MONTHLY CONSTRAINT REPORT - FEBRUARY 2018

FOR THE NATIONAL ELECTRICITY MARKET

PUBLISHED **MARCH 2018**

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about constraint equation performance and related issues, as at the date of publication.

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1. INTRODUCTION

This report details constraint equation performance and transmission congestion related issues for February 2018. Included are investigations of violating constraint equations, usage of the constraint automation and performance of Pre-dispatch constraint equations. Transmission and generation changes are also detailed along with the number of constraint equation changes.

2. CONSTRAINT EQUATION PERFORMANCE

2.1. Top 10 binding constraint equations

A constraint equation is binding when the power system flows managed by it have reached the applicable thermal or stability limit or the constraint equation is setting a Frequency Control Ancillary Service (FCAS) requirement. Normally there is one constraint equation setting the FCAS requirement for each of the eight services at any time. This leads to many more hours of binding for FCAS constraint equations - as such these have been excluded from the following table.

Table 2-1 – Top 10 binding network constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	2076 (173.0)	16/02/2018
N_X_MBTE2_B	Out= two Directlink cables, Qld to NSW limit	618 (51.5)	25/11/2013
N_X_MBTE2_A	Out= two Directlink cables, NSW to Qld limit	465 (38.75)	16/02/2018
I_CTRL_ISSUE_TE	DC Link Control Issue Constraint for Terranora	456 (38.0)	22/02/2018
T>T_NIL_110_1	Out = NIL, avoid pre-contingent O/L of the Derby to Scottsdale Tee 110 kV line, feedback	444 (37.0)	05/03/2014
N_X_MBTE_3B	Out = all three Directlink cables, Terranora_I/C_import <= Terranora_Load	372 (31.0)	25/11/2013
N^^Q_NIL_B1	Out= Nil, avoid Voltage Collapse on loss of Kogan Creek	306 (25.5)	06/12/2017
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	240 (20.0)	20/12/2016
T_ROCOF_1	Out = NIL, limit delayed rate of change of frequency in TAS to 1.076 Hz per sec following line fault and trip of Tamar CCGT. Swamped if Tamar CCGT OOS.	196 (16.33)	31/07/2014
V::N_NIL_V2	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.	161 (13.41)	26/02/2018

2.2. Top 10 binding impact constraint equations

Binding constraint equations affect electricity market pricing. The binding impact is used to distinguish the severity of different binding constraint equations.

The binding impact of a constraint is derived by summarising the marginal value for each dispatch interval (DI) from the marginal constraint cost (MCC) re-run[1] over the period considered. The marginal value is a mathematical term for the binding impact arising from relaxing the RHS of a binding constraint by one MW. As the market clears each DI, the binding impact is measured in $/MW/DI.

The binding impact in $/MW/DI is a relative comparison and a helpful way to analyse congestion issues. It can be converted to $/MWh by dividing the binding impact by 12 (as there are 12 DIs per hour). This value of congestion is still only a proxy (and always an upper bound) of the value per MW of congestion over the period calculated; any change to the limits (RHS) may cause other constraints to bind almost immediately after.

Table 2-2 – Top 10 binding impact network constraint equations

Constraint Equation ID (System Normal Bold)	Description	∑ Marginal Values	Change Date
T>T_NIL_110_1	Out = NIL, avoid pre-contingent O/L of the Derby to Scottsdale Tee 110 kV line, feedback	459,689	05/03/2014
V>>V_NIL_8	Out = Nil, avoid O/L DDTS to WOTS 330kV line for trip of LowerTumut-Wagga (051) + (991,990,99P) or (990,99M,970) ex_Yass lines - status switched ; Feedback	173,474	16/02/2018
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	104,260	16/02/2018
V>>V_NIL_1A	Out = Nil, avoid O/L Murray to Dederang No.1 330kV line (flow MSS to DDTS) for loss of the parallel No.2 line, DBUSS-Line control scheme enabled, 15 min line ratings, feedback	93,635	16/02/2018
F_I+LREG_0120	NEM Lower Regulation Requirement greater than 120 MW	89,602	21/08/2013
F_I+NIL_RREG	NEM Raise Regulation Requirement	76,123	25/10/2016
F_T+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a Tasmania Generation Event (both largest MW output and inertia), Basslink unable to transfer FCAS	62,594	12/04/2016
S_HPRG1_E	Out= Nil, Hornsdale Battery generation energy target <= 30 MW	42,334	13/12/2017
F_T+NIL_MG_RECL_R6	Out = Nil, Raise 6 sec requirement for a Tasmania Reclassified Woolnorth Generation Event (both largest MW output and inertia), Basslink unable to transfer FCAS	31,120	02/12/2016
F_T+NIL_WF_TG_R6	Out= Nil, Tasmania Raise 6 sec requirement for loss of a Smithton to Woolnorth or Norwood to Scotsdale tee Derby line, Basslink unable to transfer FCAS	30,625	12/04/2016

2.3. Top 10 violating constraint equations

A constraint equation is violating when NEMDE is unable to dispatch the entities on the left-hand side (LHS) so the summated LHS value is less than or equal to, or greater than or equal to, the right-hand side (RHS) value (depending on the mathematical operator selected for the constraint equation). The following table includes the FCAS constraint equations. Reasons for the violations are covered in 2.3.1.

Table 2-3 – Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
V>>V_NIL_8	Out = Nil, avoid O/L DDTS to WOTS 330kV line for trip of LowerTumut-Wagga (051) + (991,990,99P) or (990,99M,970) ex_Yass lines - status switched ; Feedback	40 (3.33)	16/02/2018

1 The MCC re-run relaxes any violating constraint equations and constraint equations with a marginal value equal to the constraint equation's violation penalty factor (CVP) x market price cap (MPC). The calculation caps the marginal value in each DI at the MPC value valid on that date. MPC is increased annually on 1st July.

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
F_T+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a Tasmania Generation Event (both largest MW output and inertia), Basslink unable to transfer FCAS	8 (0.66)	12/04/2016
I_CTRL_ISSUE_TE	DC Link Control Issue Constraint for Terranora	5 (0.41)	22/02/2018
T_TAMARCCGT_GCS	Tamar Valley 220 kV CCGT Generation Control Scheme (GCS) constraint to manage effective size of generation contingency for loss of Tamar CCGT. Limit output of Tamar CCGT based on load available and/or armed for shedding by Tamar GCS.	2 (0.16)	06/06/2016
V::N_NIL_Q2	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, QLD accelerates. Yallourn W G1 on 500 kV. Constraint active for QNI flows above 900 MW southwards only, swamped otherwise.	1 (0.08)	26/02/2018
F_T+LREG_0050	Tasmania Lower Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	1 (0.08)	29/01/2015
F_T+RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	1 (0.08)	29/01/2015
F_T+NIL_MG_RECL_R6	Out = Nil, Raise 6 sec requirement for a Tasmania Reclassified Woolnorth Generation Event (both largest MW output and inertia), Basslink unable to transfer FCAS	1 (0.08)	02/12/2016
F_T++NIL_MG_RECL_R6	Out = Nil, Raise 6 sec requirement for a Tasmania Reclassified Woolnorth Generation Event, Basslink able to transfer FCAS, reduce by very fast response on Basslink, include fault-ride through on windfarms+Basslink	1 (0.08)	02/12/2016
F_T+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a Tasmania Generation Event (both largest MW output and inertia), Basslink unable to transfer FCAS	1 (0.08)	12/04/2016

2.3.1. Reasons for constraint equation violations

Table 2-4 – Reasons for Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description
V>>V_NIL_8	Constraint violated for 40 DIs, 20 of which were consecutive. Max violation of 37.35 MW occurred on 07/02/2018 at 1855 hrs. Constraint equation violated due to competing requirement with Murraylink interconnector import limit set by S>NIL_NIL_NWMH2.
F_T+NIL_MG_R6	Constraint violated for 8 non-consecutive DIs. Max violation of 119.56 MW occurred on 20/02/2018 at 0145 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
I_CTRL_ISSUE_TE	Constraint violated for 5 DIs during the last month. Max violation of 1.9 MW occurred on 16/02/2018 at 1110 hrs and 1125 hrs. Constraint equation violated due to competing requirement with Terranora interconnector export limit set by N_X_MBTE2_A.
T_TAMARCCGT_GCS	Constraint violated for 2 DIs on 20/02/2018 at 0145 hrs and on 21/02/2018 at 1545 hrs. Max violation of 32.77 MW occurred on 20/02/2018 at 0145 hrs. Constraint equation violated due to reduction in load armed by the Tamar GCS (generator control scheme) and Tamar Valley CCGT being limited by its ramp down rate.
V::N_NIL_Q2	Constraint violated for 1 DI on 08/02/2018 at 0105 hrs with a violation degree of 136.44 MW. Constraint violated due to erroneous SCADA data from Yaloak South wind farm.
F_T+LREG_0050	Constraint violated for 1 DI on 14/02/2018 at 0935 hrs with a violation degree of 50 MW. Constraint equation violated due to Tasmania lower regulation service availability less than the requirement.
F_T+RREG_0050	Constraint violated for 1 DI on 14/02/2018 at 0935 hrs with a violation degree of 50 MW. Constraint equation violated due to Tasmania raise regulation service availability less than the requirement.

Constraint Equation ID (System Normal Bold)	Description
F_T+NIL_MG_RECL_R6	Constraint violated for 1 DI on 08/02/2018 at 0515 hrs with a violation degree of 32.98 MW. Constraint equation violated due to Tasmania raise 6 sec service availability less than requirement.
F_T++NIL_MG_RECL_R6	Constraint violated for 1 DI on 08/02/2018 at 0105 hrs with a violation degree of 25.68 MW. Constraint equation violated due to Tasmania raise 6 sec service availability less than requirement.
F_T+NIL_MG_R5	Constraint violated for 1 DI on 07/02/2018 at 0040 hrs with a violation degree of 0.78 MW. Constraint equation violated due to Tasmania raise 5 min service availability less than requirement.

2.4. Top 10 binding interconnector limit setters

Binding constraint equations can set the interconnector limits for each of the interconnectors on the constraint equation left-hand side (LHS). Table 2-5 lists the top (by binding hours) interconnector limit setters for all the interconnectors in the NEM and for each direction on that interconnector.

Table 2-5 – Top 10 binding interconnector limit setters

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
N^^V_NIL_1	VIC1-NSW1 Import	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	2064 (172.0)	-468.6 (-866.95)
F_MAIN++APD_TL_L5	T-V-MNSP1 Import	Out = Nil, Lower 5 min Service Requirement for a Mainland Network Event-loss of APD potlines due to undervoltage following a fault on MOPS-HYTS-APD 500 kV line, Basslink able to transfer FCAS	1006 (83.83)	-371.57 (-477.24)
N_X_MBTE2_B	N-Q-MNSP1 Import	Out= two Directlink cables, Qld to NSW limit	618 (51.5)	-75.17 (-88.9)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	490 (40.83)	-53.09 (478.0)
N_X_MBTE2_A	N-Q-MNSP1 Export	Out= two Directlink cables, NSW to Qld limit	465 (38.75)	7.95 (29.8)
I_CTRL_ISSUE_TE	N-Q-MNSP1 Export	DC Link Control Issue Constraint for Terranora	444 (37.0)	-1.26 (39.7)
F_MAIN++ML_L6_0400	T-V-MNSP1 Import	Out = Nil, Lower 6 sec requirement for a Mainland Load Event, ML = 400, Basslink able transfer FCAS	394 (32.83)	-442.51 (-477.93)
N_X_MBTE_3B	N-Q-MNSP1 Import	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	371 (30.92)	-24.75 (-46.5)
F_T++NIL_MG_RECL_R60	T-V-MNSP1 Import	Out = Nil, Raise 60 sec requirement for a Tasmania Reclassified Woolnorth Generation Event, Basslink able to transfer FCAS, reduce by very fast response on Basslink, include fault-ride through on windfarms+Basslink	318 (26.5)	129.43 (-25.64)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	313 (26.08)	82.74 (478.0)

2.5. Constraint Automation Usage

The constraint automation is an application in AEMO's energy management system (EMS) which generates thermal overload constraint equations based on the current or planned state of the power system. It is currently

used by on-line staff to create thermal overload constraint equations for power system conditions where there were no existing constraint equations or the existing constraint equations did not operate correctly.

The following section details the reason for each invocation of the non-real time constraint automation constraint sets and the results of AEMO's investigation into each case.

Non-real time constraint automation was not used.

2.5.1. Further Investigation

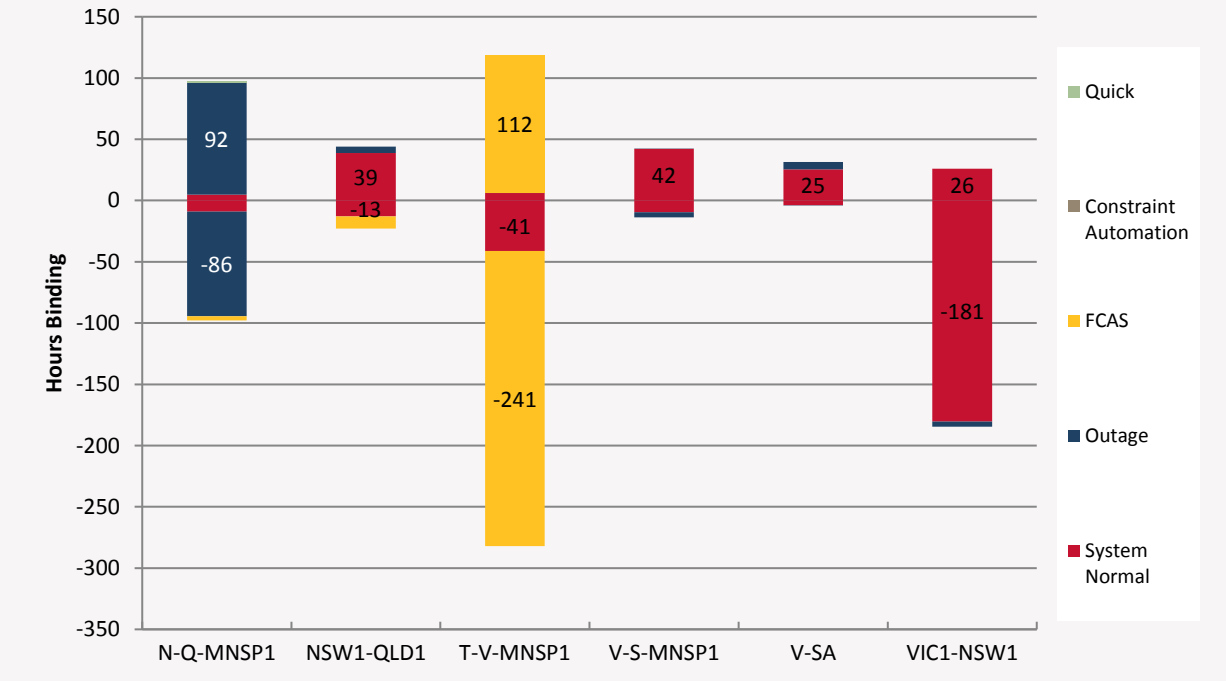
Non-real time constraint automation was not used.

2.6. Binding Dispatch Hours

This section examines the number of hours of binding constraint equations on each interconnector and by region. The results are further categorized into five types: system normal, outage, FCAS (both outage and system normal), constraint automation and quick constraints.

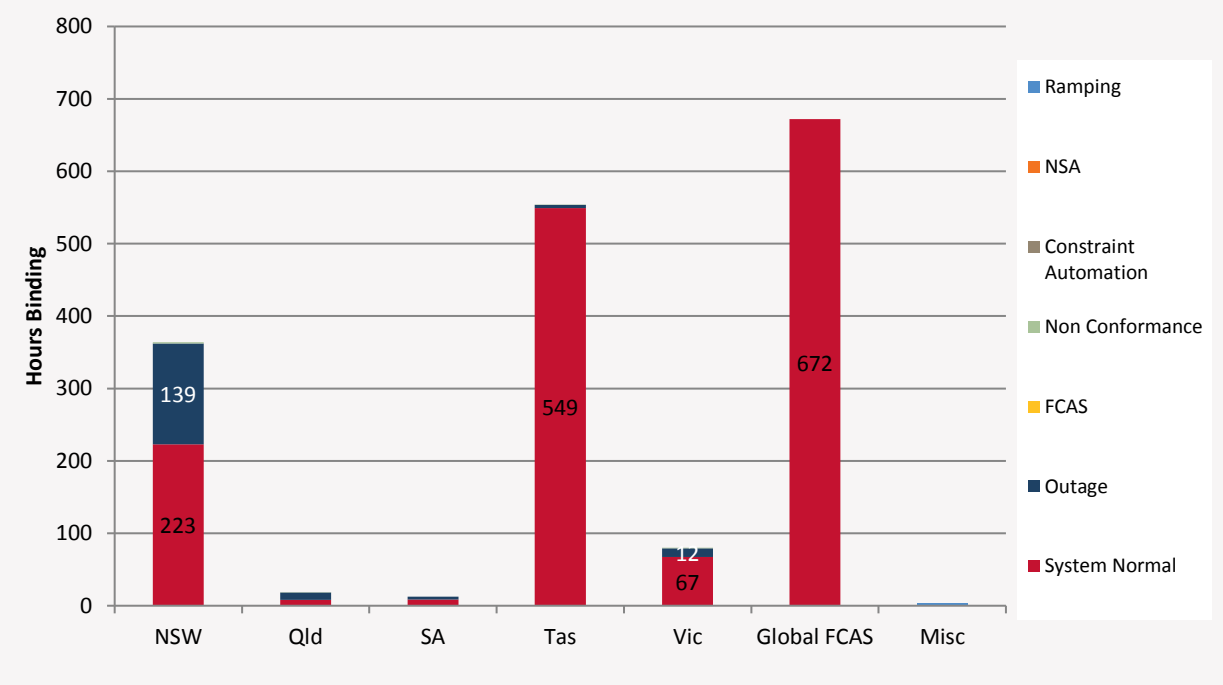
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

Figure 2-1 — Interconnector binding dispatch hours



The regional comparison graph below uses the same categories as in Figure 2-1 as well as non-conformance, network support agreement and ramping. Constraint equations that cross a region boundary are allocated to the sending end region. Global FCAS covers both global and mainland requirements.

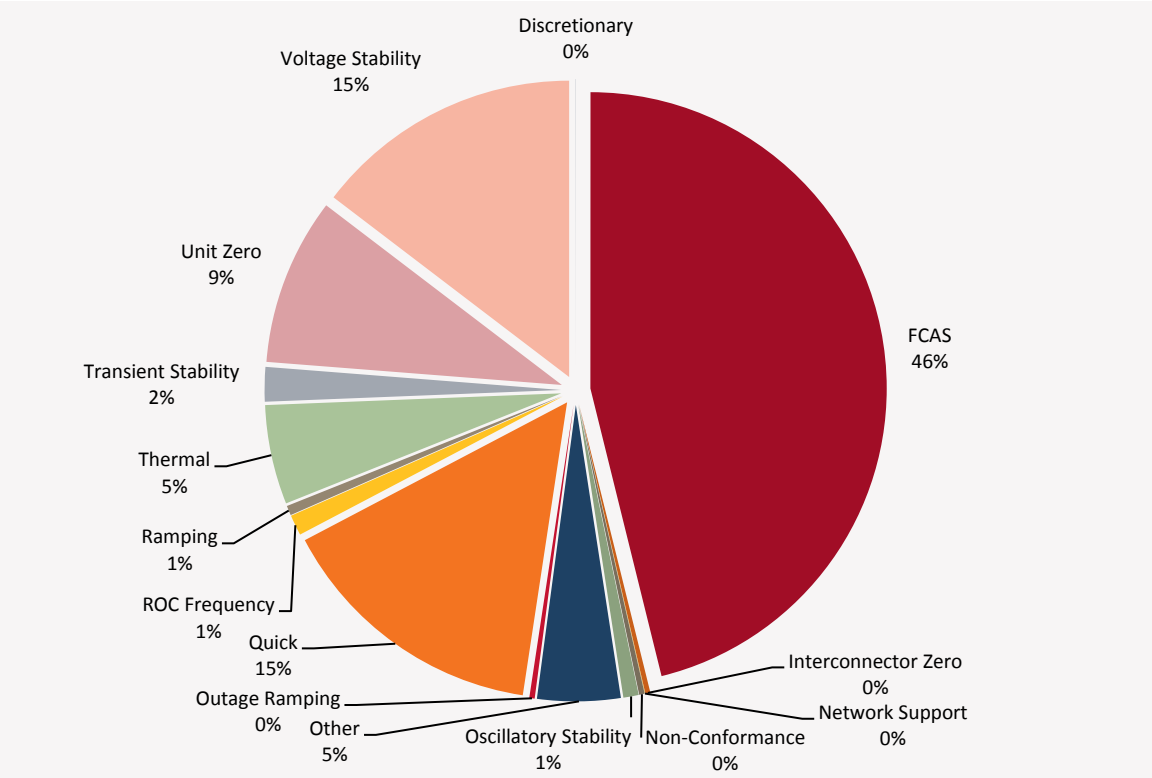
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

The following pie charts show the percentage of dispatch intervals in February 2018 that the different types of constraint equations bound.

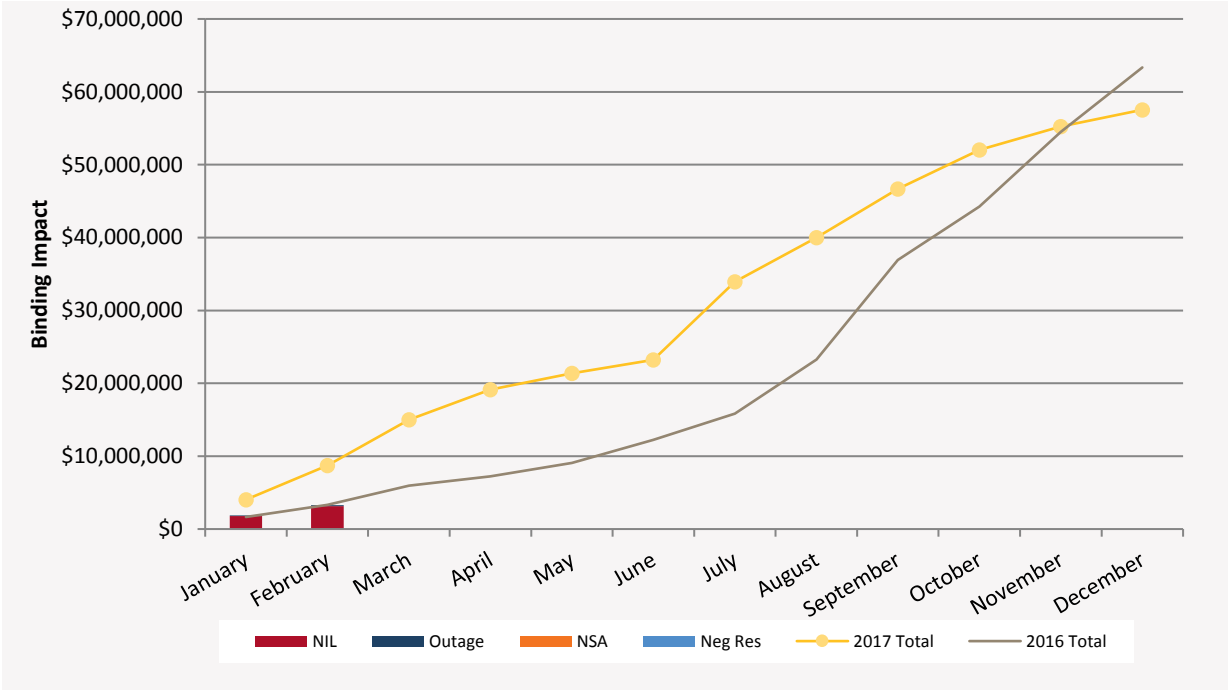
Figure 2-3 — Binding by limit type



2.8. Binding Impact Comparison

The following graph compares the cumulative binding impact (calculated by summating the marginal values from the MCC re-run – the same as in section 2.2) for each month for the current year (indicated by type as a stacked bar chart) against the cumulative values from the previous two years (the line graphs). The current year is further categorised into system normal (NIL), outage, network support agreement (NSA) and negative residue constraint equation types.

Figure 2-4 — Binding Impact comparison



2.9. Pre-dispatch RHS Accuracy

Pre-dispatch RHS accuracy is measured by the comparing the dispatch RHS value and the pre-dispatch RHS value forecast four hours in the future. The following table shows the pre-dispatch accuracy of the top ten largest differences for binding (in dispatch or pre-dispatch) constraint equations. This excludes FCAS constraint equations, constraint equations that violated in Dispatch, differences larger than ±9500 (this is to exclude constraint equations with swamping logic) and constraint equations that only bound for one or two Dispatch intervals. AEMO investigates constraint equations that have a Dispatch/Pre-dispatch RHS difference greater than 5% and ten absolute difference which have either bound for greater than 25 dispatch intervals or have a greater than $1,000 binding impact. The investigations are detailed in 2.9.1.

Table 2-6 – Top 10 largest Dispatch / Pre-dispatch differences

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
V>>V_NIL_8	Out = Nil, avoid O/L DDTS to WOTS 330kV line for trip of LowerTumut-Wagga (051) + (991,990,99P) or (990,99M,970) ex_Yass lines - status switched ; Feedback	20	129,283% (123.11)	9,902% (88.77)
V::N_NIL_S2	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, SA accelerates, Yallourn W G1 on 500 kV.	17	725% (621)	57.77% (115.98)
N_X_MBTE2_A	Out= two Directlink cables, NSW to Qld limit	115	360% (20.)	64.19% (7.04)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	56	192% (346.95)	83.84% (219.85)
N>>N-NIL__3_OPENED	Out= Nil, avoid O/L Liddell to Muswellbrook (83) using 15 mins rating on trip of Liddell to Tamworth (84) line, Feedback	23	113.9% (218.56)	68.96% (147.97)
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	479	101.55% (308.29)	28.75% (98.17)
N>>N-964__3_OPENED	Out= Taree to Port Macquarie (964) 132kV line, avoid O/L Liddell to Muswellbrook (83) on trip of Liddell to Tamworth (84) line, Feedback	9	76.56% (151.38)	28.64% (48.22)
V^SML_NSWRB_2	Out = NSW Murraylink runback scheme, avoid voltage collapse for loss of Darlington Pt to Buronga (X5) 220kV line	44	71.% (65.72)	24.6% (28.71)
T>T_NIL_BL_110_18_1	Out = Nil, avoid O/L the Lake Echo Tee to Waddamana No.1 line (flow to North) for loss of Tungatinah to Waddamana No.2 110 kV line, feedback	25	63.69% (113.12)	28.58% (55.74)
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	63	57.03% (21.1)	27.53% (9.45)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

N>>N-964__3_OPENED: Investigated and no improvement can be made to the constraint equation at this stage.

V>>V_NIL_8: Investigated and no improvement can be made to the constraint equation at this stage

V::N_NIL_S2: Investigated and no improvement can be made to the constraint equation at this stage.

N_X_MBTE2_A: Investigated and the mismatch was due to issues with forecasting of the Terranora load. Improving the Terranora load forecast is currently being investigated.

V_T_NIL_FCSPS: This constraint equation uses analog values for the load enabled for the FCSPS in Pre-dispatch. This value can change quickly in dispatch and this is not possible to predict in Pre-dispatch. No changes proposed.

N>>N-NIL__3_OPENED: Investigated and constraint equation looks normal. The mismatch may be due to the local load distribution changes near Muswellbrook and Mitchell. Local load DFS when established can help with the PD performance.

N^^V_NIL_1: The Pre-dispatch formulation for this constraint equation was recalculated in early November 2017 (with an update to the limit advice). No further improvements can be made at this stage.

V^SML_NSWRB_2: Investigated and mismatch was due to the error on load forecast at the area (Red Cliffs, Kerang, Wemen, Ballarat) and/or Waubra wind farm generation. No improvements are proposed at this stage.

T>T_NIL_BL_110_18_1: Investigated and no improvement can be made to the constraint equation at this stage.

N_X_MBTE_3B: Investigated and the mismatch was due to issues with forecasting of the Terranora load. Improving the Terranora load forecast is currently being investigated.

3. GENERATOR / TRANSMISSION CHANGES

One of the main drivers for changes to constraint equations is from power system change, whether this is the addition or removal of plant (either generation or transmission). The following table details changes that occurred in February 2018.

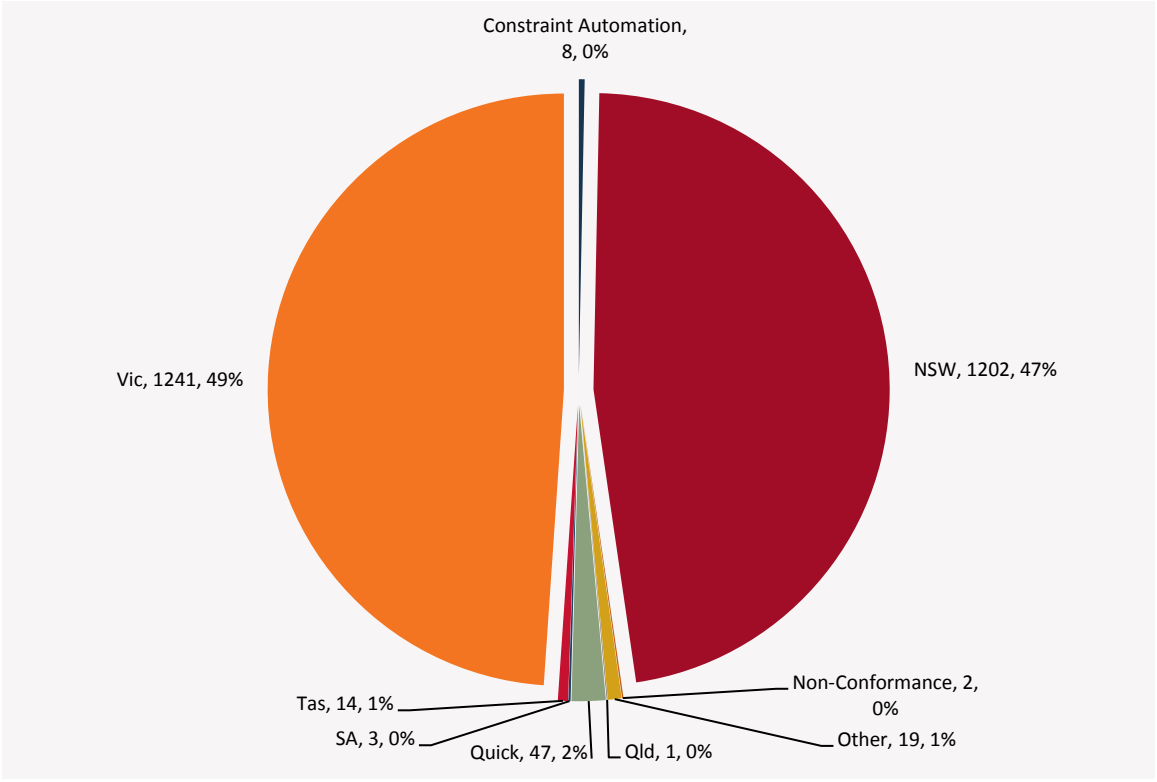
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Clare Solar Farm	14 February 2018	QLD	New Generator
Silverton Wind Farm	26 February 2018	NSW	New Generator

3.1. Constraint Equation Changes

The following pie chart indicates the regional location of constraint equation changes. For details on individual constraint equation changes refer to the Weekly Constraint Library Changes Report [2] or the constraint equations in the MMS Data Model.[3]

Figure 3-1 — Constraint equation changes



The following graph compares the constraint equation changes for the current year versus the previous two years. The current year is categorised by region.

[2] AEMO. *NEM Weekly Constraint Library Changes Report*. Available at: http://www.nemweb.com.au/REPORTS/CURRENT/Weekly_Constraint_Reports/
[3] AEMO. *MMS Data Model*. Available at: http://www.aemo.com.au/Electricity/IT-Systems/NEM

Figure 3-2 — Constraint equation changes per month compared to previous two years