MONTHLY CONSTRAINT REPORT - JUNE 2018

FOR THE NATIONAL ELECTRICITY MARKET

PUBLISHED **JULY 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 June 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
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.	1589 (132.41)	12/06/2018
Q::N_NIL_AR_2L-G	Out=Nil, limit Qld to NSW on QNI to avoid transient instability for a 2L-G fault at Armidale	577 (48.08)	15/01/2018
Q>N-MUTE_758	Out= 758 T174 Terranora to H4 Mudgeeraba 110kV line, avoid O/L on remaining Terranora to Mudgeeraba line on trip of Condong generator.	574 (47.83)	15/06/2017
V:S_600_HY_TEST_DYN	VIC to SA on Heywood upper transfer limit of 600 MW, limit for testing of Heywood interconnection upgrade, dynamic headroom, DS formulation only.	404 (33.66)	21/11/2016
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	382 (31.83)	09/04/2018
N^^V_NIL_MAXG_PP_N-2	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit + Pelican Point when they declared as single credible contingency	297 (24.75)	22/06/2018
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.	274 (22.83)	26/06/2018
VS_350	Victoria to SA on Vic-SA upper transfer limit of 350 MW	226 (18.83)	08/01/2014
V:S_600_HY_TEST	VIC to SA on Heywood upper transfer limit of 600 MW, limit for testing of Heywood interconnection upgrade.	170 (14.16)	28/07/2016
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	164 (13.66)	13/09/2016

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.	1,698,264	12/06/2018
T>T_HA_TX	Out = Hadspen 220/110 kV txfmr, avoid O/L Palmerston 220/110 kV txfmr (flow from 220 kV to 110 kV) on trip of remaining Hadspen 220/110 kV txfmr, feedback	108,133	16/06/2016
F_I+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a NEM Generation Event	106,433	21/08/2013
Q_CN1200	Qld Central to North upper transfer limit of 1200 MW (discretionary)	70,211	21/06/2018
F_MAIN+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink unable transfer FCAS	46,612	21/08/2013
Q::N_NIL_AR_2L-G	Out=Nil, limit Qld to NSW on QNI to avoid transient instability for a 2L-G fault at Armidale	44,081	15/01/2018
N^^N_NIL_1	Out= Nil, northerly flow on line 01,2,3 and 07 cut-set voltage stability limit, Feedback	42,751	02/05/2018
T_FATI	Out=Farrell-Tribute 220KV line. Energy <= 0MW	42,600	21/08/2013
N::V_BYGR_2	Out = Bannaby to Gullen Range(61), stability limit (Snowy-NSW) for loss of Yass-Marulan (4/5) 330kV line	37,990	28/06/2018
F_I+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a NEM Generation Event	37,108	21/08/2013

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
T>T_HA_TX	Out = Hadspen 220/110 kV txfmr, avoid O/L Palmerston 220/110 kV txfmr (flow from 220 kV to 110 kV) on trip of remaining Hadspen 220/110 kV txfmr, feedback	2 (0.16)	16/06/2016
NSA_V_BDL02_20	Bairnsdale Unit 2 >= 20 MW for Network Support Agreement	2 (0.16)	21/08/2013
V_ARWF_FSTTRP_5	Out= Ararat WF fast tripping scheme (disabled), Limit Ararat Windfarm upper limit to 5 MW, DS only. Swamp out if the scheme is in service (enabled).	1 (0.08)	18/05/2018
F_T_AUFLS2_R6	TAS AUFLS2 control scheme. Limit R6 enablement based on loaded armed for shedding by scheme.	1 (0.08)	04/05/2018
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_R5	Out = Nil, Raise 5 min 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_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_MINP_R6	Out= NIL, ensure minimum quantity of TAS R6 FCAS requirement provided through proportional response, considering Basslink headroom	1 (0.08)	30/04/2018

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
T>T_HA_TX	Constraint equation violated for 2 DIs last month. Max violation of 12.13 MW occurred on 06/06/2018 at 0740 hrs. Constraint equation violated due to Poatina 1 and 2 not following their dispatch target while the units were not on AGC.
NSA_V_BDL02_20	Constraint equation violated for 2 DIs last month. Max violation of 4.22 MW occurred on 24/06/2018 at 1630 hrs. Constraint equation violated due to the Bairnsdale unit 2 operating unexpectedly, resulting in a market bid that was lower than the 20 MW requirement.
V_ARWF_FSTTRP_5	Constraint equation violated for 1 DI on 30/06/2018 at 0705 hrs, with a violation degree of 37.6 MW. Constraint equation violated due to Ararat Wind Farm being limited by its ramp down rate. The Ararat Wind Farm Fast Tripping Scheme was disabled for this DI, requiring a reduction in the wind farm's output.
F_T_AUFLS2_R6	Constraint equation violated for 1 DI on 04/06/2018 at 0235 hrs with a violation degree of 12.08 MW. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
F_T+RREG_0050	Constraint equation violated for 1 DI on 02/06/2018 at 0750 hrs with a violation degree of 7.65 MW. Constraint equation violated due to Tasmania raise regulation service availability less than requirement.
F_T++NIL_MG_RECL_R5	Constraint equation violated for 1 DI on 30/06/2018 at 1230 hrs with a violation degree of 3.51 MW. Constraint equation violated due to Tasmania raise 5 minute service availability less than the requirement.
F_T+NIL_MG_RECL_R6	Constraint equation violated for 1 DI on 04/06/2018 at 0235 hrs with a violation degree of 1.7 MW. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
F_T_NIL_MINP_R6	Constraint equation violated for 1 DI on 02/06/2018 at 1715 hrs with a violation degree of 0.77 MW. Constraint equation violated due to Tasmania raise 6 second service availability less than the 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)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	721 (60.08)	331.35 (478.0)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	704 (58.67)	263.18 (478.0)
Q::N_NIL_AR_2L-G	NSW1-QLD1 Import	Out=Nil, limit Qld to NSW on QNI to avoid transient instability for a 2L-G fault at Armidale	577 (48.08)	-1109.22 (-1141.08)
Q>N-MUTE_758	N-Q-MNSP1 Import	Out= 758 T174 Terranora to H4 Mudgeeraba 110kV line, avoid O/L on remaining Terranora to Mudgeeraba line on trip of Condong generator.	574 (47.83)	-77.81 (-82.94)
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	491 (40.92)	3.93 (-477.9)
F_MAIN++NIL_MG_R60	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	488 (40.67)	294.29 (478.0)
F_MAIN++NIL_MG_R5_PP	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event (when Pelican Point GT11 +0.5STt PLUS the max Gen declared credible), Basslink able transfer FCAS	396 (33.0)	403.39 (478.0)
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	382 (31.83)	-498.34 (-1117.29)
F_MAIN++NIL_MG_R60_P	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event (when Pelican Point GT11 +0.5ST t PLUS the max Gen declared credible), Basslink able transfer FCAS	366 (30.5)	385.52 (478.0)
F_MAIN++APD_TL_L60	T-V-MNSP1 Import	Out = Nil, Lower 60 sec 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	298 (24.83)	22.87 (-476.0)

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.

Table 2-6 – Non-Real-Time Constraint Automation usage

Constraint Set ID	Date Time	Reason(s) for use
CA_SPS_4A3DEF97	21/06/2018 18:40 to 21/06/2018 18:45	Constraint Automation. Automatic constraint equation used to avoid overload on the Hazelwood A2 500/220 kV transformer for the loss of either the Hazelwood A3 or A4 500/220 kV transformers, during the outage of the Hazelwood A1 500/220 kV transformer. During this time, the Hazelwood A2 500/220 kV transformer was de-rated due to a cooling issue.

2.5.1. Further Investigation

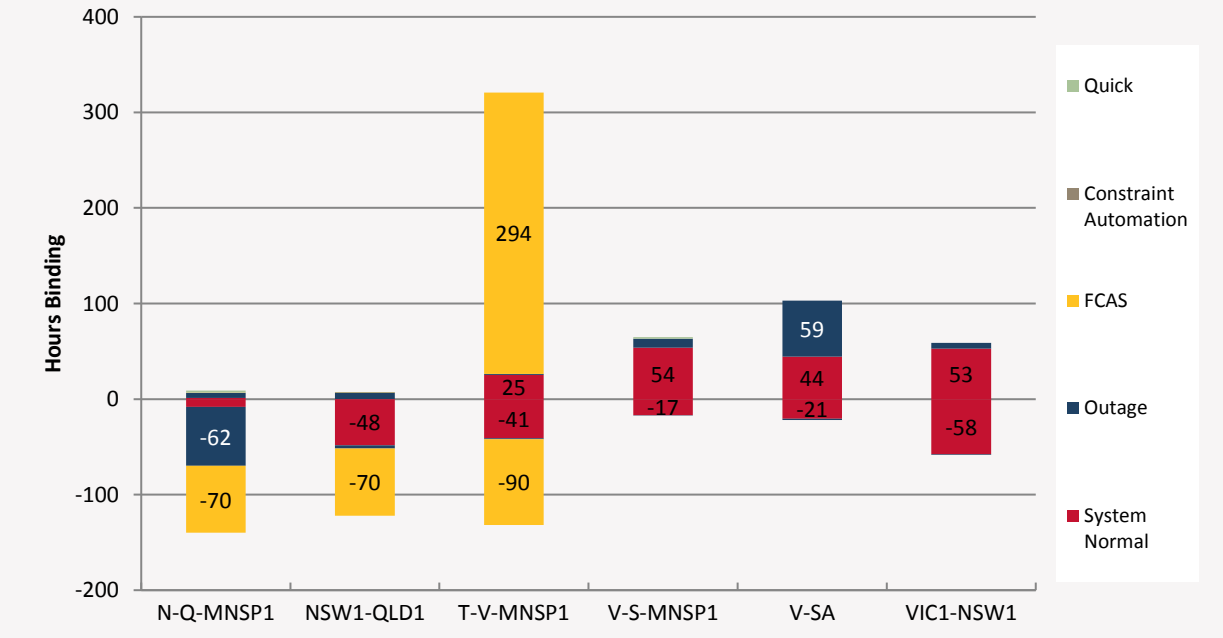
CA_SPS_4A3DEF97: The constraint for the same network configuration during the outage is unlikely to be required again as the cooling issue that the Hazelwood A2 500/220 kV transformer was de-rated to accommodate has been rectified. As a result, no constraints have been updated.

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.

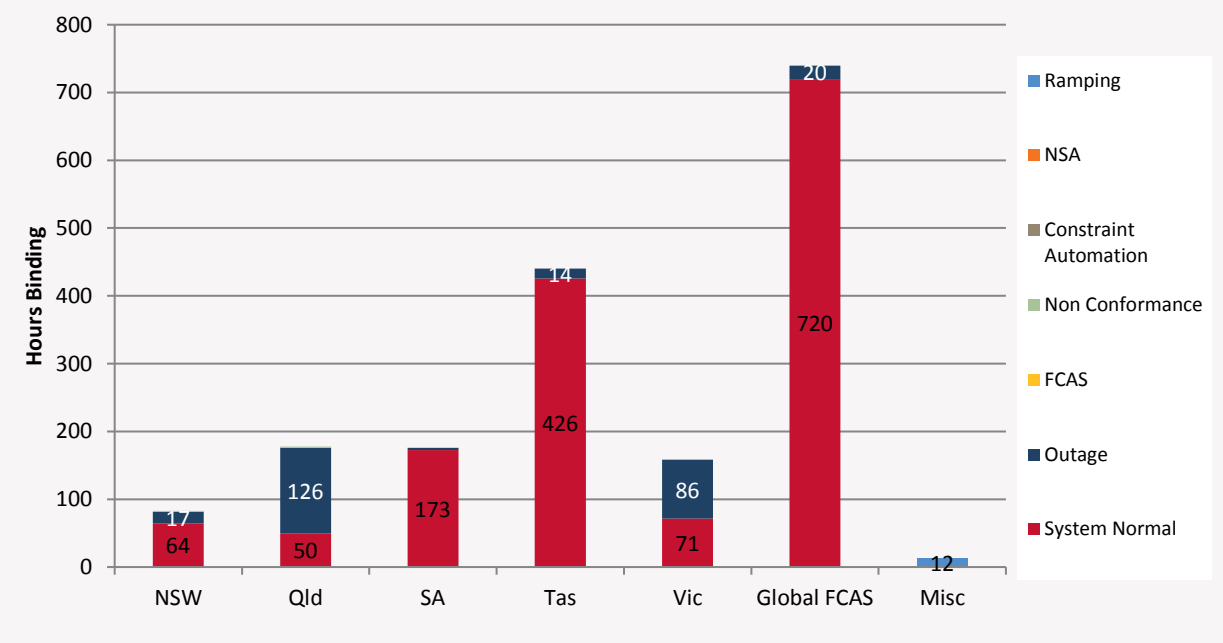
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

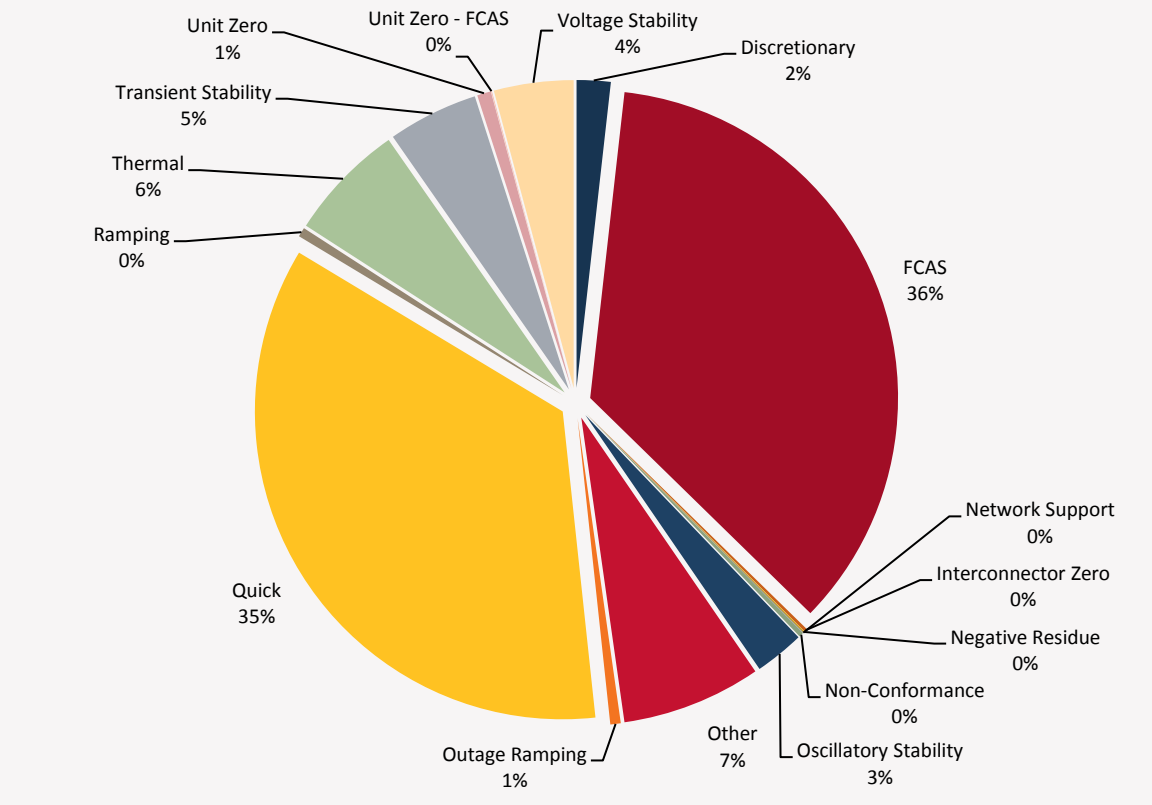
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

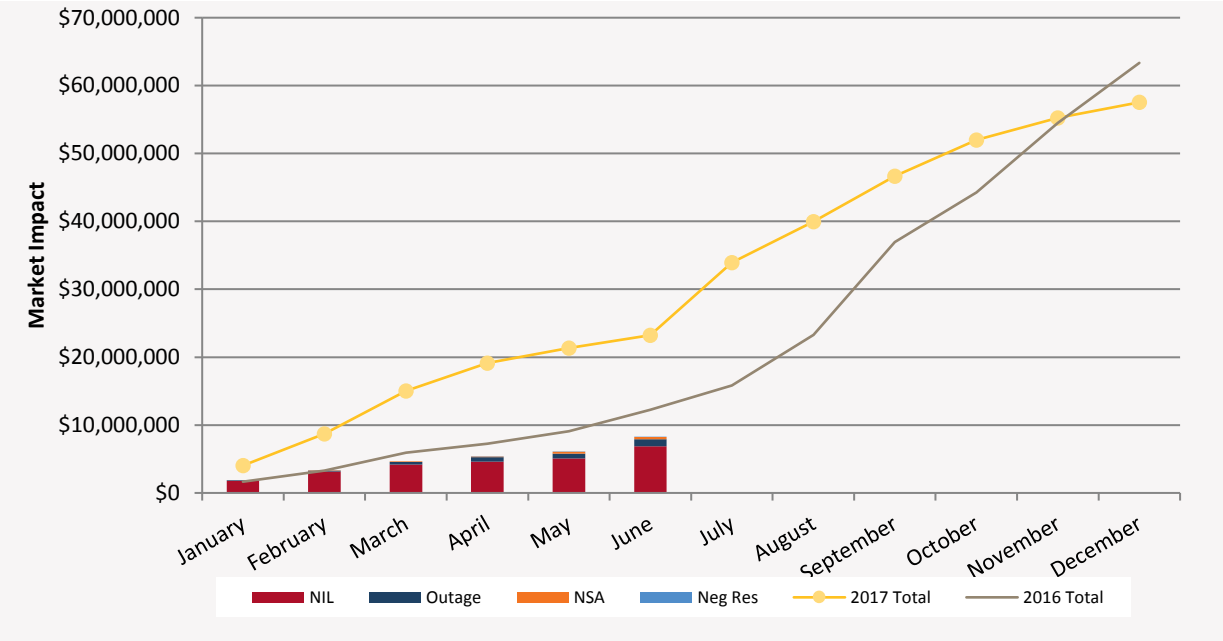
Figure 2-3 — Binding by limit type



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 2-7 – 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.	295	935% (9,496)	34.22% (1,203)
T>T_HA_TX	Out = Hadspen 220/110 kV txfmr, avoid O/L Palmerston 220/110 kV txfmr (flow from 220 kV to 110 kV) on trip of remaining Hadspen 220/110 kV txfmr, feedback	12	269% (122.19)	114.02% (75.38)
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.	6	253% (273.38)	121.7% (155.91)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
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.	22	216% (389.13)	56.96% (125.38)
N^^V_NIL_MAXG_PP_N-2	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit + Pelican Point when they declared as single credible contingency	63	141.3% (233.74)	48.72% (109.35)
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	31	139.56% (311.)	41.2% (90.61)
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.	68	125.36% (310.68)	21.73% (70.79)
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.	8	98.33% (99.95)	92.23% (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.	10	98.33% (99.95)	98.33% (99.95)
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	182	97.4% (248.05)	33.5% (87.51)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

S_NIL_STRENGTH_1: Investigated. Mismatch was due to differences in generator targets 4 hours in the future compared to targets in dispatch. No improvement can be made to the constraint equation at this stage.

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

V::N_NIL_Q2: 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^^V_NIL_MAXG_PP_N-2: Investigated and no improvement can be made to the constraint equation at this stage.

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.

V::N_NIL_V2: Investigated and no improvement can be made to the constraint equation at this stage.

Q>NIL_MUTE_757: Investigated. Mismatch was due to difference between modelling of Terranora control scheme and line status between DS and PD. No improvement can be made to the constraint equation at this stage.

Q>NIL_MUTE_758: Investigated. Mismatch was due to difference between modelling of Terranora control scheme and line status between DS and PD. 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.

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 June 2018.

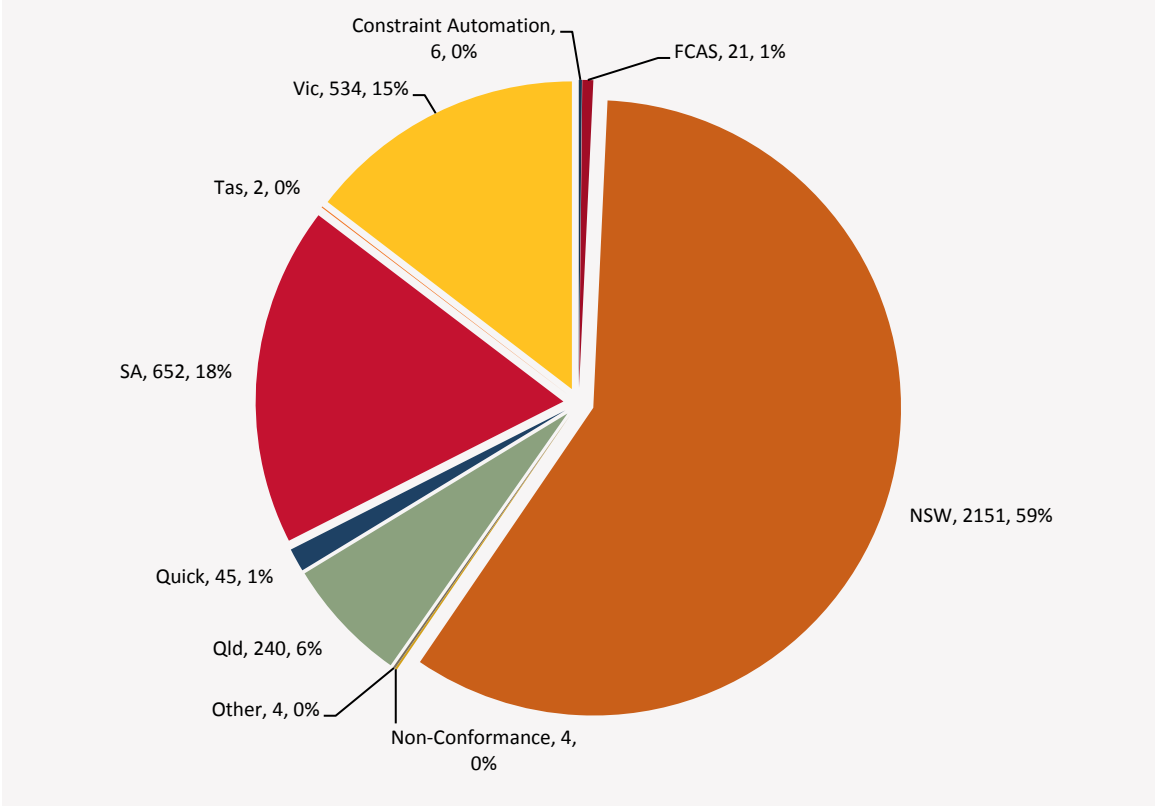
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Mt Gellibrand Wind Farm	01 June 2018	VIC	New Generator
Dalrymple Battery	05 June 2018	SA	New Battery
Crookwell Substation	05 June 2018	NSW	Crookwell substation has been energised at 330 kV. Bannaby – Gullen Range 330 kV transmission line has now been cut to form two lines connecting to Crookwell Windfarm substation. The new transmission line names are Bannaby – Crookwell 330 kV transmission line and Crookwell – Gullen Range 330 kV transmission line.

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



[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

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

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