MONTHLY CONSTRAINT REPORT - MAY 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 May 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.	1224 (102.0)	11/12/2017
T>T_NIL_BL_IMP_7CC	Out = Nil, avoid O/L Farrell to Sheffield No. 2 220 kV line for trip of the Farrell to Sheffield No. 1 220 kV line with no SPS action, feedback	466 (38.83)	26/07/2016
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	393 (32.75)	09/04/2018
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	297 (24.75)	13/09/2016
N_MBTE1_B	Out= one Directlink cable, Qld to NSW limit	280 (23.33)	25/11/2013
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	270 (22.5)	15/01/2018
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.	183 (15.25)	24/05/2018
Q::N_ARSVC_AR_2L-G	Out = Armidale SVC, limit Qld to NSW on QNI to avoid transient instability on 2L-G fault at Armidale	139 (11.58)	16/01/2018
NSA_Q_BARCALDN	Network Support Agreement for Barcaldine GT to meet local islanded demand for the planned outage of 7153 T71 Clermont to H15 Lilyvale or 7154 T72 Barcaldine to T71 Clermont 132kV line	138 (11.5)	06/05/2015
N^N-89_LSTX_SVC	Out= Coffs Harbour to Lismore (89) line and 330/132kV Lismore Txs O/S, and Lismore SVC in reactive power control mode, avoid Voltage collapse on Koolkhan to Lismore (967) trip; TG formulation only	137 (11.41)	03/05/2018

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
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.	1,229,698	11/12/2017
F_MAIN+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink unable transfer FCAS	179,962	21/08/2013
Q_RS_200	Qld, Ross cutset upper limit of 200MW (discretionary)	141,455	03/05/2018
V_OWF_TGTSNRBHTN_30	Out= Nil, TGTS-HTN-NRB-TGTS sub-transmission loop OPEN, Limit Oaklands Hill Windfarm upper limit to 30 MW, DS only. Swamp out if the loop closed.	131,004	05/05/2017
F_MAIN+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink unable transfer FCAS	97,683	21/08/2013
F_T+RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	94,437	29/01/2015
F_MAIN+LREG_0120	Mainland Lower Regulation Requirement greater than 120 MW, Basslink unable to transfer FCAS	87,352	21/08/2013
F_MAIN+NIL_MG_R60	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink unable transfer FCAS	85,407	21/08/2013
F_T+LREG_0050	Tasmania Lower Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	74,990	29/01/2015
F_MAIN+NIL_MG_R6_PP	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event (when Pelican Point PLUS the max Gen declared credible), Basslink unable transfer FCAS	54,219	18/05/2018

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
N^N-89_LSTX_SVC	Out= Coffs Harbour to Lismore (89) line and 330/132kV Lismore Txs O/S, and Lismore SVC in reactive power control mode, avoid Voltage collapse on Koolkhan to Lismore (967) trip; TG formulation only	19 (1.58)	03/05/2018
Q_RS_200	Qld, Ross cutset upper limit of 200MW (discretionary)	12 (1.0)	03/05/2018
NSA_Q_BARCALDN	Network Support Agreement for Barcaldine GT to meet local islanded demand for the planned outage of 7153 T71 Clermont to H15 Lilyvale or 7154 T72 Barcaldine to T71 Clermont 132kV line	9 (0.75)	06/05/2015
F_T+RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	5 (0.41)	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	5 (0.41)	02/12/2016
F_T_AUFLS2_R6	TAS AUFLS2 control scheme. Limit R6 enablement based on loaded armed for shedding by scheme.	3 (0.25)	04/05/2018
F_T+FASH_N-2_TG_R5	Out = Nil, loss of both Farrell to Sheffield lines declared credible, Tasmania Raise 5 min requirement for loss of the remaining Farrell to Sheffield line, Basslink unable to transfer FCAS	2 (0.16)	12/04/2016
CA_MQS_49FC5770_02	Constraint Automation, O/L HADSPEN TRANSFORMER T1 for CTG TTAG on trip of HADSPEN #2 220/110KV TRANSFORMER. Generated by STNET[MANBL] Host MANEEMP1(MQ)	2 (0.16)	03/05/2018
F_T+NIL_MG_RECL_R5	Out = Nil, Raise 5 min 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
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	2 (0.16)	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
N^N-89_LSTX_SVC	Constraint equation violated for 19 DIs, 17 of which were consecutive. Max violation of 25.48 MW occurred on 02/05/2018 at 1810 hrs. Constraint equation violated due to competing requirement with Directlink import limit set by N_MBTE1_B.
Q_RS_200	Constraint equation violated for 12 consecutive DIs. Max violation of 487.77 MW occurred on 22/05/2018 at 1020 hrs. Constraint equation violated due to being invoked without ramping constraints (invoking ramping constraints is normal practice). At 1001 hrs there was an unplanned outage of the Ross 2, Ross 3 and Ross 4 288/138/19kV transformers.
NSA_Q_BARCALDN	Constraint equation violated for 9 DIs, 6 of which were consecutive. Max violation of 5.56 MW occurred on 17/05/2018 at 0640 hrs. Constraint equation violated due to a mismatch between Barcaldine GT availability and output so that the dispatch target cannot align with the output for network support.
F_T+RREG_0050	Constraint equation violated for 5 DIs last month. Max violation of 36.95 MW occurred on 21/05/2018 at 0805 hrs. Constraint equation violated due to Tasmania raise regulation service availability less than the requirement.
F_T+NIL_MG_RECL_R6	Constraint equation violated for 5 DIs last month. Max violation of 13.24 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
F_T_AUFLS2_R6	Constraint equation violated for 3 DIs on 17/05/2018 0440 hrs and on 30/05/2018 at 1545 hrs and 1550 hrs. Max violation of 23.4 MW occurred on 30/05/2018 at 1550 hrs. Constraint equation violated due to Tasmania raise 6 second service availability less than the requirement.
F_T+FASH_N-2_TG_R5	Constraint equation violated for 2 DIs on 30/05/2018 at 1545 hrs and 1625 hrs. Max violation of 122.63 MW occurred on 30/05/2018 at 1545 hrs. Constraint equation violated due to Tasmania raise 5 minute service availability less than the requirement.
CA_MQS_49FC5770_02	Constraint equation violated for 2 DIs on 03/05/2018 at 0440 hrs and 0445 hrs. Max violation of 47.48 MW occurred on 03/05/2018 at 0440 hrs. Constraint equation violated due to Gordon, Liapootah, Catagunya, Wayatinah and Poatina units 3-6 being limited by their ramp down rates. Constraint equation revoked for DI ending 0450 hrs.
F_T+NIL_MG_RECL_R5	Constraint equation violated for 2 DIs on 18/05/2018 at 0805 hrs and on 21/05/2018 at 0805 hrs. Max violation of 37.21 MW occurred on 21/05/2018 at 0805 hrs. Constraint equation violated due to Tasmania raise 5 minute service availability less than the requirement.
F_T+NIL_WF_TG_R6	Constraint equation violated for 2 DIs on 17/05/2018 at 0440 hrs and on 20/05/2018 at 0955 hrs. Max violation of 21.51 MW occurred on 17/05/2018 at 0440 hrs. 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)
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	393 (32.75)	-345.04 (-918.31)
S>V_NIL_NIL_RBNW	V-S-MNSP1 Import	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	297 (24.75)	-166.75 (-178.86)
N_MBTE1_B	N-Q-MNSP1 Import	Out= one Directlink cable, Qld to NSW limit	280 (23.33)	-135.98 (-163.4)
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	269 (22.42)	-1098.48 (-1129.24)
F_Q++ARTW_L6	NSW1-QLD1 Import	Out = Armidale to Tamworth (85 or 86) line, Qld Lower 6 sec Requirement	239 (19.92)	-329.41 (-525.29)
F_Q++ARTW_L6	N-Q-MNSP1 Import	Out = Armidale to Tamworth (85 or 86) line, Qld Lower 6 sec Requirement	229 (19.08)	-53.33 (-65.0)
F_Q++8C_L6	NSW1-QLD1 Import	Out = Armidale to Dumaresq (8C), Qld Lower 6 sec Requirement	213 (17.75)	-249.34 (-346.59)
F_Q++ARTW_L5	NSW1-QLD1 Import	Out = Armidale to Tamworth (85 or 86) line, Qld Lower 5 min Requirement	163 (13.58)	-358.51 (-538.0)
F_Q++ARTW_L5	N-Q-MNSP1 Import	Out = Armidale to Tamworth (85 or 86) line, Qld Lower 5 min Requirement	159 (13.25)	-55.42 (-66.15)
Q::N_ARSVC_AR_2L-G	NSW1-QLD1 Import	Out = Armidale SVC, limit Qld to NSW on QNI to avoid transient instability on 2L-G fault at Armidale	139 (11.58)	-975.24 (-1005.14)

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_MQS_49FC5770	03/05/2018 00:45 to 03/05/2018 04:45	Constraint Automation. Automatic constraint equation used to avoid overload on either Hadspen No.1 or Palmerston No.2 220/110 kV transformer for the loss of Hadspen No.2 220/110 kV transformer, during the outage of Palmerston to Sheffield 220 kV line. During the outage, both Hadspen to Palmerston 220 kV lines would be offloaded for loss of Hadspen No.2 220/110 kV transformer due to changes on Hadspen 220 kV bus configuration.

2.5.1. Further Investigation

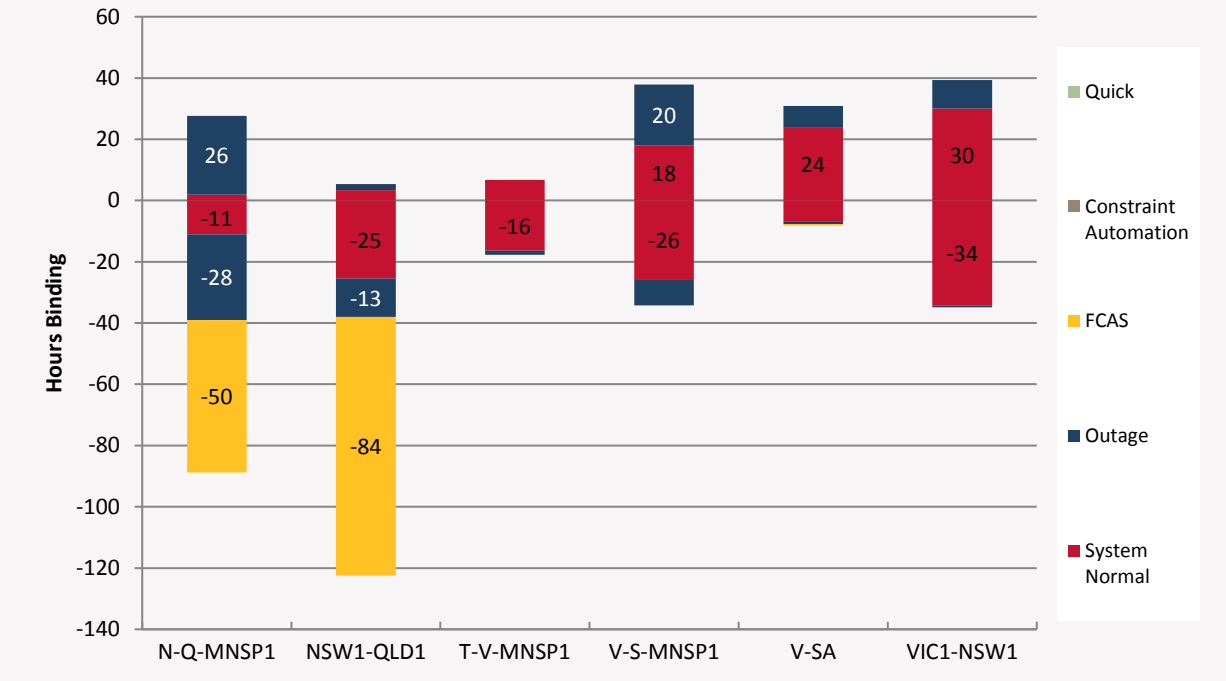
CA_MQS_49FC5770: The constraint for the same network configuration during the outage is unlikely to be required again as the Hadspen 220kV bus has been switched back to its normal configuration. As a result, no constraints have been updated.

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.

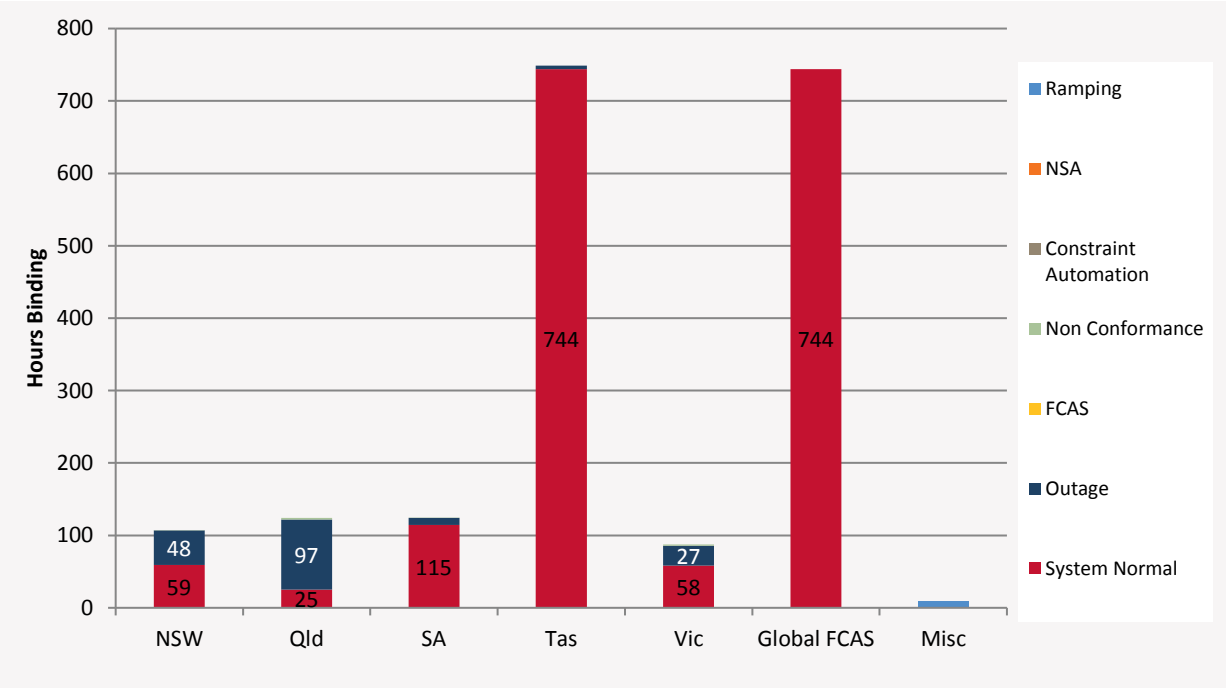
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

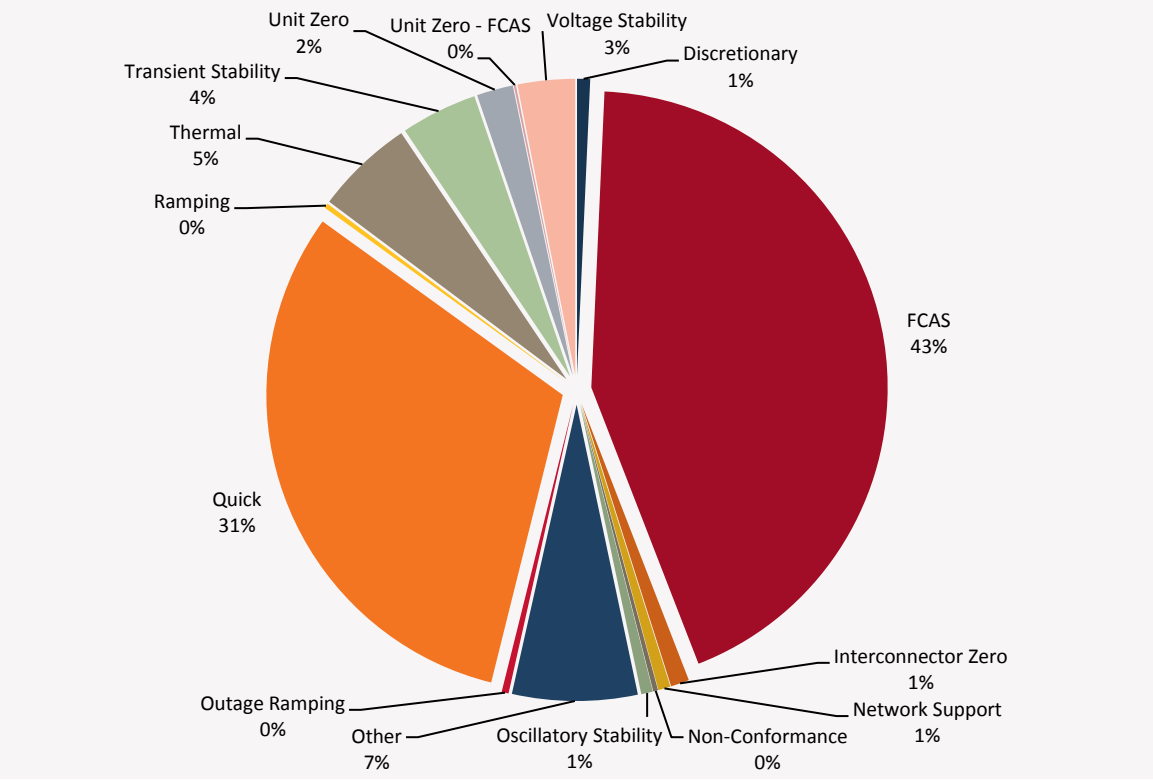
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

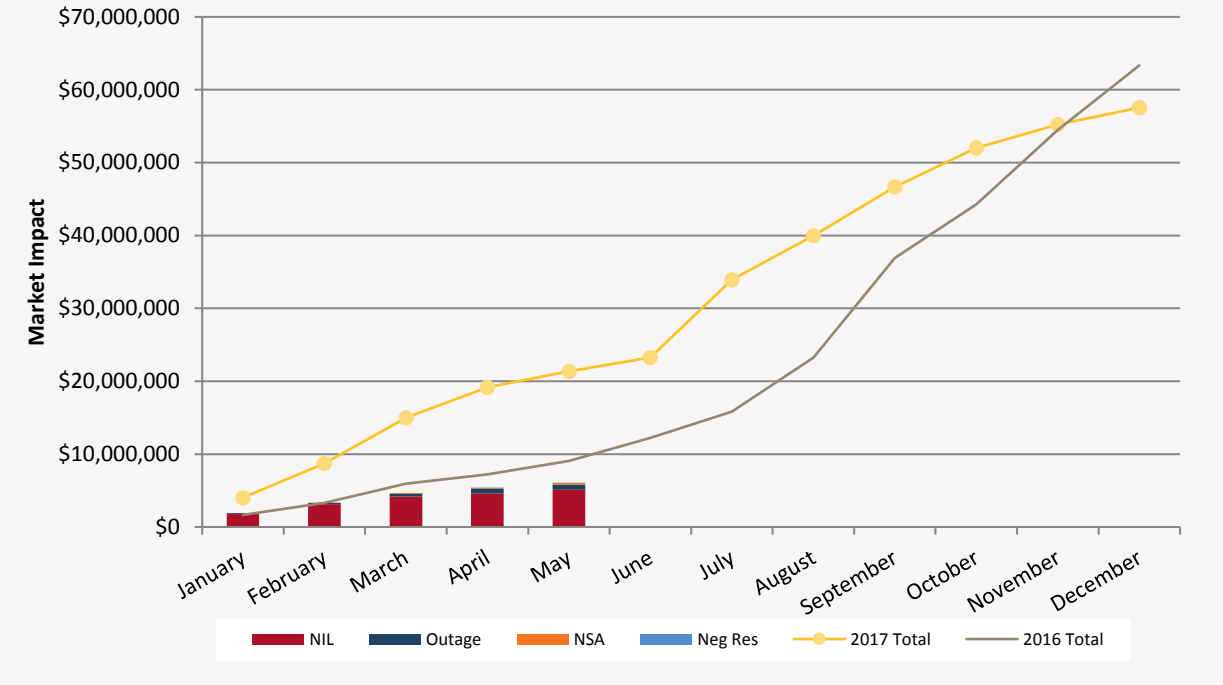
Figure 2-3 — Binding by limit type



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
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.	3	98.33% (99.95)	98.33% (99.95)
N_X_MBTE_3A	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	14	96.% (19.2)	34.91% (9.06)
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.	242	88.75% (8,882)	3.57% (70.25)
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	14	87.27% (19.6)	44.36% (12.61)
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	66	84.64% (162.96)	34.88% (65.43)
N^N_CHLS_1	Out= Coffs Harbour to Lismore (89), avoid voltage collapse on trip of Koolkhan to Lismore (967), swamp out when all 3 Directlink O/S	10	80.11% (32.2)	36.13% (16.6)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
NSA_Q_BARCALDN	Network Support Agreement for Barcaldine GT to meet local islanded demand for the planned outage of 7153 T71 Clermont to H15 Lilyvale or 7154 T72 Barcaldine to T71 Clermont 132kV line	22	80.04% (28.01)	40.85% (10.9)
N>>Q_LDMU_B	Out= Liddell-Muswellbrook(83), avoid Liddell->Tamworth(84) OL on largest QLD generator trip ; FBk	4	78.78% (345.29)	58.99% (220.22)
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	30	75.17% (212.56)	30.25% (74.35)
N>>N-NIL__G_15M	Out= Nil, avoid O/L Upper Tumut to Yass (2) using 15 mins rating on trip of Lower Tumut to Yass (3) line, Feedback	10	75.12% (2,586)	74.5% (2,563)

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-NIL__G_15M: Investigated and the mismatch was due to an error in the dispatch formulation of the constraint equation. This was corrected on 14/05/2018.

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.

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.

NSA_Q_BARCALDN: Investigated and the PD formulation will be changed to improve its performance.

N^^V_NIL_MAXG_PP_N-2: 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 May 2018.

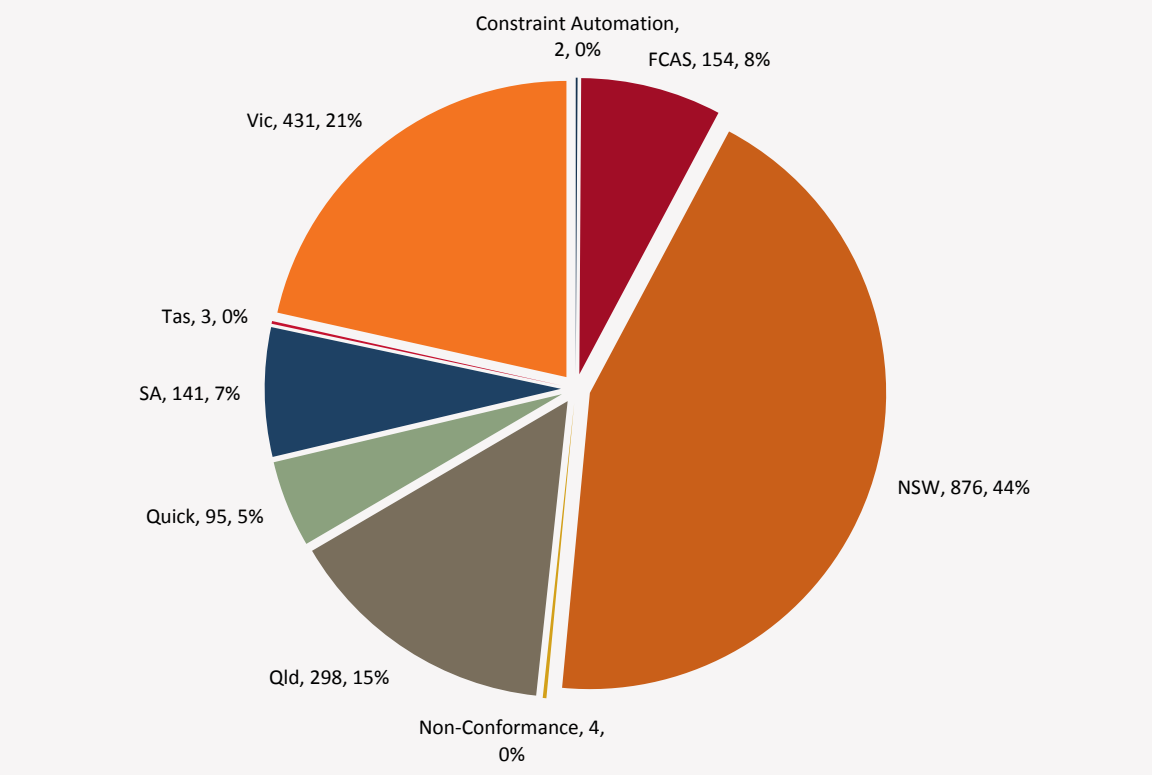
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Bungala Solar Farm Stage 1	1 May 2018	SA	New Generator
Salt Creek Wind Farm	29 May 2018	VIC	New Generator
Whitsunday Solar Farm	29 May 2018	QLD	New Generator
Hamilton Solar Farm	29 May 2018	QLD	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