lismore SVC*
V-X_DDSM_EPTT	0.9	*Dederang to South Morang (DDTS-SMTS) 330kV line and Eildon to Thomastown (EPS-TTS) 220 kV line* These lines were out following the Victorian bushfires in Feb 2009[5].
F-I-HYSE	0.8	*One Heywood to South East (HYTS-SESS) 275kV line*
S-NW_TX3+CB	0.8	*North West Bend Transformer #3, CB6033 and CB6225*
S-NW_CB6033	0.7	*North West Bend CB6033*
V-HWRO3_R	0.7	*Hazelwood to Rowville No.3 500kV line, Radial*
I-HYSE	0.5	*Heywood to South East 275kV line*
S-SETB_N-2	0.5	*Loss of both South East to Tailem Bend 275kV lines reclassified as credible contingency.*

9 Other Developments

9.1 Constraint Automation

The Constraint Automation is an application in AEMO's EMS which generates thermal overload Constraint Equations based on the current or planned state of the power system. AEMO's intention is that the Constraint Automation will eventually create and invoke the Constraint Equations in real time automatically. However, this goal is being achieved via a staged

implementation with long periods of testing and confirmation of results in between. Currently only the 1st stage has been implemented.

Stage 1 was made available for use in December 2007. This stage allows building thermal overload Constraint Equations from a study case with the Constraint Equations being sent to the market systems manually and the Constraint Sets invoked manually. This stage is only intended for use in scenarios where there are no existing Constraint Equations available or the existing ones are not working correctly. Stage 1 includes all the Constraint Equations in a single Constraint Set and these have unique IDs as they are intended for single use only.

9.2 Issues

A number of issues have been found with the Constraint Automation in the 2 years since it was made available.

9.2.1 RHS Factors on transformers

In late March 2008 an issue was found with the sign of the RHS factors used for transformers (due to the Constraint Automation not knowing which end of the transformer the SCADA measurement was located). This was later found to also affect some line overload Constraint Equations so the Constraint Automation was disabled for Control Room use until a fix was applied October 2008. The fix took a long time as it changed the main code which calculated the RHS terms and extensive testing was required.

A side effect of this is it reduced AEMO's control room staff confidence in use of the Constraint Automation which has taken a further 12 months to restore.

9.2.2 Tasmanian and Victorian Ratings

On 1 June 2009 a planned outage of the New Norfolk to Chapel St 110kV line in Tasmania the Constraint Automation was unable to create Constraint Equations when the existing ones were not working correctly[9].

The Constraint Automation needs to include in its modelling the MMS identifiers (called SPD IDs) for each line flow, rating, interconnector and generator. If a rating is not available for a line or transformer then the Constraint Automation is unable to create a Constraint Equation.

Due to a modelling error in the EMS the Constraint Automation was unable to find the SPD ID associated with the lines indicated in AEMO's Contingency Analysis on 1 June. It was later determined that the modelling error extended to all plant in Tasmania and Victoria. The modelling error was fixed in the EMS on 11 June 2009 and extra validation was introduced in late 2009 to ensure this error is not re-introduced.

9.2.3 No SPD ID Available

When the Constraint Automation cannot find a line flow for the tripped or monitored line it will not build a feedback style Constraint Equation for the Dispatch RHS which uses the current line flows. Instead it will build a Predispatch style Constraint Equation which uses regional demands instead of line flows which gives a less accurate result.

On 26 August 2009 the Constraint Automation was unable to find line flow SPD IDs for a multiple outage condition in South Australia[10] and built a Predispatch style Constraint Equation. There were no overload issues on the day; however, the Constraint Equation would have been ineffective in managing these issues. Upon further analysis a bug was found in the calculation of the Predispatch style RHS for this special case where a feedback RHS could not be created.

[9] http://www.aemo.com.au/reports/0232-0009.html
[10] http://www.aemo.com.au/reports/0232-0030.pdf

AEMO rectified the missing SPD IDs soon after this incident and has subsequently introduced 6 monthly reviews of the SPD ID modelling in the Constraint Automation. A bug fix for the issue found with the Predispatch RHS is expected in early 2010.

9.3 Usage

The graphs below show the usage of the Constraint Automation in 2008 and 2009. This usage has been generated based on the Constraint Sets and does not indicate the number of Constraint Equations created. The usage is categorised into 4 main areas:

- Invoked
- Control room not invoked – Constraint Automation was used to create Constraint Equations but these were subsequently not invoked. In most of these cases AEMO's Control Room prepared Constraint Equations using the Constraint Automation but the issue was resolved before they were required. In a several cases a second Constraint Set was created as adjustments were required such as increasing an operating margin or including another Constraint Equation.
- Constraint Builders. The Constraint Automation is used by the Constraint Builders for two main tasks. One is for quick creation of a Constraint Equation for a current issue or short notice multiple outage. The second is for checking the factors on currently invoked Constraint Equations to confirm they do not require an update. In this case Constraint Equations do not have to be sent to the market systems as the factors can be viewed on AEMO's EMS so this number could be much higher.
- Testing the Constraint Automation. Testing the Constraint Automation is occasionally performed to test bug fixes.

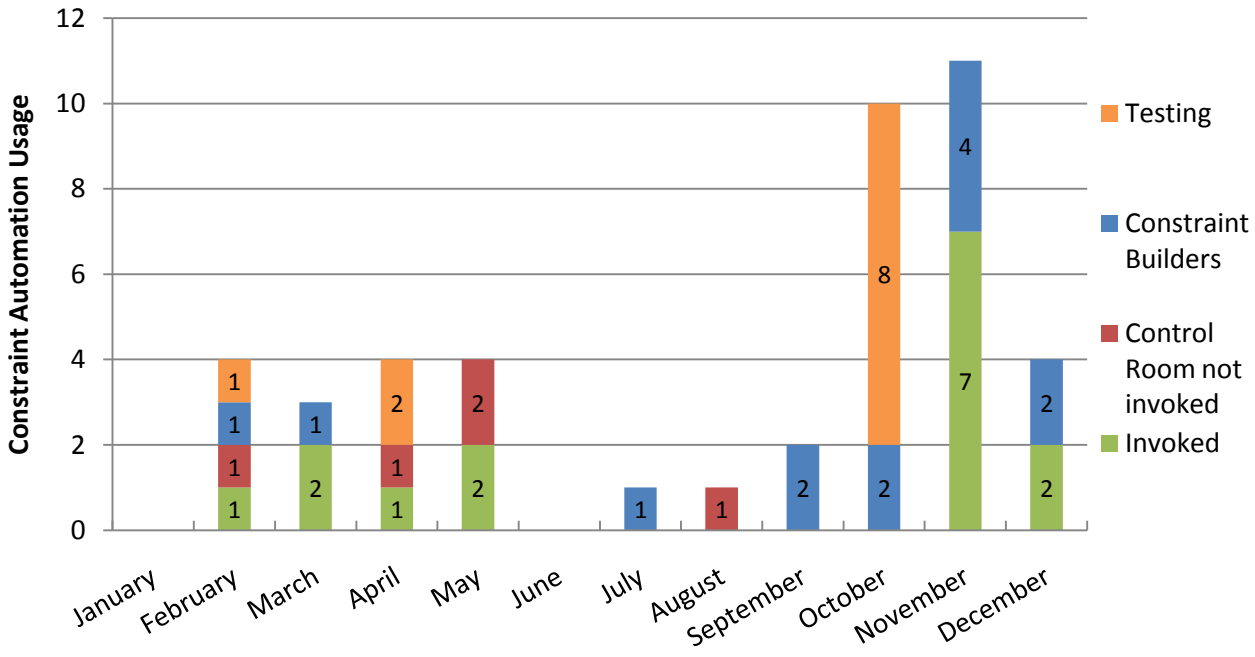


Figure 12: Constraint Automation usage in 2008

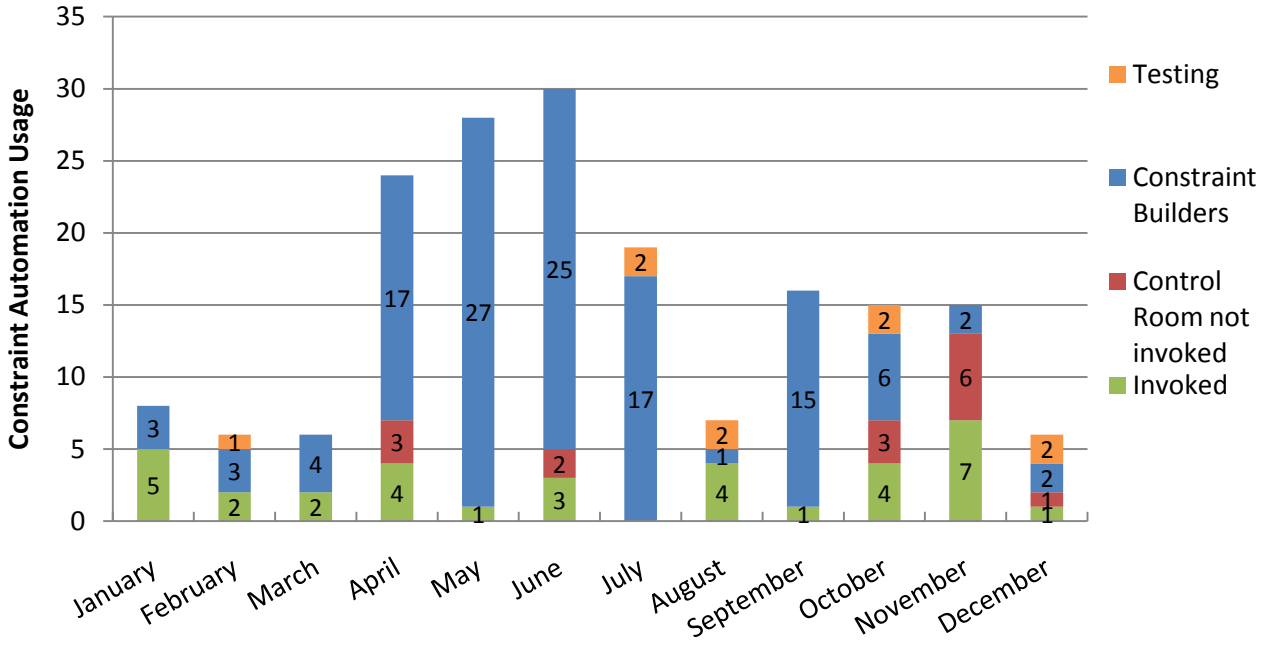


Figure 13: Constraint Automation usage in 2009

9.4 "Plain English" converter

As a part of our RIEMNS NER obligations a conversion tool was developed which would produce a more readable version of a Constraint Equation, known as "Plain English". After a number of iterations internally AEMO made the "Plain English" Constraint Equation converter available to all participants via the MMS Web portal[11] on 18th March 2009.

Participants could either type in the Constraint Equation ID or select from a list of Constraint Equations that had been binding in the previous 24 hours.

The MMS Web portal was further modified in October 2009 to allow retrieval of all or a particular Constraint Equation from a Constraint Set. The Constraint Set ID can be typed in or selected from a list of the Constraint Sets invoked currently and up to 2 weeks into the future.

9.5 Congestion Information Resource

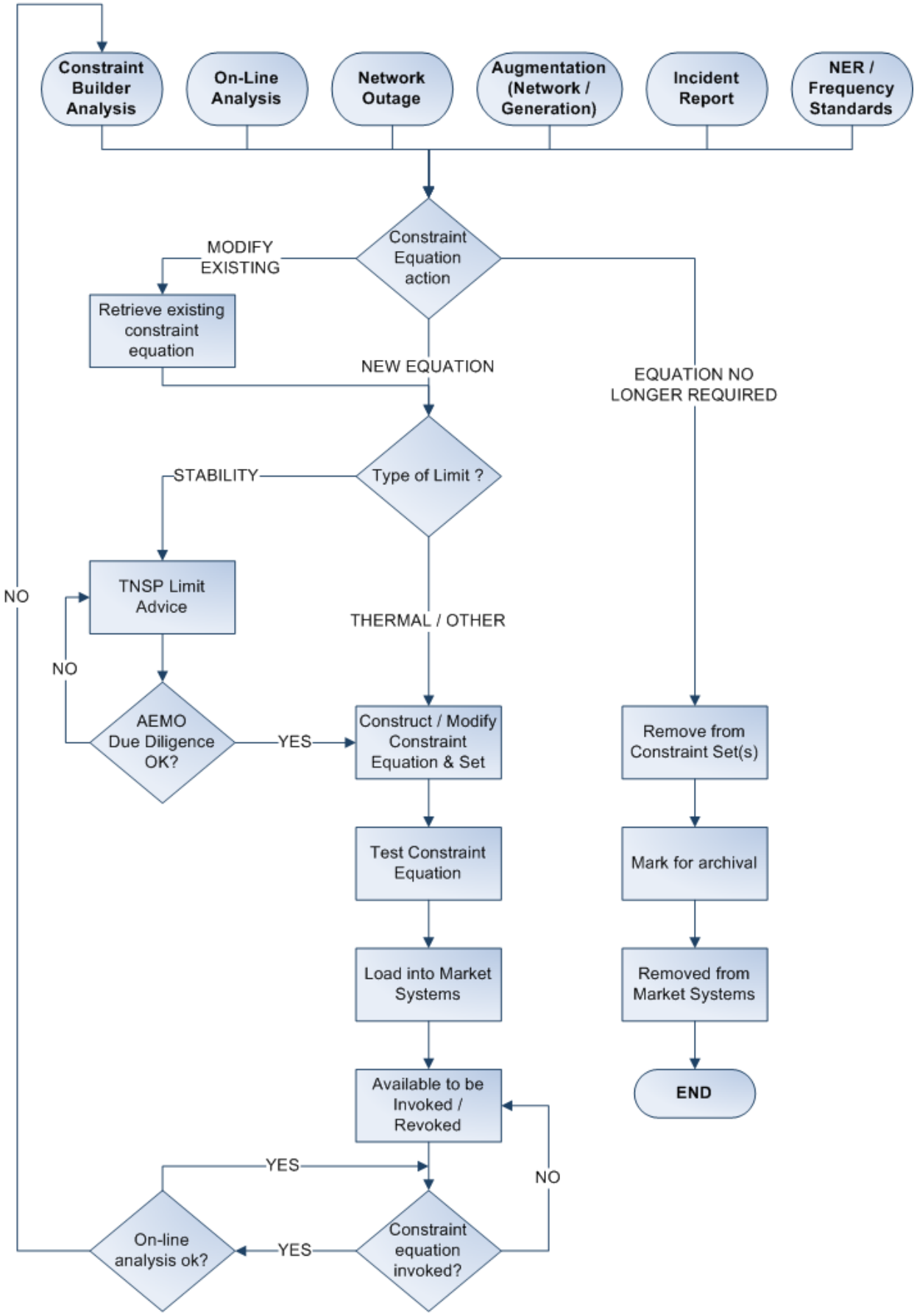
The NER requires AEMO to establish a Congestion Information Resource (CIR) which will consolidate and enhance existing sources of information relevant to the understanding and management of transmission network congestion risk. The Interim Congestion Information Resource (CIR) was launched in late 2009 and a consultation started for the first CIR. The CIR is located on the AEMO website:

http://www.aemo.com.au/electricityops/congestion.html

This report will be included in the CIR.

[11] https://mms.prod.nemnet.net.au/Mms/login.aspx

10 Appendix 1: Drivers of Constraint Equation changes



11 Appendix 2: Top 20 binding network Constraint Equations in 2008

Table 19: Top 20 binding network Constraint Equations in 2008

EQUATION ID	HOURS	*DESCRIPTION* / NOTES
V_T_NIL_FCSPS	6000	*Basslink limit from Vic to Tas for load enabled for the Basslink Frequency Control Special Protection Scheme (FCSPS)*
N_X_MBTE2_B	442	*Out= two Directlink cables, Qld to NSW limit*
V::N_NILVxxx & V::N_NILQxxx & V::H_NILVxxx & V::H_NILQxxx	262	*Out = Nil, avoid transient instability for fault and trip of a Hazelwood to South Morang 500kV line, Radial or Parallel modes in Victoria* This also includes the pre Snowy abolition Constraint Equations
Q>>NIL_855_871	248	*Out = Nil, avoid overload on Calvale to Wurdong 275kV fdr 871 on trip of Calvale to Stanwell (855)*
Q:N_NIL_BI_POT	224	*Out=Nil, avoid transient instability on trip of a Boyne Island potline*
V::S_NIL	219	*Out = Nil, Vic to SA Long Term Voltage Stability limit for loss of one Northern unit*
Q:N_NIL_OSC	219	*Out = Nil, limit Qld to NSW on QNI to avoid Oscillatory Instability*
NC_S_LKBONNY2	214	*Non Conformance Constraint for Lake Bonney 2 Windfarm*
S_V_NIL-300	185	*Out= Nil, limit SA to Vic to reduce time and amount exceeding 300 MW due to non-conformance or FCAS raise regulation flows*
N^^V_NIL_1_P & N^^V_NIL_1 & H^^V_NIL1_P & H^^V_NIL1	162	*Out = Nil, avoid voltage collapse for trip of the largest Vic generating unit* This also includes the pre Snowy abolition Constraint Equations
S>>V_NIL_SETX_SETX	152	*Out= Nil, avoid O/L the remaining South East 275/132 kV transformer on trip of one South East 275/132 kV transformer*
N_MBTE1_B	141	*Out= one Directlink cable, Qld to NSW limit*
S>V_NIL_NIL_RBNW	129	*Out=Nil, avoid overloading North West Bend to Robertstown 132kV line on no line trips*
N>N-KKLS_TE_1	127	*Out= Koolkhan to Lismore (967), avoid O/L Tenterfield to Lismore (96L) on trip of Coffs Harbour to Lismore (89)*
N^^Q_NIL_B1, 2, 3, 4, 5, 6 & N^Q_NIL_B	123	*Out= Nil, avoid Voltage Collapse on loss of the largest Queensland unit*
N::V_KC_VC1	122	*Out= one Kemps Creek SVC, NSW to Snowy Transient Limit*
NC_S_OSB-AG	107	*Non Conformance Constraint for Osborne Power Station*
N_X_MBTE_3	106	*Out= all three Directlink cables*
V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P	98	*Out = Nil, avoid pre-contingent overloading the South Morang 500/330kV (F2) transformer, for Radial/Parallel modes and Yallourn W1 on the 500 or 220kV*
SV_300	89	*Out= one Directlink cable, Qld to NSW limit*