MONTHLY CONSTRAINT REPORT - AUGUST 2017

FOR THE NATIONAL ELECTRICITY MARKET

PUBLISHED **SEPTEMBER 2017**

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 August 2017. 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_X_MBTE2_B	Out= two Directlink cables, Qld to NSW limit	6122 (510.16)	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	1834 (152.83)	08/01/2014
S_WIND_1200_AUTO	Discretionary upper limit for South Australian wind generation of 1200 MW. Automatically swamps out when required sync generation combination is online	1694 (141.16)	31/08/2017
N^^V_NIL_1	Out = Nil, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	709 (59.08)	20/04/2017
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	695 (57.91)	25/11/2013
Q:N_NIL_BI_POT	Out=Nil, limit Qld to NSW on QNI to avoid transient instability on trip of a Boyne Island potline (400 + j189 MVA)	461 (38.41)	08/01/2014
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.	417 (34.75)	20/04/2017
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.	396 (33.0)	25/11/2015
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.	266 (22.16)	20/04/2017
SVML_ZERO	SA to Vic on ML upper transfer limit of 0 MW	216 (18.0)	21/08/2013

2.2. Top 10 Market impact constraint equations

Binding constraint equations affect electricity market pricing. The relative importance of binding constraints are determined by their market impacts.

The market 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 market impact arising from relaxing the RHS of a binding constraint by one MW. As the market clears each DI, the market impact is measured in $/MW/DI.

The market impact in $/MW/DI is a relative comparison but not otherwise a meaningful measure. However, it can be converted to $/MWh by dividing the market 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 market impact network constraint equations

Constraint Equation ID (System Normal Bold)	Description	∑ Marginal Values	Change Date
S_WIND_1200_AUTO	Discretionary upper limit for South Australian wind generation of 1200 MW. Automatically swamps out when required sync generation combination is online	1,703,938	31/08/2017
F_S+RREG_0035	SA Raise Regulation FCAS Requirement greater than 35 MW	1,038,001	08/01/2015
F_S+LREG_0035	SA Lower Regulation FCAS Requirement greater than 35 MW	1,030,305	08/01/2015
T_MRWF_QLIM_1	Out = NIL, limit Musselroe Wind Farm to 150 MW if less than 96% of DVAr capacity online. Swamped if 96% or more of DVAr capacity online.	203,234	08/12/2014
S_SA_WIND_1200	Discretionary upper limit for South Australian wind generation of 1200 MW.	178,450	30/06/2017
S>NIL_WERB_WEWT	Out= Nil, avoid O/L Waterloo East-Waterloo 132kV line on trip of Waterloo East-Morgan Whyalla 4 - Robertstown 132kV line, Feedback	166,730	13/09/2016
F_I+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a NEM Generation Event	149,009	21/08/2013
F_I+LREG_0120	NEM Lower Regulation Requirement greater than 120 MW	146,551	21/08/2013
F_I+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a NEM Generation Event	137,493	21/08/2013
F_I+NIL_RREG	NEM Raise Regulation Requirement	111,969	25/10/2016

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.

Table 2-3 – Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
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	9 (0.75)	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
Q>STBS_STBS_BADU	Out= Stanwell to Broadsound (856 or 8831), avoid O/L Baralaba to Duaringa (7113/1) on trip of remaining Stanwell to Broadsound (856 or 8831)	2 (0.16)	22/05/2015

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+FASH_N-2_TG_R6_1	Out = Nil, loss of both Farrell to Sheffield lines declared credible, Tasmania Raise 6 sec requirement for loss of the remaining Farrell to Sheffield line, Basslink unable to transfer FCAS, Segment1	1 (0.08)	12/04/2016
F_Q++LDTW_L5	Out = Liddell to Tamworth (84) line, Qld Lower 5 min Requirement	1 (0.08)	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	1 (0.08)	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
F_T+NIL_MG_RECL_R6	Constraint equation violated for 9 DIs during the week. Max violation of 38.49 MW occurred on 12/08/2017 at 0115 hrs. Constraint equation violated due to Tasmania raise 6 second availability less than the requirement.
F_T+NIL_MG_R6	Constraint equation violated for 3 DIs, on 11/08/2017 at 2155 hrs, and on 12/08/2017 at 0115 hrs and 01120 hrs. Max violation of 38.64 MW occurred on 12/08/2017 at 0115 hrs. Constraint equation violated due to Tasmania raise 6 second availability less than the requirement.
Q>STBS_STBS_BADU	Constraint equation violated for 2 DIs on 04/08/2017 at 0125 hrs and 0200 hrs. Max violation of 18.81 MW occurred at 0200 hrs. Constraint equation violated due to Mt Stuart GT unit 1, 2 and 3 were limited by their start-up profile.
F_T+FASH_N-2_TG_R6_1	Constraint equation violated for 1 DI on 11/08/2017 at 1150 hrs with a violation of 18 MW. Constraint equation violated due to Tasmania raise 6 second availability less than the requirement.
F_Q++LDTW_L5	Constraint equation violated for 1 DI on 05/08/2017 at 1440 hrs with a violation of 14.31 MW. Constraint equation violated due to Queensland lower 5 mins service availability less than requirement.
F_T+NIL_WF_TG_R6	Constraint equation violated for 1 DI on 11/08/2017 at 1150 hrs with a violation of 2.71 MW. Constraint equation violated due to Tasmania raise 6 second 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_X_MBTE2_B	N-Q-MNSP1 Import	Out= two Directlink cables, Qld to NSW limit	6122 (510.17)	-76.95 (-104.2)
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	1833 (152.75)	-1025.75 (-1036.81)
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	1269 (105.75)	81.28 (-438.06)
N^^V_NIL_1	VIC1-NSW1 Import	Out = Nil, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	709 (59.08)	-279.38 (-975.42)

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
N^^V_NIL_1	V-S-MNSP1 Export	Out = Nil, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	705 (58.75)	-7.46 (209.75)
N_X_MBTE_3B	N-Q-MNSP1 Import	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	695 (57.92)	-27.47 (-72.6)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	589 (49.08)	-121.23 (569.17)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	531 (44.25)	-32.02 (538.79)
Q:N_NIL_BI_POT	NSW1-QLD1 Import	Out=Nil, limit Qld to NSW on QNI to avoid transient instability on trip of a Boyne Island potline (400 + j189 MVA)	461 (38.42)	-1022.13 (-1031.66)
F_MAIN++NIL_MG_R60	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	418 (34.83)	-10.64 (523.36)

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

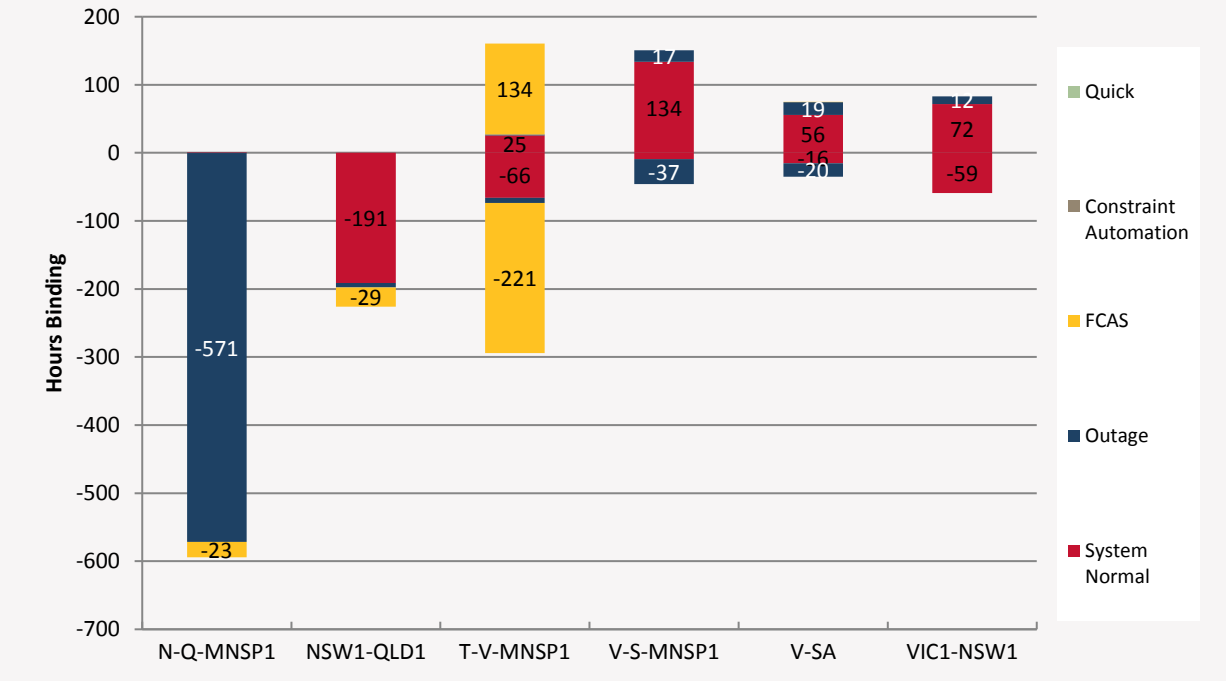
Non-real time constraint automation was not used.

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.

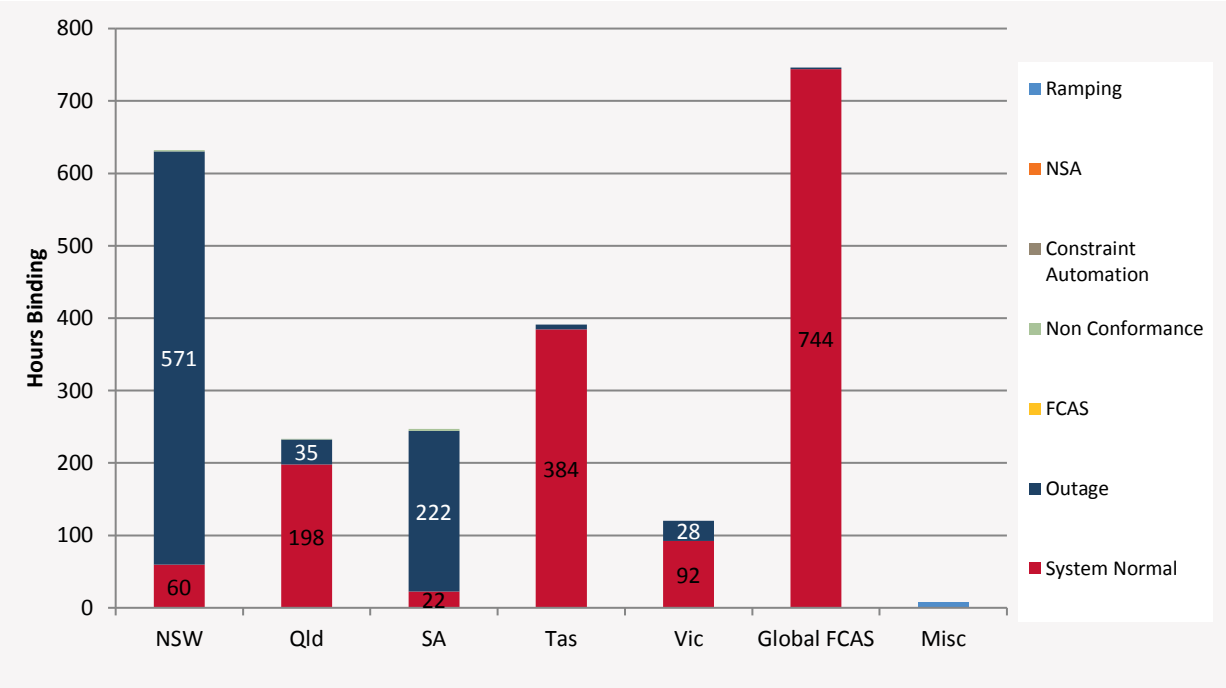
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

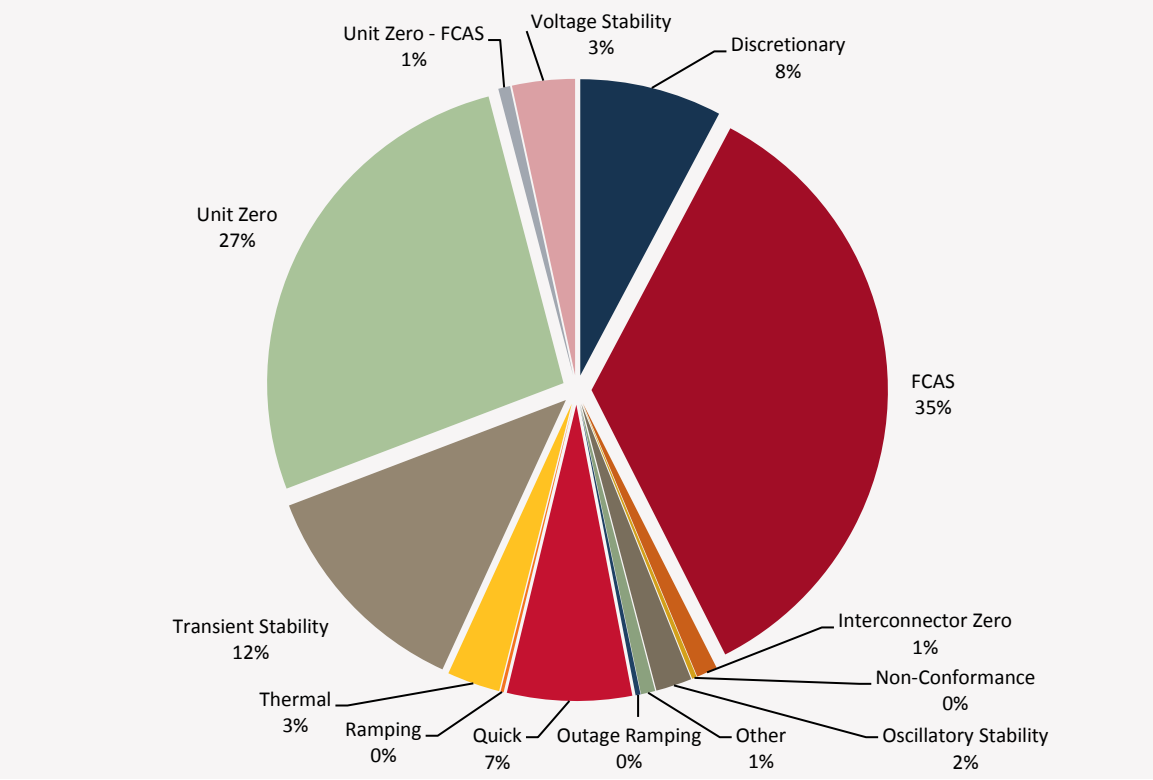
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

The following pie charts show the percentage of dispatch intervals in August 2017 that the different types of constraint equations bound.

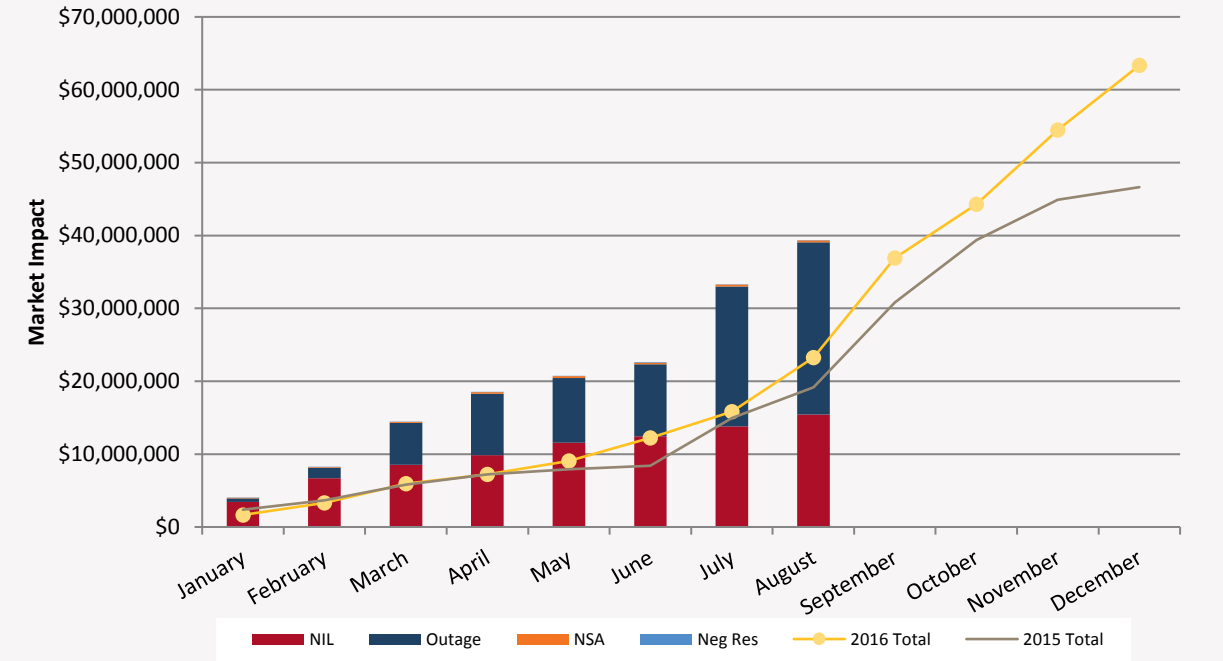
Figure 2-3 — Binding by limit type



2.8. Market Impact Comparison

The following graph compares the cumulative market 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 — Market 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 market 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^^V_NIL_1	Out = Nil, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	140	1,592% (270.19)	66.91% (119.2)
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.	157	792% (387.3)	36.7% (63.48)
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.	63	340% (249.14)	35.69% (70.79)
V^SML_HORC_3	Out = Horsham to Red Cliffs 220kV line, avoid voltage collapse for loss of Bendigo to Kerang 220kV line	7	289% (54.3)	146.01% (33.47)
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	92	193% (33.8)	40.37% (10.2)
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	41	146.68% (291.12)	26.64% (55.84)
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	17	60.15% (115.35)	24.86% (47.53)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
T::T_NIL_4	Out = NIL, prevent poorly damped TAS North - South oscillations following fault and trip of Palmerston to Sheffield 220 kV line, Tamar CCGT OOS. Swamped if Tamar CCGT in service	70	49.27% (245.09)	14.69% (82.9)
N_X_MBTE2_B	Out= two Directlink cables, Qld to NSW limit	1098	39.1% (34.2)	7.06% (5.89)
S>BGTX_BGBR_HUWT	Out= Bungama 275/132kV TX, avoid O/L Hummocks-Waterloo 132kV line on trip of Bungama-Redhill tee-Brinkworth 132kV line (this trips Clements Gap windfarm), Feedback	10	36.28% (42.93)	29.% (32.75)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

N^^V_NIL_1: The Pre-dispatch for this constraint equation was recalculated in early May 2014 (with an update to the limit advice to take into account increased transfer on the Heywood interconncector). No further improvements can be made at this time.

V::N_NIL_V2: 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_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.

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.

T::T_NIL_4: Investigated and no improvement can be made at this time.

N_X_MBTE2_B: Investigated and the mismatch was due to issues with forecasting of the Terranora load. Improving the Terranora load forecast is currently being investigated.

S>BGTX_BGBR_HUWT: 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 August 2017.

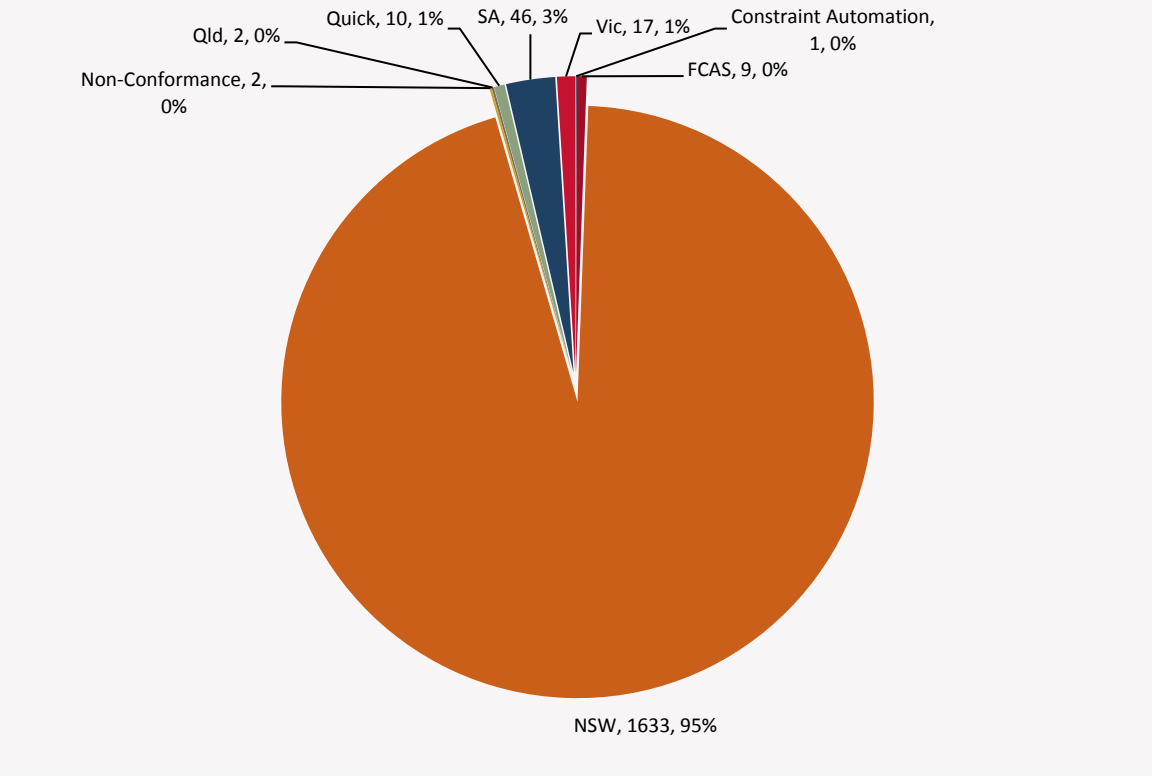
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Hornsdale Wind Farm Stage 3	14 August 2017	SA1	New Generator
Gullen Range Solar Farm	15 August 2017	NSW1	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