MONTHLY CONSTRAINT REPORT - MARCH 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 March 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	2007 (167.25)	16/02/2018
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.	477 (39.75)	11/12/2017
T>T_NIL_110_1	Out = NIL, avoid pre-contingent O/L of the Derby to Scottsdale Tee 110 kV line, feedback	355 (29.58)	05/03/2014
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	270 (22.5)	25/11/2013
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	267 (22.25)	20/12/2016
N>>V-NIL_O	Out = Nil, avoid overloading Upper Tumut to Murray (65) using 15 mins rating line on trip of Lower Tumut to Wagga (051) + 970,990,99M (out of Yass) line, Feedback	163 (13.58)	23/02/2018
N_X_MBTE_3A	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	154 (12.83)	25/11/2013
V>>V_NIL_2A_R	Out = Nil, avoid pre-contingent O/L of South Morang F2 500/330kV transformer, radial mode, YWPS unit 1 on 500kV, feedback	151 (12.58)	20/03/2018
V_BALDHILL_ZERO	Bald Hill Windfarm upper limit of 0 MW	107 (8.91)	21/01/2015
V_OAKHILL_TFB_42	Out = Nil, Oaklands Hill Windfarm upper limit of 42.7 MW due to Oaklands Hill windfarm TFB mode operation, DS only. Swamp out if TFB mode is OFF	103 (8.58)	18/04/2017

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.	471,856	11/12/2017
T>T_NIL_110_1	Out = NIL, avoid pre-contingent O/L of the Derby to Scottsdale Tee 110 kV line, feedback	203,989	05/03/2014
V_OAKHILL_TFB_42	Out = Nil, Oaklands Hill Windfarm upper limit of 42.7 MW due to Oaklands Hill windfarm TFB mode operation, DS only. Swamp out if TFB mode is OFF	111,089	18/04/2017
S_HALWF2_0	Discretionary upper limit for Hallett 2 Wind Farm generation of 0 MW	102,329	21/08/2013
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	83,281	16/02/2018
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	62,781	12/04/2016
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	61,581	02/12/2016
V_MORTLAKE12_ZERO	Mortlake unit 1 & 2 upper limit of 0 MW	57,888	21/08/2013
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	56,767	12/04/2016
F_I+LREG_0120	NEM Lower Regulation Requirement greater than 120 MW	51,241	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.

Table 2-3 – Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
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	17 (1.41)	12/04/2016

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	11 (0.91)	12/04/2016
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	8 (0.66)	02/12/2016
Q_RS_560	Qld, Ross cutset upper limit of 560MW (discretionary)	3 (0.25)	20/12/2017
F_T+RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	3 (0.25)	29/01/2015
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.	1 (0.08)	06/06/2016

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
F_T+NIL_WF_TG_R6	Constraint violated for 17 non-consecutive DIs. Max violation of 25.04 MW occurred on 12/03/2018 at 0335 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
F_T+NIL_MG_R6	Constraint violated for 11 non-consecutive DIs. Max violation of 28.19 MW occurred on 12/03/2018 at 0335 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
F_T+NIL_MG_RECL_R6	Constraint violated for 8 non-consecutive DIs. Max violation of 7.61 MW occurred on 17/03/2018 at 1255 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
Q_RS_560	Constraint equation violated for 3 DIs on 14/03/2018 at 1925 hrs, 1930 hrs and 1935 hrs. Max violation of 140.71 MW occurred at 1925 hrs. Constraint equation violated due to Townsville GT (Yabulu) unit 1 was limited by its start-up profile.
F_T+RREG_0050	Constraint equation violated for 3 DIs on 28/03/2018 at 0700 hrs and 0705 hrs and on 29/03/2018 at 0700 hrs. Max violation of 49 MW occurred on 28/03/2018 at 0705 hrs. Constraint equation violated due to Tasmania raise regulation service availability less than the requirement.
T_TAMARCCGT_GCS	Constraint violated for 1 DI on 06/03/2018 at 0910 hrs with a violation degree of 11.37 MW. Constraint equation violated due to reduction in load armed by the Tamar GCS (generator control scheme) and Tamar Valley 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 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	1988 (165.67)	-587.22 (-966.22)

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
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	1300 (108.33)	-229.4 (-477.2)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	392 (32.67)	-44.52 (478.0)
N_X_MBTE_3B	N-Q-MNSP1 Import	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	270 (22.5)	-47.13 (-67.6)
V_T_NIL_FCSPS	T-V-MNSP1 Import	Basslink limit from Vic to Tas for load enabled for FCSPS	237 (19.75)	-374.9 (-469.18)
F_MAIN++NIL_MG_R60	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	233 (19.42)	-85.59 (475.0)
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	202 (16.83)	-361.61 (-477.96)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	173 (14.42)	83.26 (478.0)
F_MAIN++ML_L6_APD	T-V-MNSP1 Import	Out = Nil, Lower 6 sec requirement for a Mainland Load Event, ML = APD, Basslink able transfer FCAS	154 (12.83)	-333.7 (-477.01)
N_X_MBTE_3A	N-Q-MNSP1 Export	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	154 (12.83)	-64.69 (-42.5)

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

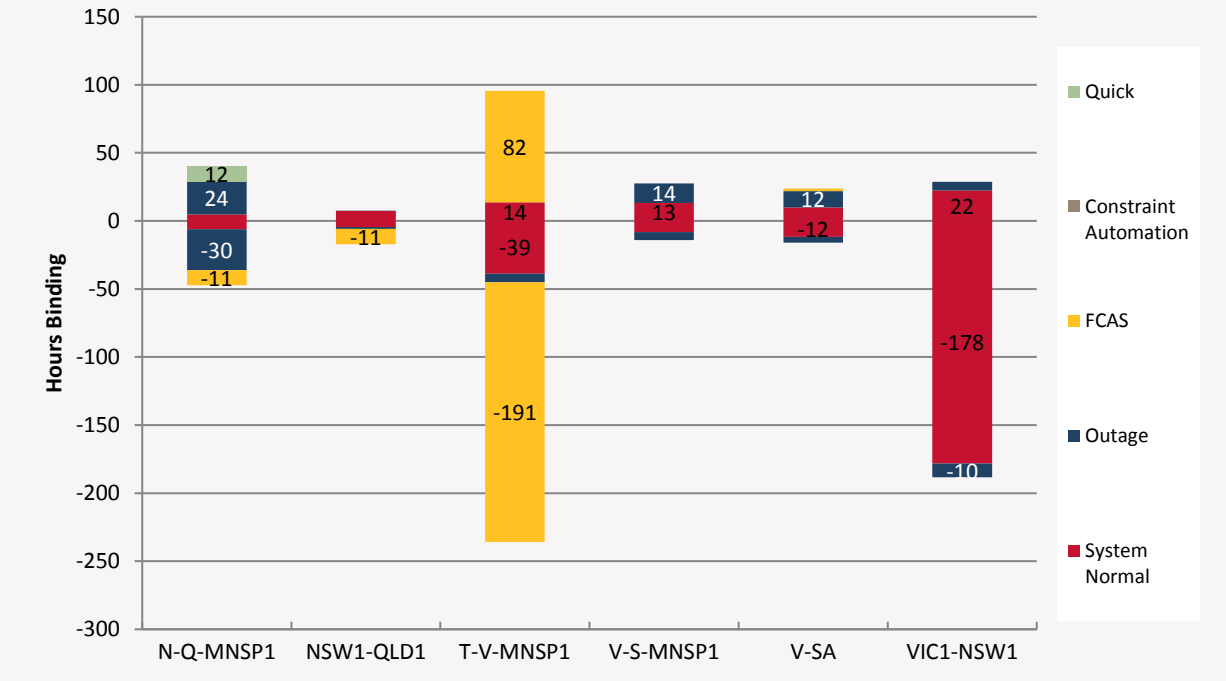
Non-real time constraint automation was not used.

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.

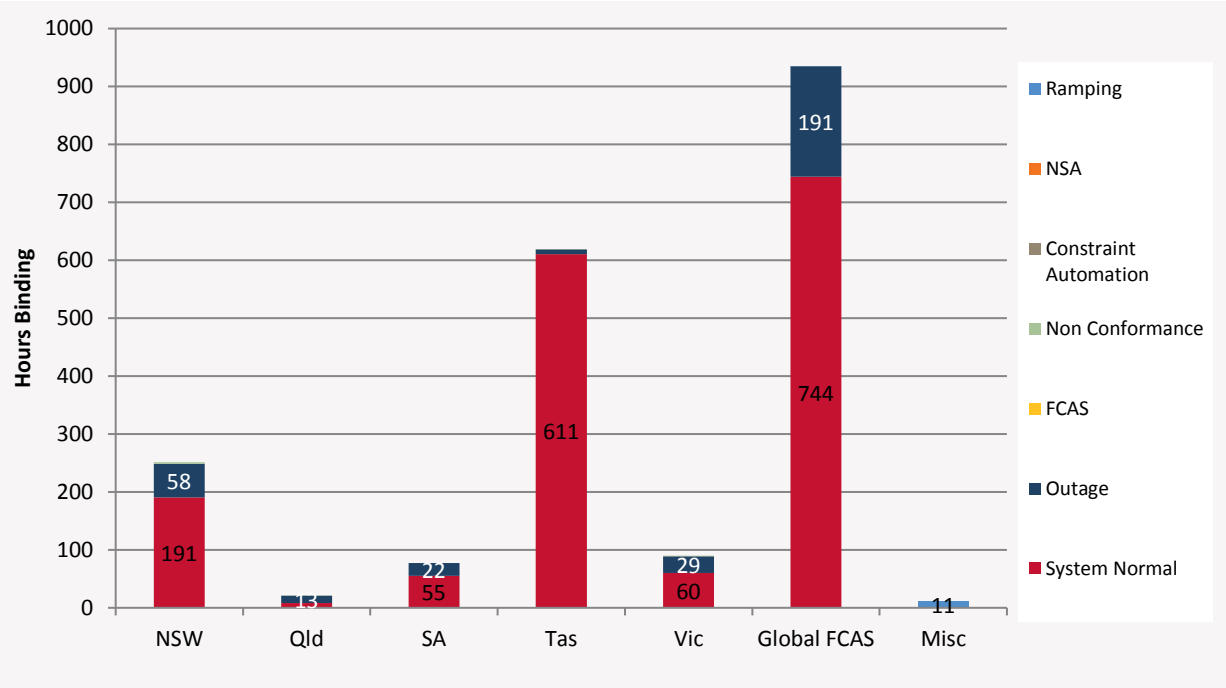
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

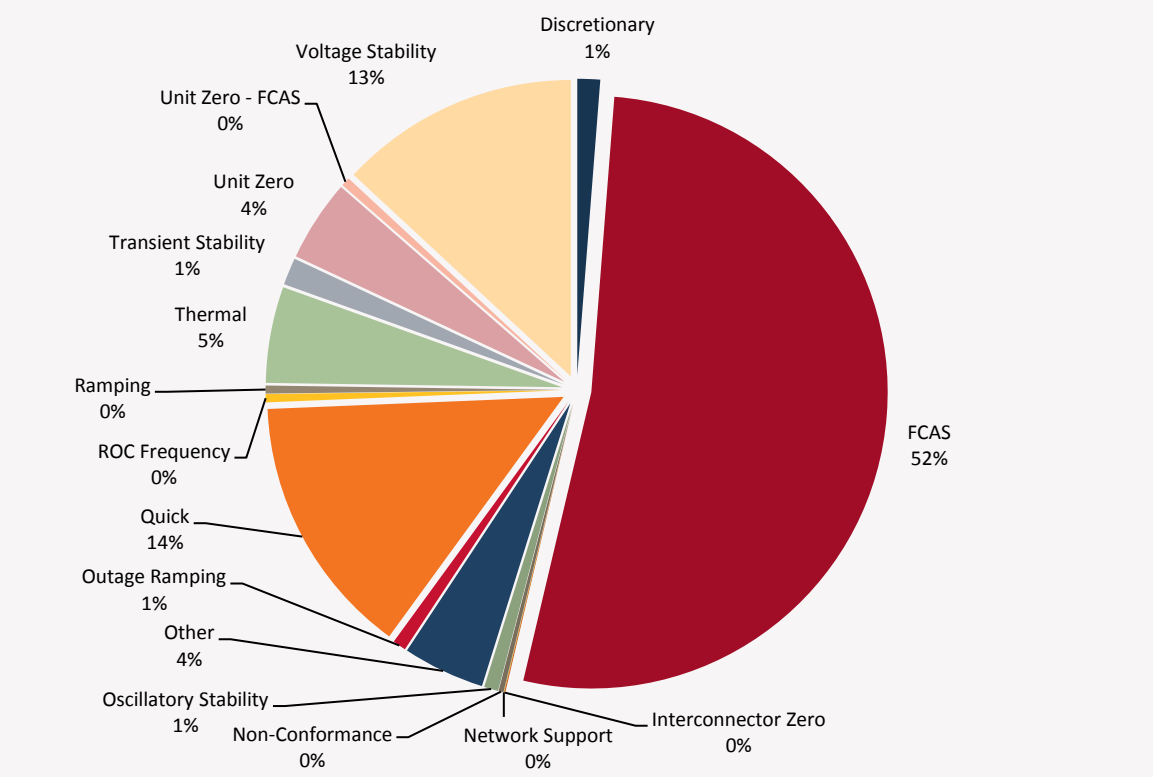
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

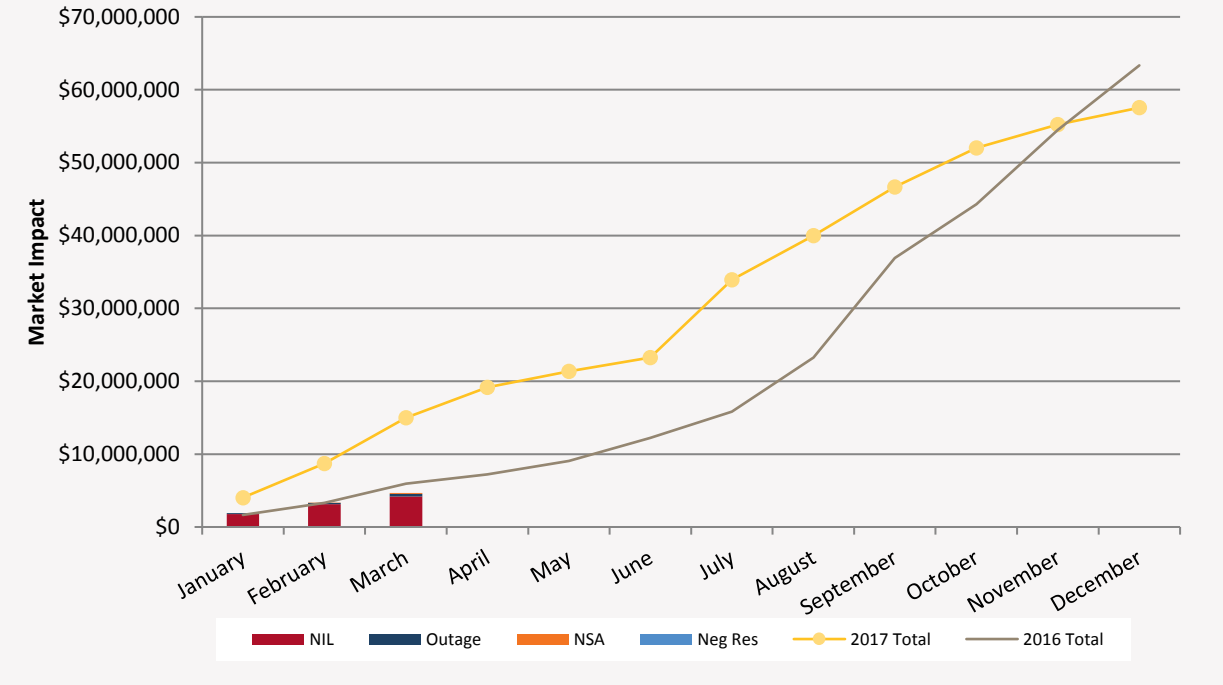
Figure 2-3 — Binding by limit type



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
N_X_MBTE2_A	Out= two Directlink cables, NSW to Qld limit	14	2,780% (27.8)	440% (12.93)
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.	91	846% (8,957)	49.24% (523)
N::V_DDMS	Out=Dederang to Murray (67 or 68) line, NSW to Victoria Transient stability limit.	3	451% (595)	326% (512)
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	54	236% (378.89)	54.69% (154.32)
V^SML_BUDP_3	Out = Buronga to Balranald to Darlington Pt (X5) 220kV line, avoid voltage collapse for loss of Bendigo to Kerang 220kV line	6	134.86% (86.52)	103.08% (75.61)
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	10	131.76% (232.85)	81.88% (144.43)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
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.	12	108.72% (270.85)	32.95% (113.34)
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.	21	98.33% (99.95)	98.33% (99.95)
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	44	89.62% (30.3)	21.67% (11.4)
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	462	58.41% (257.55)	24.08% (82.09)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

S_NIL_STRENGTH_1: This constraint has been investigated and no further improvement can be made 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.

S>V_NIL_NIL_RBNW: investigated and the mismatch is due to forecast differences between the SA demand and the change in the entered ratings for the monitored line elements. No improvements can be made to this 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.

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 March 2018.

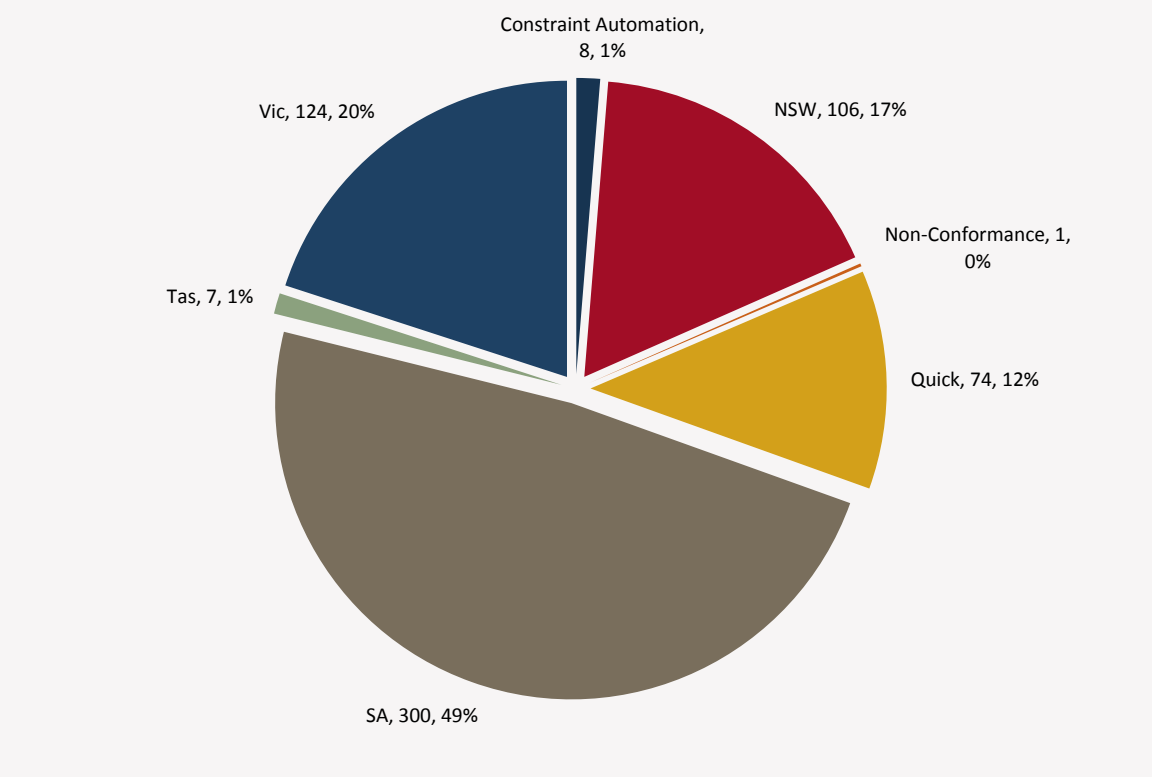
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Gannawarra Solar Farm	20 March 2018	VIC	New Generator
Willalo Substation	27 March 2018	SA	Willalo substation has been energised at 275 kV. Belalie – Mokota 275 kV transmission line has now been cut to form two lines connecting to Willogoleche Windfarm substation. The new transmission line names are Belalie – Willalo 275 kV transmission line and Willalo – Mokota 275 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



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