MONTHLY CONSTRAINT REPORT - JULY 2017

FOR THE NATIONAL ELECTRICITY MARKET

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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 July 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^^V_NIL_1	Out = Nil, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	4964 (413.66)	20/04/2017
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	1421 (118.41)	08/01/2014
N_X_MBTE2_B	Out= two Directlink cables, Qld to NSW limit	1109 (92.41)	25/11/2013
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	639 (53.25)	13/09/2016
S_PLN_ISL2	Out = Yadnarie to Port Lincoln line, Port Lincoln units 1 and 2 islanded	309 (25.75)	20/08/2010
S_PLN_ISL32	Out = Yadnarie to Port Lincoln line, Port Lincoln unit #3 islanded	307 (25.58)	20/08/2010
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.	293 (24.41)	25/11/2015
N_NIL_TE_B	Out=Nil, Terranora Interconnector Qld to NSW flow overall limits	273 (22.75)	04/07/2012
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	234 (19.5)	05/08/2017
S_SA_WIND_1200	Discretionary upper limit for South Australian wind generation of 1200 MW.	219 (18.25)	30/06/2017

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_PLN_ISL2	Out = Yadnarie to Port Lincoln line, Port Lincoln units 1 and 2 islanded	4,278,378	20/08/2010
S_PLN_ISL32	Out = Yadnarie to Port Lincoln line, Port Lincoln unit #3 islanded	4,152,742	20/08/2010
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	238,309	05/08/2017
N^^V_NIL_1	Out = Nil, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	193,790	20/04/2017
F_I+NIL_RREG	NEM Raise Regulation Requirement	157,732	25/10/2016
F_I+LREG_0120	NEM Lower Regulation Requirement greater than 120 MW	143,161	21/08/2013
S_HALWF2_0	Discretionary upper limit for Hallett 2 Wind Farm generation of 0 MW	129,510	21/08/2013
F_S+LREG_0035	SA Lower Regulation FCAS Requirement greater than 35 MW	123,965	08/01/2015
F_S+RREG_0035	SA Raise Regulation FCAS Requirement greater than 35 MW	107,220	08/01/2015
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	104,173	13/09/2016

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 3 – Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Change Date
V_MORTLAKE12_ZERO	Mortlake unit 1 & 2 upper limit of 0 MW	6 (0.5)	21/08/2013
S_PLN_ISL2	Out = Yadnarie to Port Lincoln line, Port Lincoln units 1 and 2 islanded	3 (0.25)	20/08/2010
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

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
S_PLN_ISL32	Out = Yadnarie to Port Lincoln line, Port Lincoln unit #3 islanded	2 (0.16)	20/08/2010
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
F_T++RREG_0050	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink able transfer FCAS	1 (0.08)	29/01/2015
NC_V_BDL02	Non Conformance Constraint for Bairnsdale 2 Power Station	1 (0.08)	21/08/2013

2.3.1. Reasons for constraint equation violations

Table 4 – Reasons for Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description
V_MORTLAKE12_ZERO	Constraint equation violated for 6 non-consecutive DIs on 31/07/2017. Max violation of 432 MW occurred at 1330 hrs. Constraint equation violated due to Mortlake unit 1 and 2 were limited by their ramp down rate.
S_PLN_ISL2	Constraint equation violated for 3 DIs on 07/07/2017 from 1650 hrs to 1700 hrs. Max violation of 14.04 MW occurred at 1655 hrs. Constraint equation violated due to Port Lincoln GT 1 & 2 were limited by their start-up profile.
F_T+NIL_MG_RECL_R6	Constraint equation violated for 2 DIs, with a max violation of 6.94 MW on 13/07/2017 at 2340 hrs. Constraint equation violated due to the same reason as F_T+NIL_WF_TG_R6.
S_PLN_ISL32	Constraint equation violated for 2 DIs on 07/07/2017 at 1740 hrs and 1745 hrs. Max violation of 5.02 MW occurred at 1740 hrs. Constraint equation violated due to Port Lincoln GT 3 was limited by its start-up profile.
F_T+NIL_WF_TG_R6	Constraint equation violated for 1 DI on 14/07/2017 at 0135 hrs with a violation of 14.03 MW. Constraint equation violated due to Tasmania raise 6 sec service availability less than requirement.
F_T++RREG_0050	Constraint equation violated for 1 DI on 07/07/2017 at 0825 hrs with a violation of 1.04 MW. Constraint equation violated due to Tasmania raise regulation service availability less than requirement.
NC_V_BDL02	Constraint equation violated for 1 DI on 28/07/2017 at 0655 hrs with a violation of 0.06 MW. Constraint equation violated due to Bairnsdale unit 2 was not following its target.

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 in Southern NSW for loss of the largest VIC generating unit or Basslink	4964 (413.67)	-186.27 (-906.76)
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	4737 (394.75)	-26.8 (72.0)
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	1421 (118.42)	-1027.26 (-1039.31)

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	1289 (107.42)	-164.47 (533.0)
N_X_MBTE2_B	N-Q-MNSP1 Import	Out= two Directlink cables, Qld to NSW limit	1109 (92.42)	-78.21 (-104.9)
F_MAIN++NIL_MG_R60	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	600 (50.0)	-115.57 (560.05)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	565 (47.08)	-129.16 (562.66)
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	523 (43.58)	-55.54 (-477.0)
F_MAIN++ML_L6_0400	T-V-MNSP1 Import	Out = Nil, Lower 6 sec requirement for a Mainland Load Event, ML = 400, Basslink able transfer FCAS	382 (31.83)	-279.66 (-477.78)
F_MAIN++NIL_BL_L60	T-V-MNSP1 Import	Mainland Lower 60 second Requirement for loss of Basslink, Basslink flow into Tas	308 (25.67)	-393.23 (-477.0)

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.

Non-real time constraint automation was not used.

2.5.1. Further Investigation

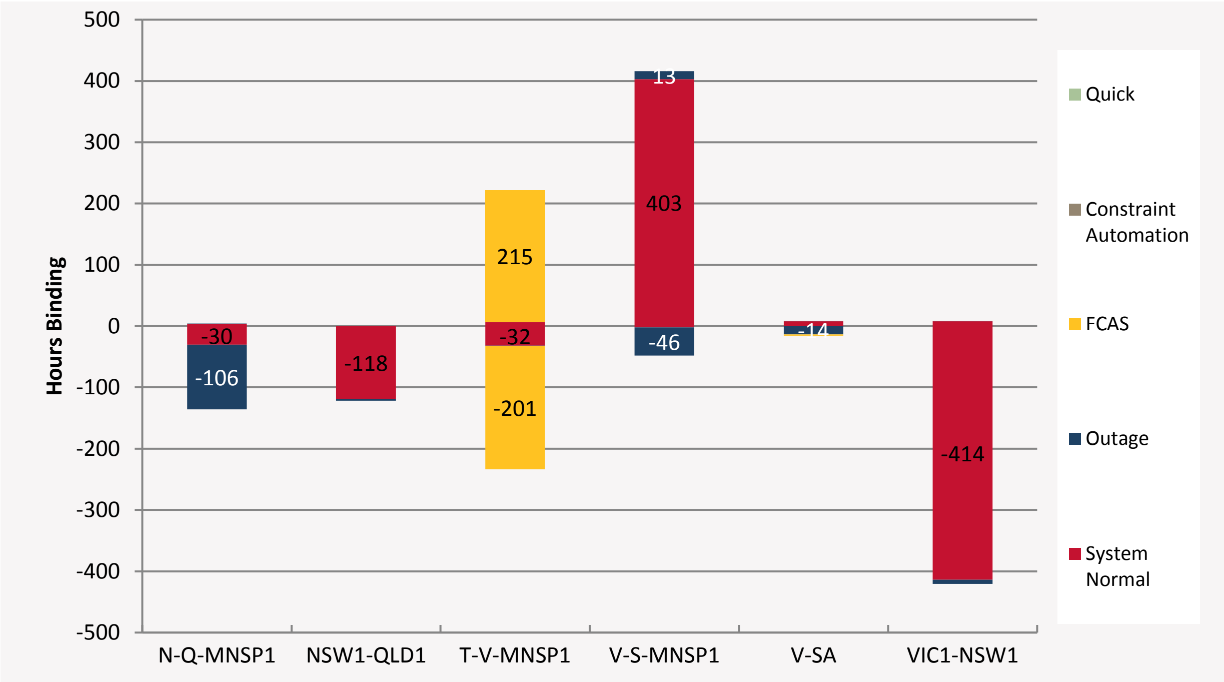
Non-real time constraint automation was not used.

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.

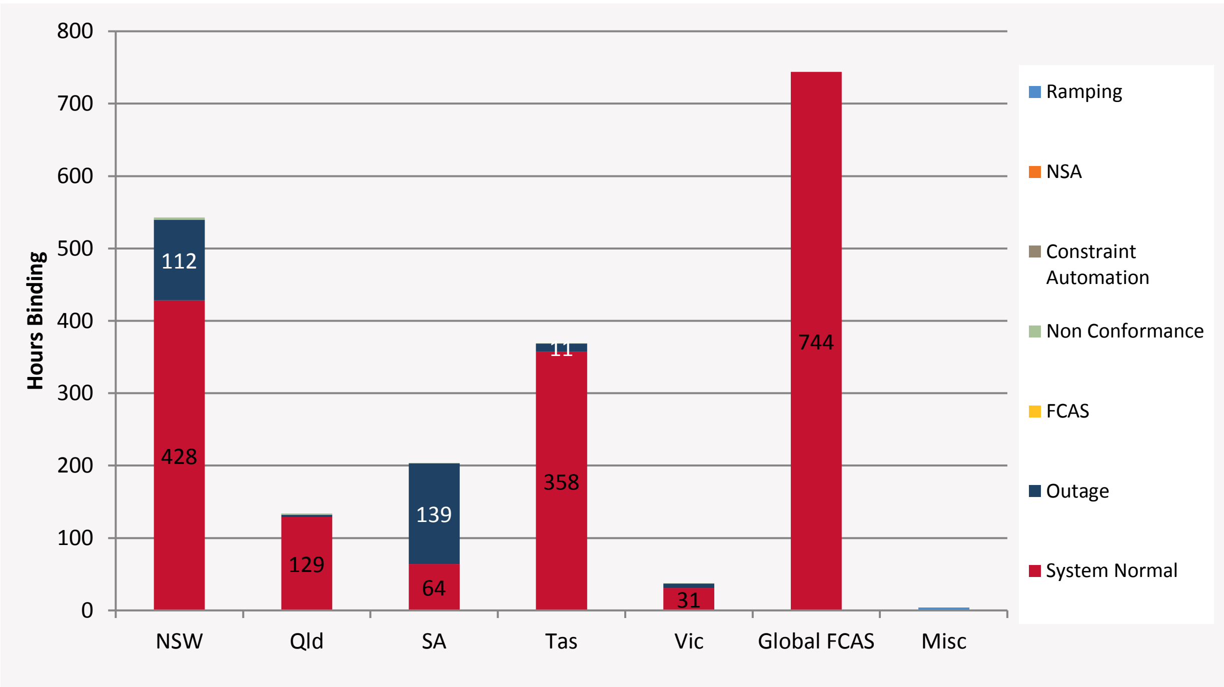
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

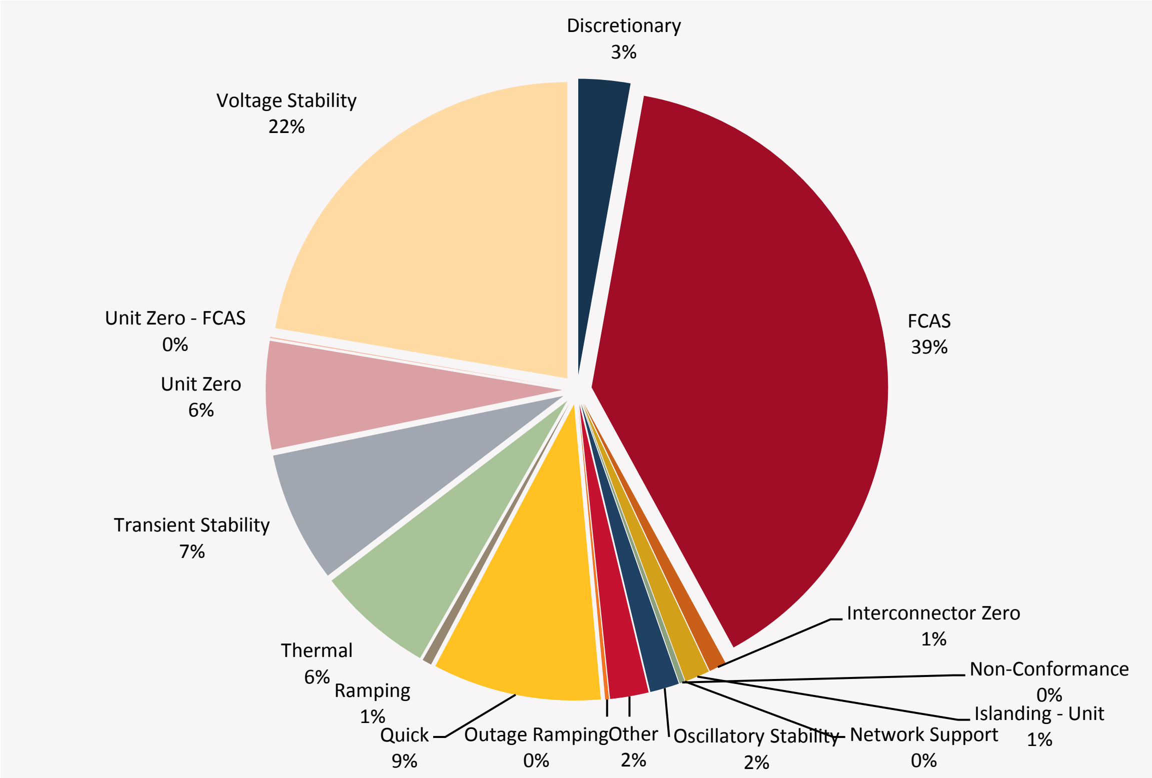
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

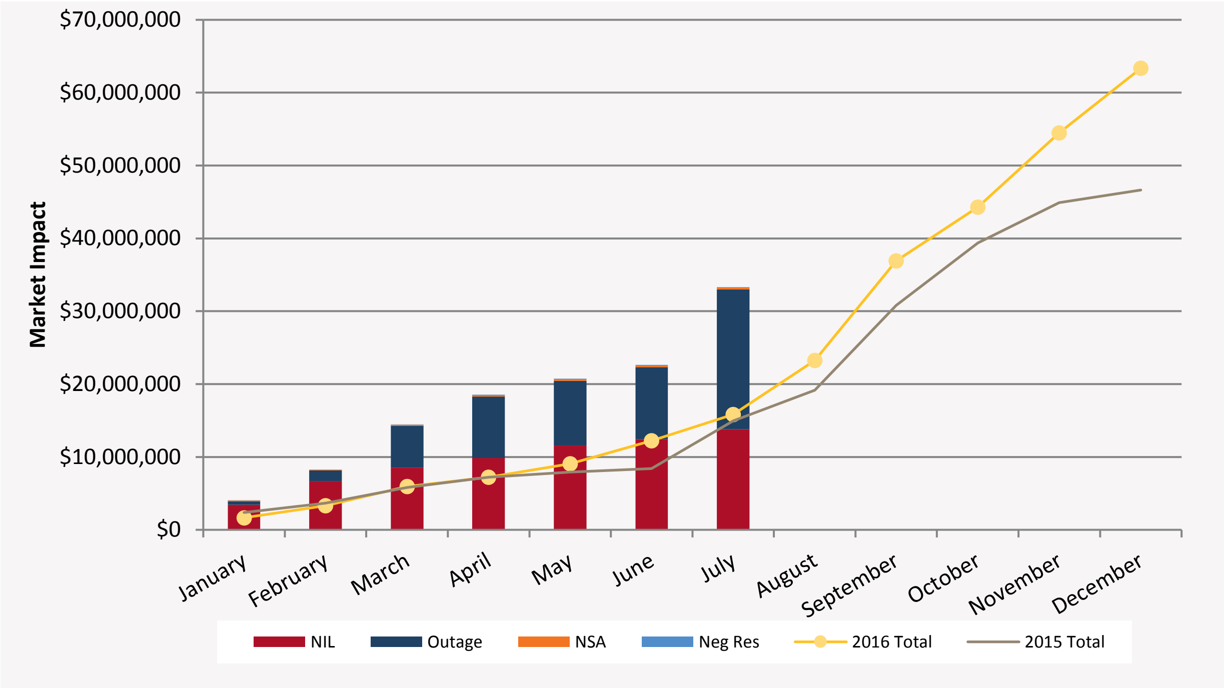
Figure 2-3 — Binding by limit type



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	964	3,803% (467.13)	68.78% (146.03)
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.	31	2,392% (196.17)	173% (70.03)
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	38	178% (354.26)	66.38% (206.18)
S_PLN_ISL2	Out = Yadnarie to Port Lincoln line, Port Lincoln units 1 and 2 islanded	38	137.49% (13.74)	44.11% (4.41)
N^^V_DDWG	Out = 330 kV line between Dederang to Wodonga to Jindera to Wagga, avoid voltage collapse in Southern NSW for loss of the largest VIC generating unit or Basslink	12	112.5% (153.26)	67.78% (107.93)
T::T_NIL_2	Out = NIL, prevent transient instability for fault and trip of a Farrell to Sheffield line, Tamar Valley CCGT out of service, Basslink importing	21	101.31% (311.48)	36.45% (142.88)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
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.	3	98.33% (99.95)	65.83% (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.	33	98.33% (99.95)	76.17% (99.95)
T>T_TUNN3_110_1	Out= Tungatinah to New Norfolk No.3 110kV line, avoid O/L Meadowbank Tee 2 to New Norfolk 110kV line on trip of Tungatinah to Meadowbank Tee 1 to New Norfolk 110kV lines, Feedback	32	65.1% (64.43)	22.19% (22.67)
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	60	51.38% (280.52)	18.79% (112.73)

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 updated to the limit advice). 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_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_PLN_ISL2: Investigated and no improvement can be made to the constraint equation at this stage.

N^^V_DDWG: Investigated and no improvement can be made to the constraint equation at this stage.

T::T_NIL_2: Investigated and no improvement can be made to the constraint equation at this stage

Q>NIL_MUTE_758: Investigated. Mismatch was due to difference between modeling of Terranora control scheme and line status between DS and PD. No improvement can be made to the constraint equation at this stage.

T>T_TUNN3_110_1: Investigated and no improvement can be made to the constraint equation at this stage.

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

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 July 2017.

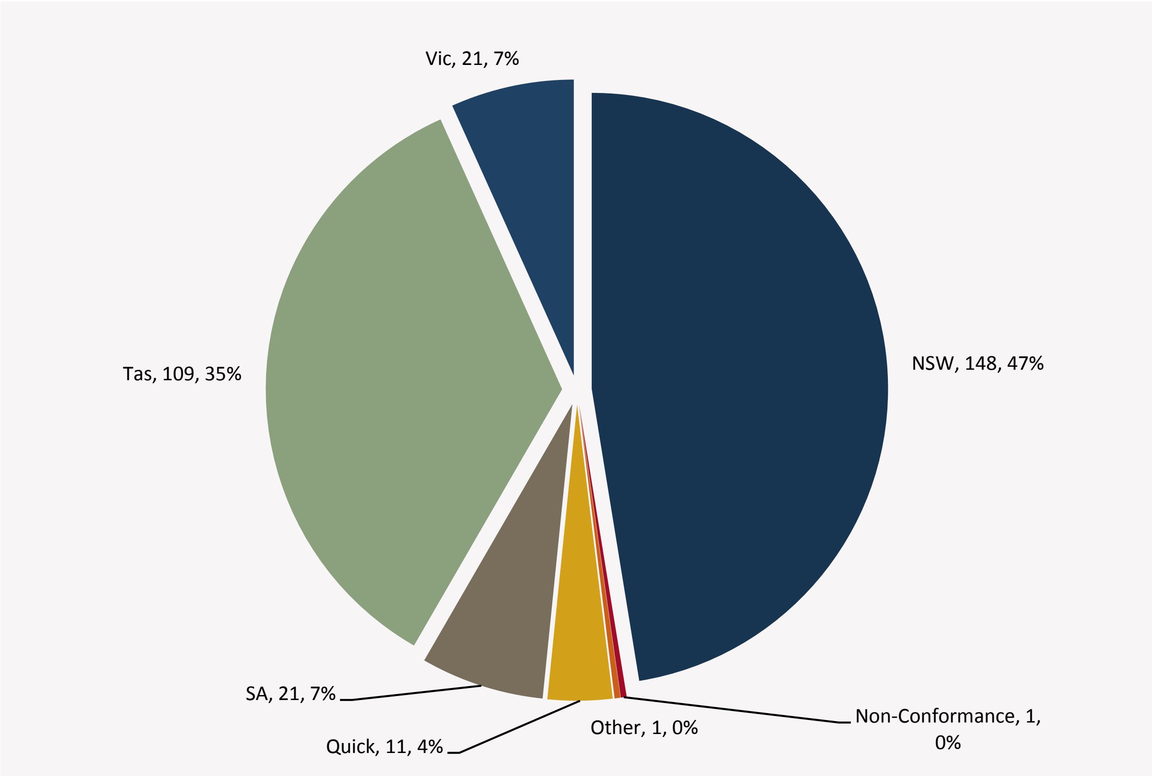
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
White Rock Wind Farm	6 July 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