AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Monthly Constraint Report

October 2018

A report for the National Electricity Market

Important notice

PURPOSE

This publication has been prepared by AEMO 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 October 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 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	1717 (143.08)	04/09/2018
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.	1029 (85.75)	04/10/2018
NSA_S_POR03_ISLD	Network Support Agreement for Port Lincoln Unit 3 to meet local islanded demand for the planned outage.	845 (70.41)	15/10/2014
NSA_S_POR01_ISLD	Network Support Agreement for Port Lincoln Units 1 and 2 to meet local islanded demand for the planned outage.	845 (70.41)	15/10/2014
N_X_MBTE2_B	Out= two Directlink cables, Qld to NSW limit	614 (51.16)	25/11/2013
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	566 (47.16)	25/11/2013
S>>PATW_BWPA_TPRS	Out= Para-Templers West 275kV line, avoid O/L Templers-Roseworthy 132kV line on trip of Blyth West-Munno Para 275kV line, Feedback	424 (35.33)	16/10/2018
Q>NIL_BI_CAGS_CALV_O	Out= Nil, H8 Boyne Island feeder bushing (FB) limit on Calliope River to Boyne Island 132 kV lines, 7104/7105 (T022 Callide A to T152 Gladstone South) 132 kV lines closed with 132 kV split between T022 Callide A and H015 Lilyvale.	342 (28.5)	27/09/2017

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
N_STWF1_ZERO	Silverton wind farm upper limit of 0 MW	283 (23.58)	06/02/2018
N_MBTE1_B	Out= one Directlink cable, Qld to NSW limit	189 (15.75)	25/11/2013

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 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.	1,082,229	04/10/2018
N_STWF1_ZERO	Silverton wind farm upper limit of 0 MW	308,273	06/02/2018
Q_CN0540	Qld Central to North upper transfer limit of 540 MW (discretionary)	230,713	30/08/2018
F_T_AUFLS2_R6	TAS AUFLS2 control scheme. Limit R6 enablement based on loaded armed for shedding by scheme.	217,606	04/05/2018
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	203,156	04/09/2018
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	154,198	12/04/2016
S>>PATW_BWPA_TPRS	Out= Para-Templers West 275kV line, avoid O/L Templers-Roseworthy 132kV line on trip of Blyth West-Munno Para 275kV line, Feedback	145,061	16/10/2018
F_I+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a NEM Generation Event	125,700	21/08/2013
F_T_NIL_MINP_R6	Out= NIL, ensure minimum quantity of TAS R6 FCAS requirement provided through proportional response, considering Basslink headroom	124,398	30/04/2018
F_I+LREG_0150	NEM Lower Regulation Requirement greater than 150 MW	56,350	12/10/2018

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.

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 3 Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
Q>NIL_BI_CAGS_CALV_O	Out= Nil, H8 Boyne Island feeder bushing (FB) limit on Calliope River to Boyne Island 132 kV lines, 7104/7105 (T022 Callide A to T152 Gladstone South) 132 kV lines closed with 132 kV split between T022 Callide A and H015 Lilyvale.	23 (1.91)	27/09/2017
F_T_AUFLS2_R6	TAS AUFLS2 control scheme. Limit R6 enablement based on loaded armed for shedding by scheme.	17 (1.41)	04/05/2018
Q_CN0540	Qld Central to North upper transfer limit of 540 MW (discretionary)	15 (1.25)	30/08/2018
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	11 (0.91)	12/04/2016
NSA_S_POR03_ISLD	Network Support Agreement for Port Lincoln Unit 3 to meet local islanded demand for the planned outage.	5 (0.41)	15/10/2014
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	2 (0.16)	02/12/2016
N^N-LS_SVC	Out= Lismore SVC O/S or in reactive power control mode, avoid Voltage collapse on Armidale to Coffs Harbour (87) trip; TG formulation only	2 (0.16)	27/08/2018
F_Q++BCDM_L5	Out = Bulli Creek to Dumaresq (8L or 8M) or Dumaresq to Sapphire (8J) line, Qld Lower 5 min Requirement	1 (0.08)	26/04/2018
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
T::T_HA_GT_PM_4	Out = Hadspen to George Town or Hadspen to Palmerston 220 kV line, prevent poorly damped TAS North - South oscillations following fault and trip of Palmerston to Sheffield 220 kV line, Tamar CCGT out of service.	1 (0.08)	31/07/2014

2.3.1 Reasons for constraint equation violations

Table 4 Reasons for constraint equation violations

Constraint Equation ID (System Normal Bold)	Description
Q>NIL_BI_CAGS_CALV_O	Constraint equation violated for 23 DIs during the month, 9 of which were consecutive. Max violation of 34.39 MW occurred on 09/10/2018 at 0845hrs. Constraint equation violated due to an issue with the control system of Gladstone Unit 3, which reduced its ramp down rate capability.
F_T_AUFLS2_R6	Constraint equation violated for 17 DIs during the month, 4 of which were consecutive. Max violation of 24 MW occurred on 30/10/2018 at 1625hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than requirement.

Constraint Equation ID (System Normal Bold)	Description
Q_CN0540	Constraint equation violated for 15 consecutive DIs in the month. Max violation of 145.26 MW occurred on 23/10/2018 at 0635hrs. Constraint equation violated due to a lack of generation availability in northern Queensland following the unplanned outage of the Stanwell to Broadsound (8831) 275kV line.
F_T+NIL_WF_TG_R6	Constraint equation violated for 11 DIs over the month. Max violation of 31.16 MW occurred on 09/10/2018 at 2355hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than requirement.
NSA_S_POR03_ISLD	Constraint equation violated for 5 DIs over the month. Max violation of 3 MW occurred on 29/10/2018 at 1645hrs. Constraint equation violated due to Port Lincoln unit 3 being limited by its start-up profile.
F_T+NIL_MG_RECL_R6	Constraint equation violated for 2 DIs in the month. Max violation of 28.84 MW occurred on 07/10/2018 at 0035hrs. Constraint equation violated due to Tasmania raise 6 second service availability being limited by constraint equation F_T_AUFLS2_R6
N^N-LS_SVC	Constraint equation violated for 2 DIs over the month with a violation degree of 28 MW occurring on 04/10/2018 at both 1740hrs and 1745hrs. Constraint equation violated due to competing requirement with the Terranora Interconnector import limit set by N_X_MBTE_3B.
F_Q++BCDM_L5	Constraint equation violated for 1 DI during the month on 18/10/2018 at 1140hrs with a violation degree of 38.44 MW. Constraint equation violated due to Queensland lower 5-minute service availability being less than the requirement, following the reclassification of the simultaneous loss of the Dumaresq to Bulli Creek (8L and 8M) 330kV lines as a credible contingency.
F_T_NIL_MINP_R6	Constraint equation violated for 1 DI during the month on 03/10/2018 at 0405hrs with a violation degree of 11 MW. Constraint equation violated due to Tasmania raise 6 second service availability being limited by constraint equation F_T_AUFLS2_R6.
T::T_HA_GT_PM_4	Constraint equation violated for 1 DI on 31/10/2018 at 0630hrs with a violation degree of 8.2 MW. Constraint equation violated due to Reece unit 1 being limited by its ramp down rate.

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 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 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	1717 (143.08)	-328.05 (-671.88)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	1263 (105.25)	-104.15 (477.99)
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	1207 (100.58)	6.09 (-474.05)
F_MAIN++NIL_MG_R60	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	777 (64.75)	-11.31 (478.0)

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	739 (61.58)	-16.12 (478.0)
N_X_MBTE2_B	N-Q-MNSP1 Import	Out= two Directlink cables, Qld to NSW limit	614 (51.17)	-69.96 (-88.4)
N_X_MBTE_3B	N-Q-MNSP1 Import	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	566 (47.17)	-13.59 (-41.9)
S>>PATW_BWPA_TPRS	V-S-MNSP1 Export	Out= Para-Templers West 275kV line, avoid O/L Templers-Roseworthy 132kV line on trip of Blyth West-Munno Para 275kV line, Feedback	424 (35.33)	-105.57 (-14.19)
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	410 (34.17)	-107.69 (-476.85)
F_Q++BCDM_L6	NSW1-QLD1 Import	Out = Bulli Creek to Dumaresq (8L or 8M) or Dumaresq to Sapphire (8J) line, Qld Lower 6 sec Requirement	209 (17.42)	-290.05 (-399.75)

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

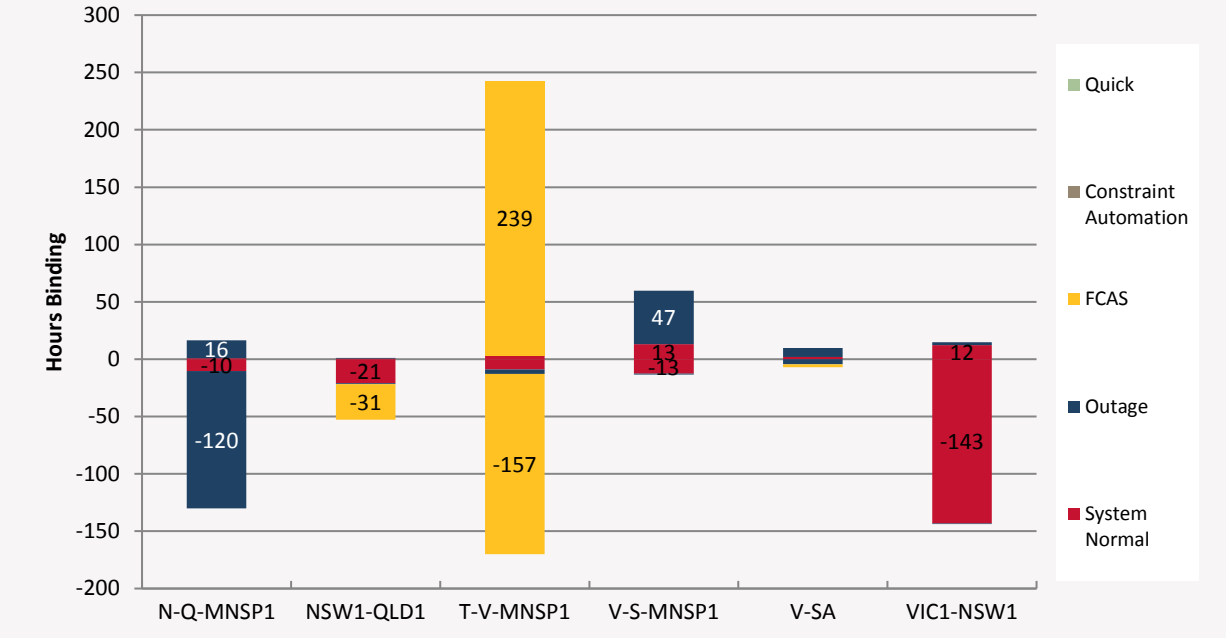
Non-real time constraint automation was not used.

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.

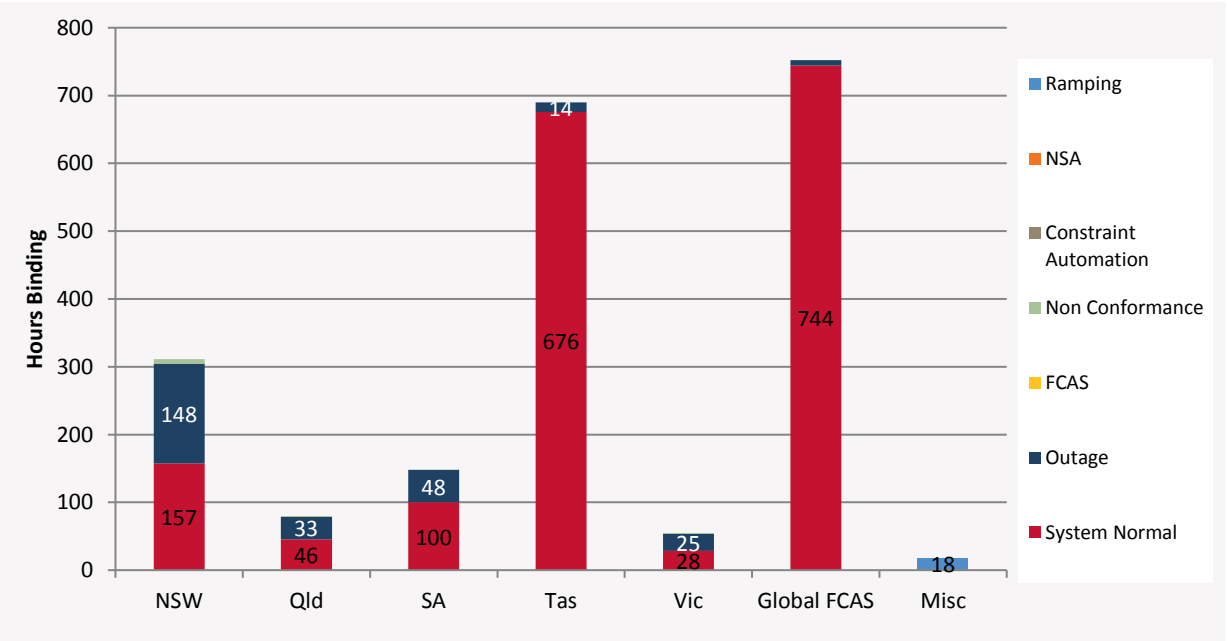
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

Figure 1 Interconnector binding dispatch hours



The regional comparison graph below uses the same categories as in Figure 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.

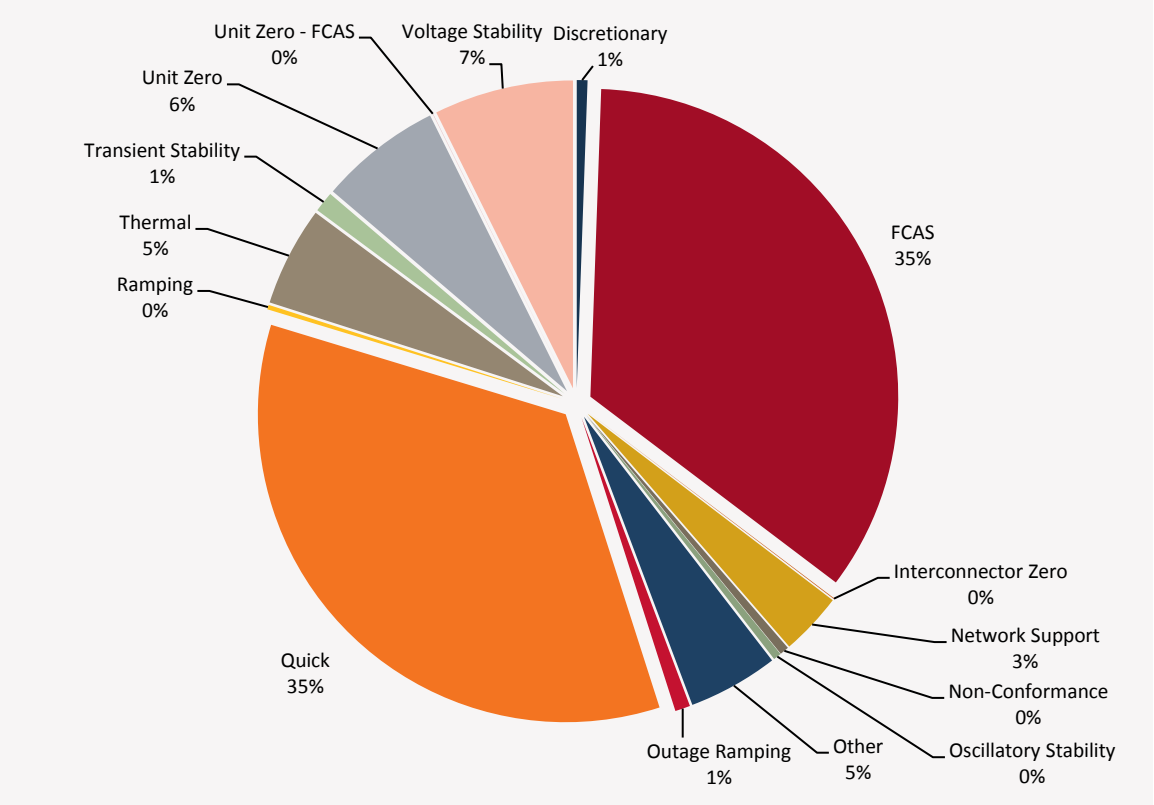
Figure 2 Regional binding dispatch hours



2.7 Binding Constraint Equations by Limit Type

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

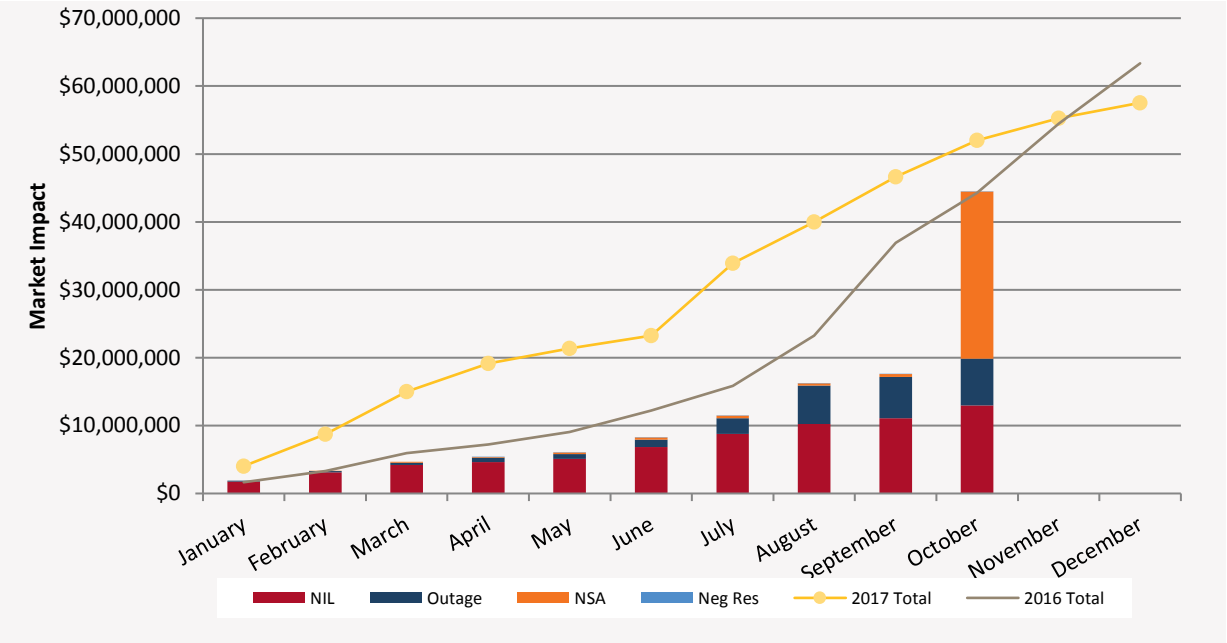
Figure 3 Binding by limit type



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 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 6 Top 10 largest Dispatch / Pre-dispatch differences

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
V^SML_HORC_3	Out = Horsham to Red Cliffs 220kV line, avoid voltage collapse for loss of Bendigo to Kerang 220kV line	9	2,971% (44.95)	474% (13.22)
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.	178	917% (9,248)	9.45% (187.38)
N^N-LS_SVC	Out= Lismore SVC O/S or in reactive power control mode, avoid Voltage collapse on Armidale to Coffs Harbour (87) trip; TG formulation only	34	758% (100.97)	130.96% (31.27)
NSA_S_POR03_ISLD	Network Support Agreement for Port Lincoln Unit 3 to meet local islanded demand for the planned outage.	148	330% (7.99)	59.23% (2.52)
V>SMLARHO1	Out = Ararat to Crowlands or Crowlands to Horsham 220kV line, avoid O/L or voltage collapse on Buronga to Balranald to Darlington Point (X5) line for trip of Bendigo to Kerang 220kV line	4	180% (44.01)	96.02% (32.21)
NSA_S_POR01_ISLD	Network Support Agreement for Port Lincoln Units 1 and 2 to meet local islanded demand for the planned outage.	148	153% (8.61)	36.64% (3.02)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	92	153% (34.6)	52.29% (10.18)
T^V_HAPM_220_1	Out = Hadspen to Palmerston 220 kV line, prevent voltage collapse at George Town 220 kV bus for loss of parallel Hadspen to Palmerston 220 kV line	10	109.43% (144.12)	55.91% (80.28)
T_V_NIL_BL1	Out=Nil, Basslink no go zone limits Tas to Vic	4	108.42% (644)	108.42% (644)
N_X_MBTE_3A	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	3	100.91% (11.1)	78.47% (9.5)

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.

N^N-LS_SVC: Investigated and constraint equation was updated on 27/08 to improve PD performance.

V>SMLARHO1: 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 October 2018.

Table 7 Generator and transmission changes

Project	Date	Region	Notes
Karadoc Solar Farm	9 October 2018	VIC	New Generator
Coopers Gap 275 kV substation	17 October 2018	QLD	A new substation cut-in between Halys and Western Downs on the previous 8866 275 kV line
Corraberra Hill 275 kV substation	17 October 2018	SA	A new substation cut-in between Cultana and Davenport. Previous Cultana to Davenport No. 1 275 kV line is now Cultana to Corraberra Hill to Davenport 275 kV line

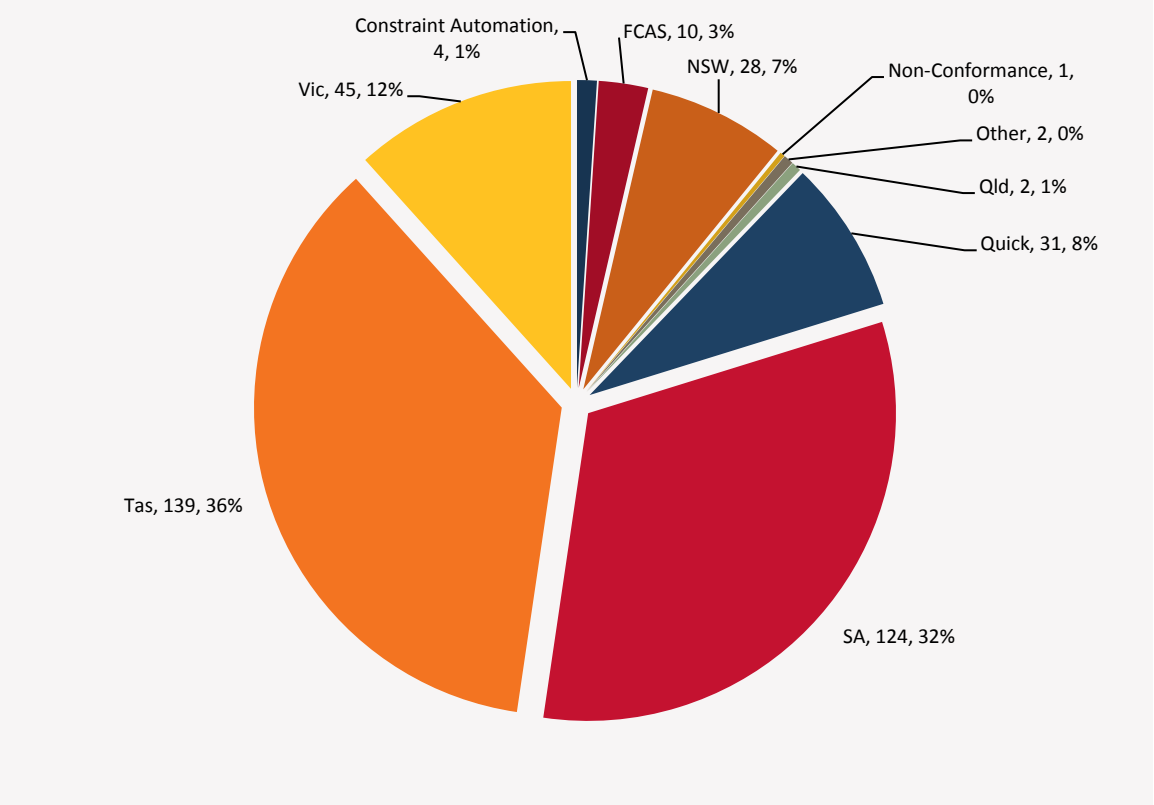
3.1 Constraint Equation Changes

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]

[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 5 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.

Figure 6 Constraint equation changes per month compared to previous two years