MONTHLY CONSTRAINT REPORT - APRIL 2018

FOR THE NATIONAL ELECTRICITY MARKET

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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 April 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
VSML_ZERO	Vic to SA on ML upper transfer limit of 0 MW	4829 (402.41)	21/08/2013
SVML_ZERO	SA to Vic on ML upper transfer limit of 0 MW	2446 (203.83)	21/08/2013
S_NIL_STRENGTH_1	Upper limit of 1295 MW for South Australian non-synchronous generation for minimum synchronous generators online for system strength requirements. Automatically swamps out when required combination is online.	420 (35.0)	11/12/2017
V>>V_ROTS_TX_2A_R	Out = Rowville A1 or A2 500/220 kV txfmr, avoid pre-contingent overload of the South Morang F2 500/330 kV txfmr, radial mode, YWG1 on 500 kV, feedback	280 (23.33)	09/04/2018
S:V_500_HY_TEST_DYN	SA to VIC on Heywood upper transfer limit of 500 MW, limit for testing of Heywood interconnection upgrade, dynamic headroom, DS formulation only.	242 (20.16)	25/11/2015
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.	234 (19.5)	05/04/2018
T^V_HA_GT_220_1	Out= one George Town to Hadspen 220kV line, limit post-contingency loading on Palmerston to Sheffield 220kV line (flow to north) to avoid voltage collapse on trip of the remaining Hadspen to George Town 220kV line.	228 (19.0)	27/04/2015
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	213 (17.75)	09/04/2018
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.	124 (10.33)	05/04/2018
NQTE_ROC	Out=Nil, Rate of Change (NSW to Qld) constraint (80 MW / 5 Min) for Terranora Interconnector	119 (9.91)	08/11/2010

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
S_NIL_STRENGTH_1	Upper limit of 1295 MW for South Australian non-synchronous generation for minimum synchronous generators online for system strength requirements. Automatically swamps out when required combination is online.	590,759	11/12/2017
VSML_ZERO	Vic to SA on ML upper transfer limit of 0 MW	224,246	21/08/2013
N_BLOWERNG_ZERO	Blowering generation upper limit of 0 MW	213,000	12/04/2017
V_GANNAWR_ZERO	Gannawarra solar farm upper limit of 0 MW	213,000	26/02/2018
V::S_SETB_TBSE_2	Out= one South East to Tailem Bend 275kV line (NOTE: with both Black Range series capacitors O/S or I/S); Vic to SA Transient Stability limit for loss of one of the Tailembend-South East 275kV lines (South East Capacitor Available).	131,916	14/02/2017
F_T+RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	130,303	29/01/2015
F_MAIN+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink unable transfer FCAS	118,160	21/08/2013
F_MAIN+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink unable transfer FCAS	99,059	21/08/2013
F_T+LREG_0050	Tasmania Lower Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	93,168	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	87,982	02/12/2016

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.

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.

Table 2-3 – Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
I_CTRL_ISSUE_TE	DC Link Control Issue Constraint for Terranora	5 (0.41)	22/02/2018
V::S_SETB_TBSE_2	Out= one South East to Tailem Bend 275kV line (NOTE: with both Black Range series capacitors O/S or I/S); Vic to SA Transient Stability limit for loss of one of the Tailembend-South East 275kV lines (South East Capacitor Available).	3 (0.25)	14/02/2017
V^^S_SETB_TBSE_2	Out= one South East to Tailem Bend 275kV line (NOTE: with both Black Range series capacitors O/S or I/S); Vic to SA Long Term Voltage Stability limit for loss of one of the Tailembend-South East 275kV lines (South East Capacitor Available).	3 (0.25)	14/02/2017
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	3 (0.25)	02/12/2016
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	3 (0.25)	12/04/2016
T>T_FASH_1_N-2	Out = Nil, loss of both Farrell to Sheffield lines declared credible, Farrell 220 kV bus split, West Coast 220/110 kV parallel closed, avoid O/L Waratah Tee to Hampshire to Burnie 110 kV lines	2 (0.16)	16/02/2018
T_FASH_MAXGEN_1	Upper limit on Mackintosh + Reece 1 + Tribute with both Farrell to Sheffield 220 kV lines declared credible, Farrell 220 kV bus split, West Coast 220/110 kV parallel closed. Constraint swamped if only one machine on line	2 (0.16)	21/05/2015
F_T+LREG_0050	Tasmania Lower Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	2 (0.16)	29/01/2015
F_T+RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	2 (0.16)	29/01/2015
T>T_FASH_2_N-2	Out = Nil, loss of both Farrell to Sheffield lines declared credible, Farrell 220 kV bus split, avoid O/L Farrell 220/110kV No.2 transformer	2 (0.16)	16/02/2018

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
I_CTRL_ISSUE_TE	Constraint violated for 5 DIs. Max violation of 4.2 MW occurred on 23/04/2018 at 0005 hrs. Constraint violated due to competing requirement with Directlink import limit set by N_MBTE1_B.
V::S_SETB_TBSE_2	Constraint violated for 3 DIs on 26/04/2018 at 1130 hrs and 1135 hrs and on 27/04/2018 at 1850 hrs. Max violation of 243.47 MW occurred on 26/04/2018 at 1130 hrs. Constraint violated due to being invoked without ramping constraints (invoking ramping constraints is normal practice). In the DI prior, there was an unplanned outage of one the South East to Tailem Bend lines.
V^^S_SETB_TBSE_2	Constraint violated for 3 DIs on 26/04/2018 at 1130 hrs and 1135 hrs and on 27/04/2018 at 1850 hrs. Max violation of 228.61 MW occurred on 26/04/2018 at 1130 hrs. Constraint violated due to same reason as V::S_SETB_TBSE_2.
F_T+NIL_MG_RECL_R6	Constraint violated for 3 DIs on 16/04/2018 at 0405 hrs, 19/04/2018 at 0045 hrs and on 22/04/2018 at 2340 hrs. Max violation of 36.29 MW occurred on 16/04/2018 at 0405 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
F_T+NIL_MG_R6	Constraint equation violated for 3 DIs on 02/05/2018 at 1135 hrs and on 03/05/2018 at 0940 hrs. Max violation of 10.76 MW occurred on 03/05/2018 at 0445 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.

Constraint Equation ID (System Normal Bold)	Description
T>T_FASH_1_N-2	Constraint violated for 2 DIs on 24/04/2018 at 1440 hrs and 1445 hrs. Max violation of 131.94 MW occurred on 24/04/2018 at 1440 hrs. Constraint violated due to Mackintosh, Reece and Tribute being limited by their ramp down rates.
T_FASH_MAXGEN_1	Constraint violated for 2 DIs on 24/04/2018 at 1440 hrs and 1445 hrs. Max violation of 96.57 MW occurred on 24/04/2018 at 1440 hrs. Constraint violated due to same reason as T>T_FASH_1_N-2.
F_T+LREG_0050	Constraint violated for 2 DIs on 05/04/2018 at 1225 hrs and on 12/04/2018 at 1140 hrs. Max violation of 50 MW occurred on both violations. Constraint equation violated due to Tasmania lower regulation service availability less than the requirement.
F_T+RREG_0050	Constraint violated for 2 DIs on 05/04/2018 at 1225 hrs and on 12/04/2018 at 1140 hrs. Max violation of 50 MW occurred on both violations. Constraint equation violated due to Tasmania raise regulation service availability less than the requirement.
T>T_FASH_2_N-2	Constraint violated for 2 DIs on 24/04/2018 at 1440 hrs and 1445 hrs, Max violation of 28.72 MW occurred on 24/04/2018 at 1440 hrs. Constraint violated due to Reece and Tribute being limited by their ramp down rates.

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)
VSML_ZERO	V-S-MNSP1 Export	Vic to SA on ML upper transfer limit of 0 MW	4826 (402.17)	0.0 (0.0)
SVML_ZERO	V-S-MNSP1 Import	SA to Vic on ML upper transfer limit of 0 MW	2446 (203.83)	0.0 (0.0)
F_Q++MUTW_L6	NSW1-QLD1 Import	Out = Muswellbrook to Tamworth (88) line, Qld Lower 6 sec Requirement	635 (52.92)	-434.84 (-662.66)
F_Q++MUTW_L5	NSW1-QLD1 Import	Out = Muswellbrook to Tamworth (88) line, Qld Lower 5 min Requirement	604 (50.33)	-436.81 (-731.4)
F_Q++MUTW_L6	N-Q-MNSP1 Import	Out = Muswellbrook to Tamworth (88) line, Qld Lower 6 sec Requirement	577 (48.08)	-58.83 (-78.16)
F_Q++MUTW_L5	N-Q-MNSP1 Import	Out = Muswellbrook to Tamworth (88) line, Qld Lower 5 min Requirement	569 (47.42)	-59.88 (-81.0)
#N-Q-MNSP1_I_E	N-Q-MNSP1 Export	N-Q-MNSP1.ENERGY * -1 = 73 (Wt = 0.0001)	328 (27.33)	-69.0 (-65.0)
V>>V_ROTS_TX_2A_R	T-V-MNSP1 Export	Out = Rowville A1 or A2 500/220 kV txfmr, avoid pre-contingent overload of the South Morang F2 500/330 kV txfmr, radial mode, YWG1 on 500 kV, feedback	279 (23.25)	0.0 (0.0)
V>>V_ROTS_TX_2A_R	VIC1-NSW1 Export	Out = Rowville A1 or A2 500/220 kV txfmr, avoid pre-contingent overload of the South Morang F2 500/330 kV txfmr, radial mode, YWG1 on 500 kV, feedback	275 (22.92)	941.62 (1123.64)
V::N_NIL_V2	T-V-MNSP1 Import	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.	234 (19.5)	0.0 (-0.0)

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

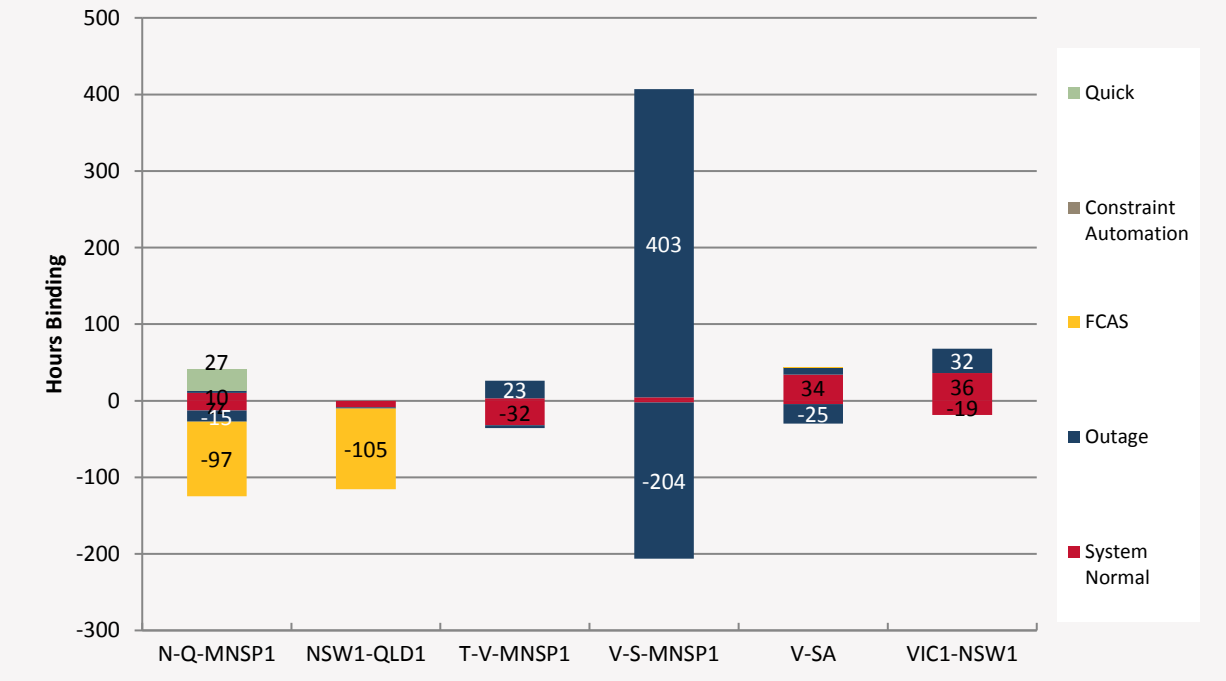
Non-real time constraint automation was not used.

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.

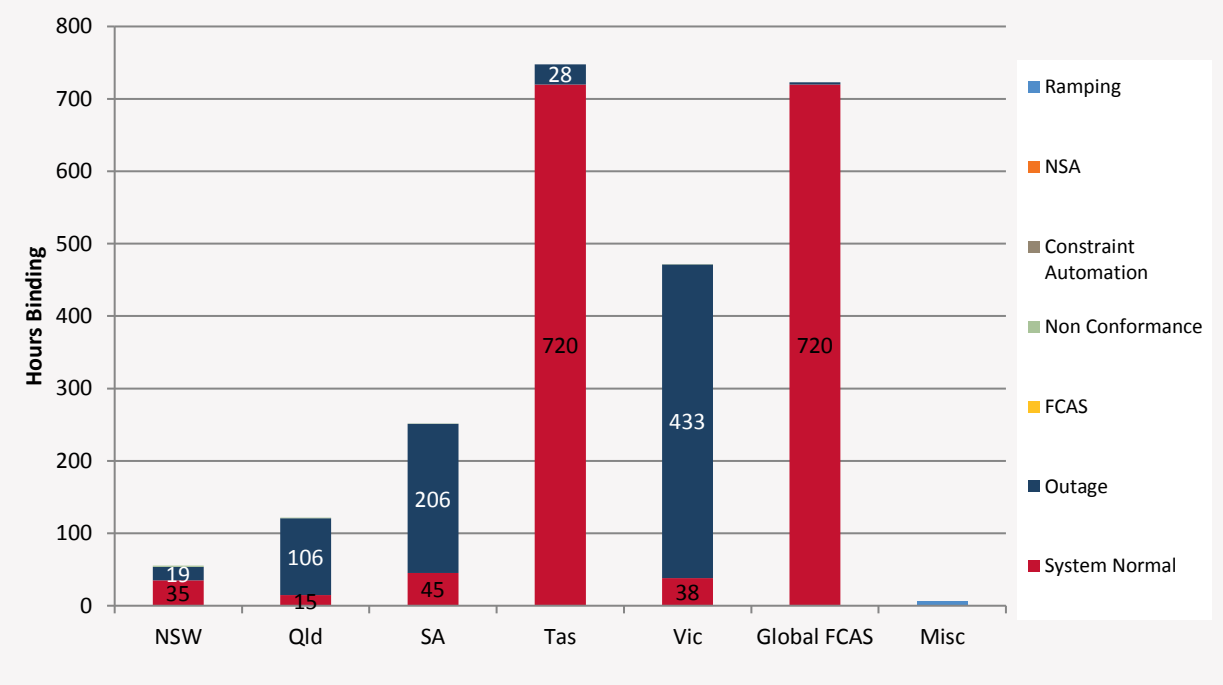
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

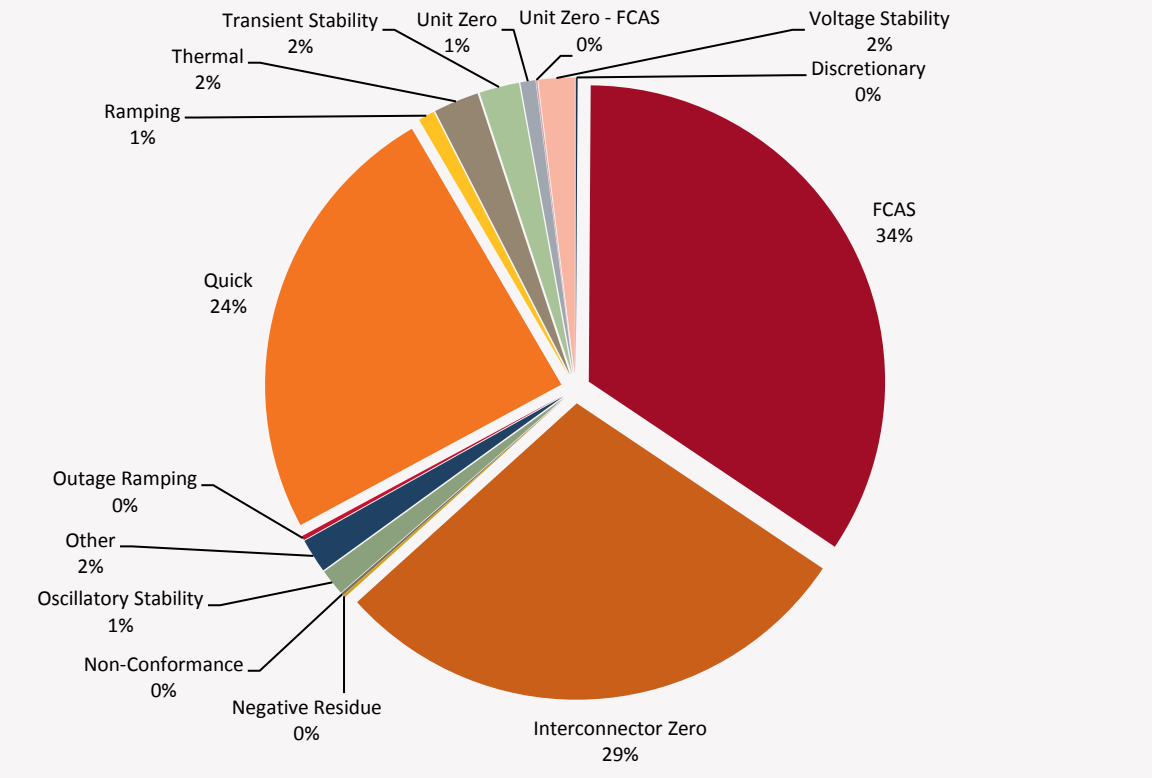
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

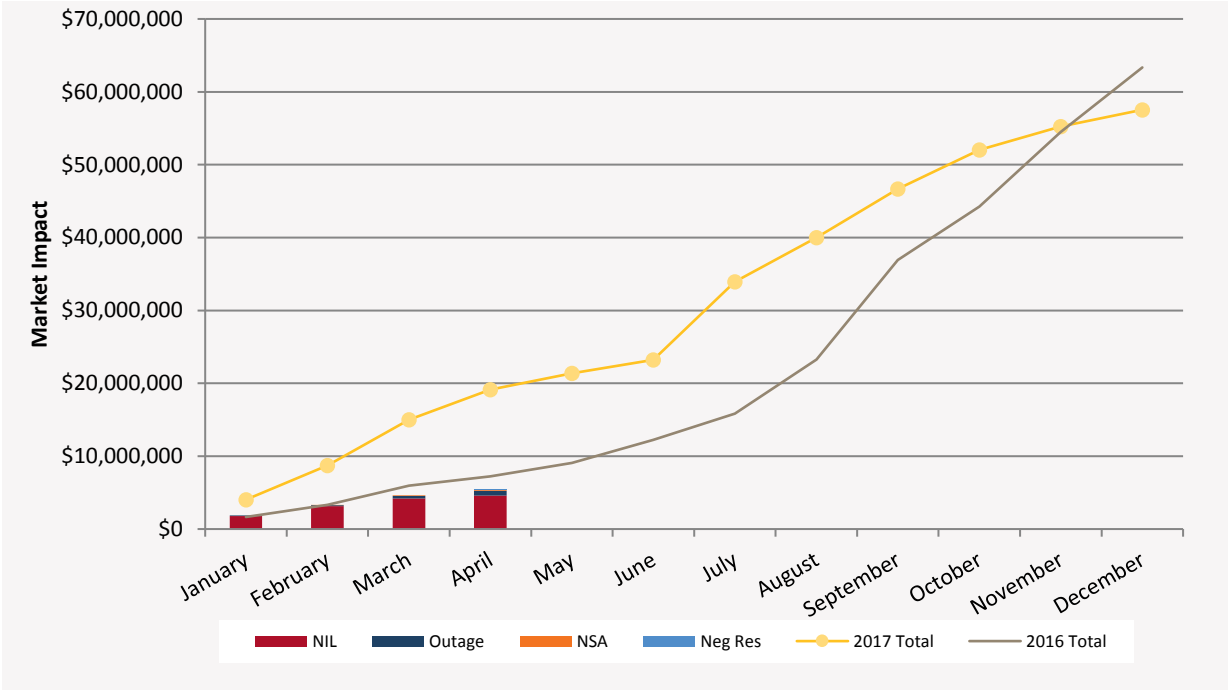
Figure 2-3 — Binding by limit type



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
S_NIL_STRENGTH_1	Upper limit of 1295 MW for South Australian non-synchronous generation for minimum synchronous generators online for system strength requirements. Automatically swamps out when required combination is online.	120	915% (9,419)	102.02% (1,120)
N>N-NIL_LSDU	Out = Nil, avoid overloading Lismore to Dunoon line (9U6 or 9U7) on trip of the other Lismore to Dunoon line (9U7 or 9U6), Feedback	20	234% (228.61)	57.8% (50.89)
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	3	128.71% (227.46)	122.12% (216.6)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
NRM_SA1_VIC1	Negative Residue Management constraint for SA to VIC flow	7	100.% (9,455)	100.% (9,423)
Q>NIL_MUTE_757	Out= Nil, ECS for managing 757 H4 Mudgeeraba to T174 Terranora 110kV line, Summer and Winter ECS ratings selected by SCADA status.	3	98.33% (99.95)	82.08% (99.95)
Q>NIL_MUTE_758	Out= Nil, ECS for managing 758 H4 Mudgeeraba to T174 Terranora 110kV line, Summer and Winter ECS ratings selected by SCADA status.	14	98.33% (99.95)	84.4% (99.95)
V>>V-MSUT_1	Out= Murray-UpperTumut(65), avoid Dederang to Wodonga (DDWO) O/L on Murray-LowerTumut(66) trip; Feedback	6	65.02% (452.58)	27.99% (194.88)
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	88	63.15% (263.24)	23.93% (76.87)
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	15	55.36% (16.8)	29.97% (8.41)
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.	32	50.91% (325.25)	25.49% (145.75)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

S_NIL_STRENGTH_1: Investigated and no improvement can be made to the constraint equation at this stage.

V>>V-MSUT_1: Investigated and no improvement can be made to the constraint equation at this stage.

NRM_SA1_VIC1: Investigated and no improvement can be made to the constraint equation at this stage.

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

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 April 2018.

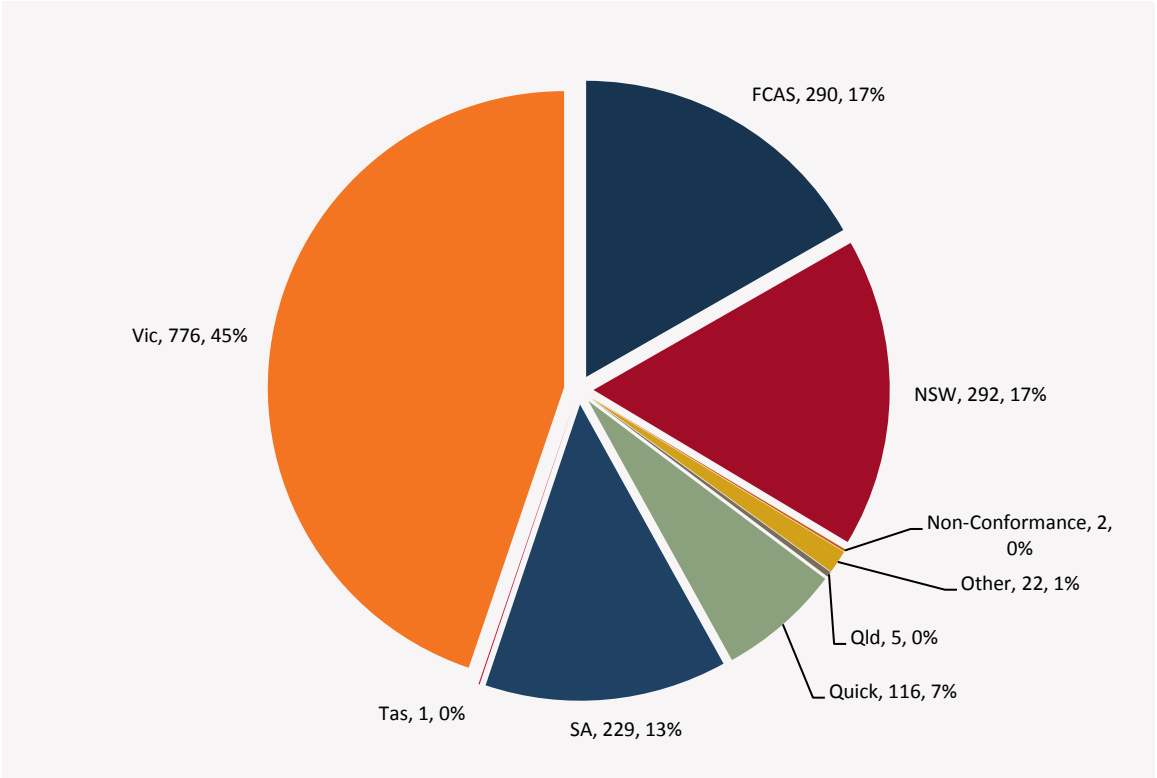
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Manildra Solar Farm	20 April 2018	NSW	New Generator
George Town No.3 Capacitor Bank	18 April 2018	TAS	George Town No.3 42 MVAr 110 kV capacitor bank commissioned.

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