MONTHLY CONSTRAINT REPORT - SEPTEMBER 2017

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 September 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	3490 (290.83)	25/11/2013
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	1956 (163.0)	08/09/2017
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	634 (52.83)	08/01/2014
S_HALWF_0	Discretionary upper limit for Hallett Wind Farm generation of 0 MW	627 (52.25)	21/08/2013
S>NIL_SGBN_SGSE-T2	Out= NIL, avoid O/L Snuggery Mayura -South East T 132kV line on trip of Snuggery-Blanche 132kV line (for Line component SECS assumed O/S), Feedback	558 (46.5)	13/09/2016
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.	532 (44.33)	20/04/2017
V>>V_NIL_2_TIE	Out = Nil, avoid pre-contingent O/L of the South Morang F2 500/330 kV transformer, Yallourn unit 1 in 220kV mode, all 220kV buses tied at Hazelwood, feedback	508 (42.33)	15/08/2017
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	499 (41.58)	13/09/2016
V::N_SMF2_V2	Out = South Morang F2 500/330kV txfmr, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.	428 (35.66)	07/04/2017
S>NWBCB6225_TX1	Out= North West Bend 132kV CB6225, avoid O/L of North West Bend 66/132kV TX1 on trip of North West Bend-Monash #2 132kV line, Feedback	417 (34.75)	02/08/2017

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_WIND_1200_AUTO	Discretionary upper limit for South Australian wind generation of 1200 MW. Automatically swamps out when required sync generation combination is online	2,023,552	08/09/2017
F_S+LREG_0035	SA Lower Regulation FCAS Requirement greater than 35 MW	1,059,858	08/01/2015
F_S+RREG_0035	SA Raise Regulation FCAS Requirement greater than 35 MW	1,058,727	08/01/2015
S_HALWF_0	Discretionary upper limit for Hallett Wind Farm generation of 0 MW	660,008	21/08/2013
S>NIL_SGBN_SGSE-T2	Out= NIL, avoid O/L Snuggery Mayura -South East T 132kV line on trip of Snuggery-Blanche 132kV line (for Line component SECS assumed O/S), Feedback	202,624	13/09/2016
S-SNWWF_0	Discretionary upper limit for Snowtown WF generation of 0 MW	156,802	21/08/2013
F_I+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a NEM Generation Event	154,027	21/08/2013
F_I+LREG_0120	NEM Lower Regulation Requirement greater than 120 MW	148,254	21/08/2013
F_I+NIL_MG_R5	Out = Nil, Raise 5 min requirement for a NEM Generation Event	139,437	21/08/2013
F_I+NIL_RREG	NEM Raise Regulation Requirement	129,847	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
S>NIL_SGBN_SGSE-T2	Out= NIL, avoid O/L Snuggery Mayura -South East T 132kV line on trip of Snuggery-Blanche 132kV line (for Line component SECS assumed O/S), Feedback	9 (0.75)	13/09/2016
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.	3 (0.25)	06/06/2016
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	1 (0.08)	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
S>NIL_NIL_SGMYSE-T2	Out= NIL, avoid O/L Snuggery Mayura -South East T 132kV line on Nil trip (for Line component SECS assumed O/S or I/S), Feedback	1 (0.08)	13/09/2016

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
S>NIL_SGBN_SGSE-T2	Constraint equation violated for 9 non-consecutive DIs. Max violation of 15.92 MW occurred on 13/09/2017 at 1805 hrs. Constraint equation violated due to Lake Bonney 2 and 3 being limited by their ramp down rate.
T_TAMARCCGT_GCS	Constraint violated for 3 DIs on 13/09/2017 from 1210 hrs to 1220 hrs. Max violation of 19.02 MW occurred at 1210 hrs. Constraint equation violated due to reduction in load armed by the Tamar GCS (generator control scheme) and Tamar Valley CCGT unit being limited by its ramp down rate.
F_T+NIL_WF_TG_R6	Constraint equation violated for 1 DI on 07/09/2017 at 0355 hrs with a violation of 11 MW. Constraint equation violated due to Tasmania raise 6 second availability less than the requirement.
S>NIL_NIL_SGMYSE-T2	Constraint violated for 1 DI on 15/09/2017 at 0300 hrs with a violation of 0.29 MW. Constraint equation violated due to Lake Bonney 2 and 3 being limited by their 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_X_MBTE2_B	N-Q-MNSP1 Import	Out= two Directlink cables, Qld to NSW limit	3490 (290.83)	-73.97 (-93.5)
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	1408 (117.33)	165.82 (-467.99)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	753 (62.75)	416.6 (592.0)
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	634 (52.83)	-1020.53 (-1026.22)
V::N_NIL_V2	VIC1-NSW1 Export	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.	527 (43.92)	969.01 (1333.49)
V::N_NIL_V2	V-SA Export	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.	526 (43.83)	-313.82 (-46.08)
V>>V_NIL_2_TIE	VIC1-NSW1 Export	Out = Nil, avoid pre-contingent O/L of the South Morang F2 500/330 kV transformer, Yallourn unit 1 in 220kV mode, all 220kV buses tied at Hazelwood, feedback	505 (42.08)	1183.02 (1469.25)

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
V>>V_NIL_2_TIE	V-S-MNSP1 Export	Out = Nil, avoid pre-contingent O/L of the South Morang F2 500/330 kV transformer, Yallourn unit 1 in 220kV mode, all 220kV buses tied at Hazelwood, feedback	505 (42.08)	-123.22 (-0.0)
V>>V_NIL_2_TIE	T-V-MNSP1 Export	Out = Nil, avoid pre-contingent O/L of the South Morang F2 500/330 kV transformer, Yallourn unit 1 in 220kV mode, all 220kV buses tied at Hazelwood, feedback	502 (41.83)	394.68 (547.89)
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	499 (41.58)	-165.01 (-181.21)

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_48D013FF	17/09/2017 06:25 to 17/09/2017 09:20	Constraint Automation. Automated constraint equation was created to manage RTCA (Real Time Contingency Analysis) violation on the Robertstown to Waterloo East 132 kV line for the loss of Belali to Makota 132 kV line.

2.5.1. Further Investigation

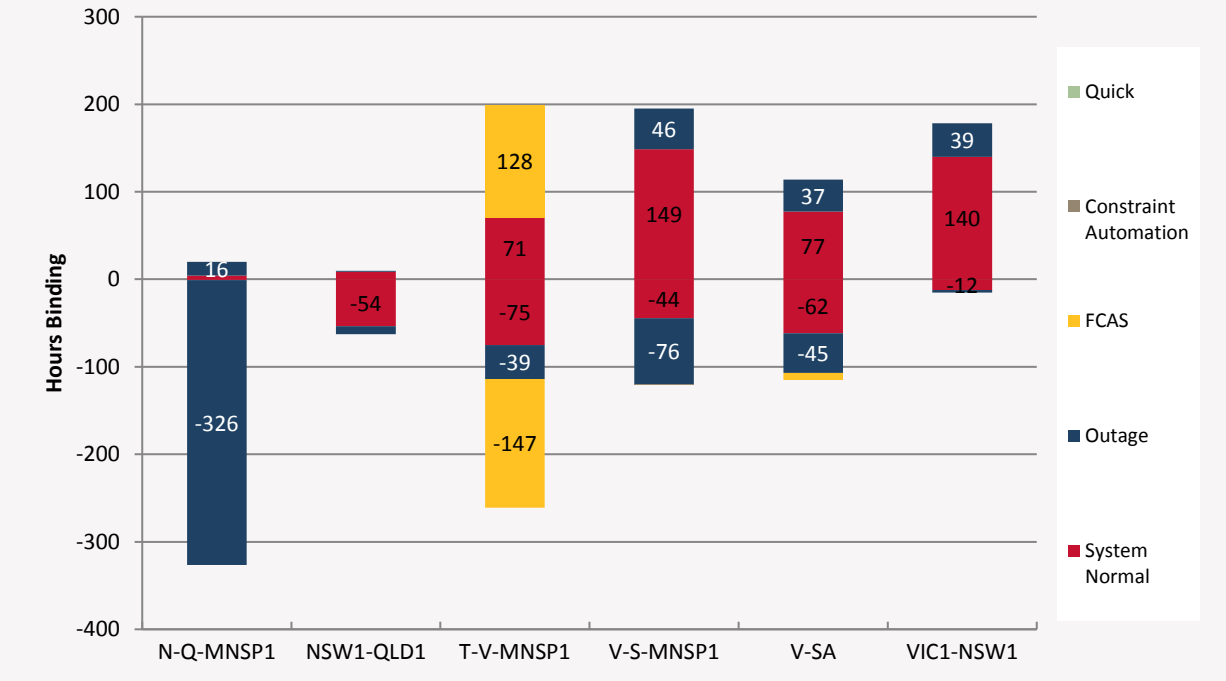
CA_MQS_48D013FF: Constraint automation was used to manage the RTCA violation due to the unplanned outage of the Templers West to Brinkworth 275 kV line in combination with the planned outage of the Canowie to Robertstown 275 kV line.

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.

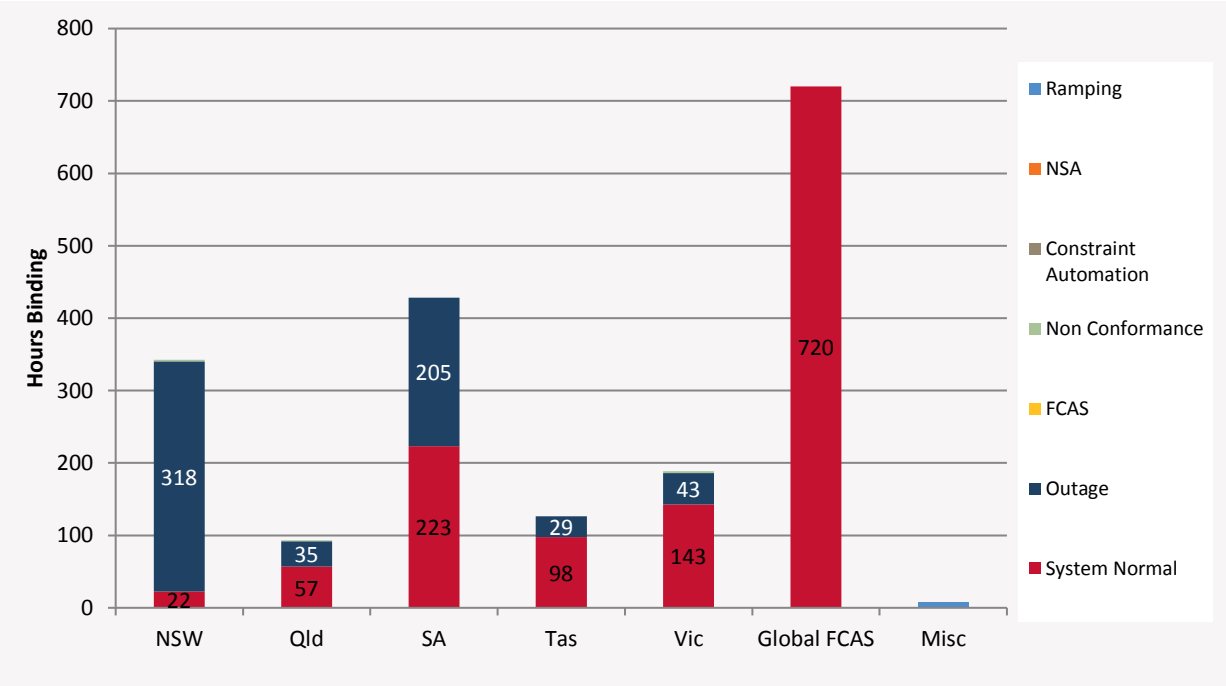
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

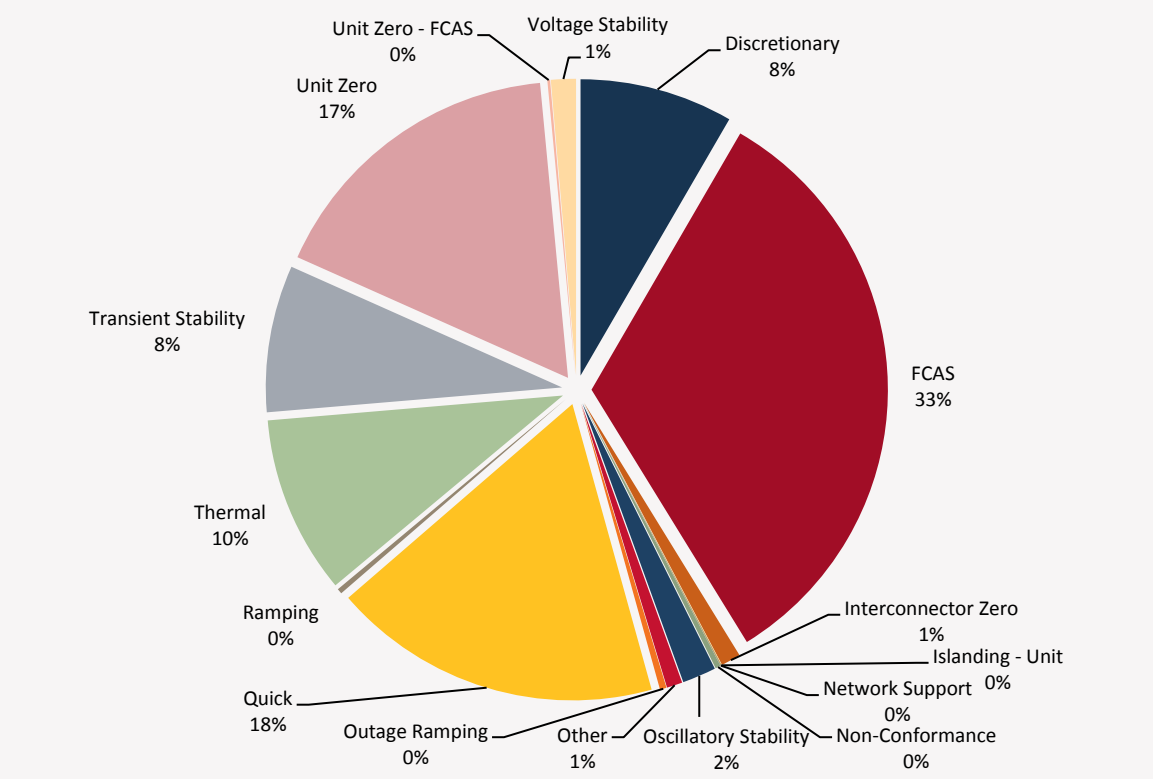
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

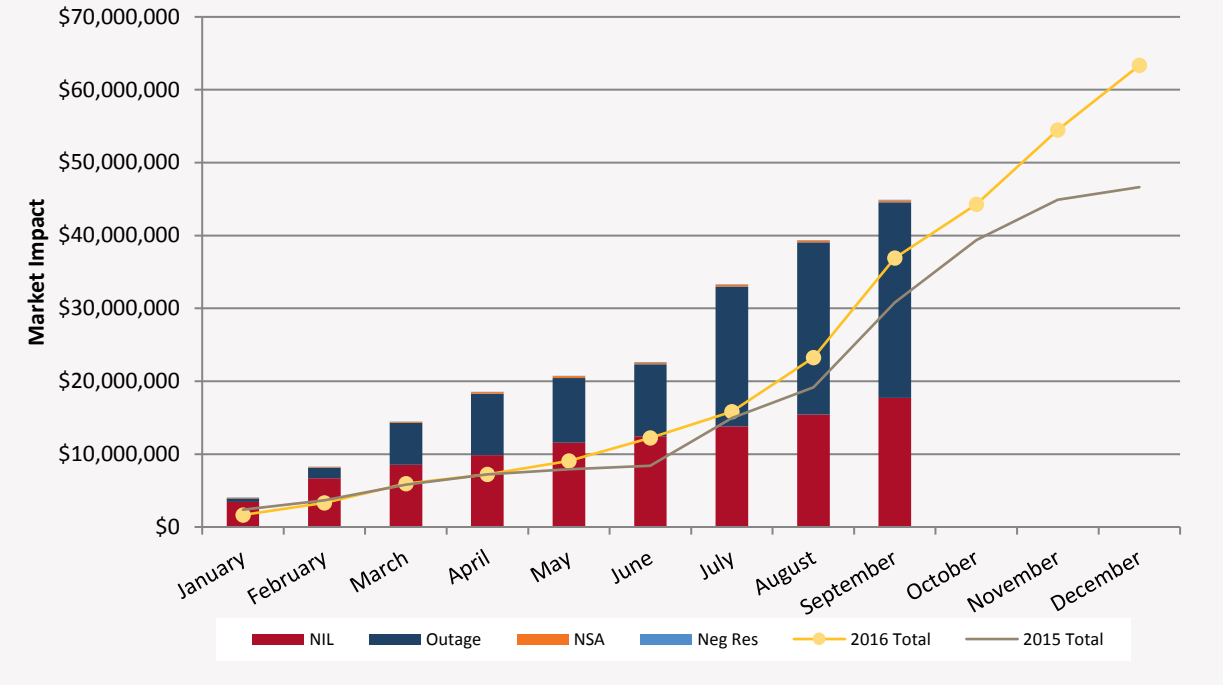
Figure 2-3 — Binding by limit type



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 2-7 – Top 10 largest Dispatch / Pre-dispatch differences

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
S>NWBCB6225_TX1	Out= North West Bend 132kV CB6225, avoid O/L of North West Bend 66/132kV TX1 on trip of North West Bend-Monash #2 132kV line, Feedback	67	1,980,338 % (12.58)	76,768% (4.01)
V^SML_BAWB_3	Out = Ballarat to Waubra 220kV line, avoid voltage collapse for loss of Bendigo to Kerang 220kV line	30	3,881% (84.45)	443% (47.14)
V::N_NIL_S1	Out = NIL, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, SA accelerates, Yallourn W G1 on 220 kV.	8	3,825% (331.15)	506% (94.93)
N^^V_LTWG	Out = Lower Tumut to Wagga 330 kV line, avoid voltage collapse in Southern NSW for either loss of the largest VIC generating unit or Basslink, or loss of a Murray to Dederang 330 kV line	4	2,061% (190.78)	1,542% (176.54)
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.	127	676% (263.29)	33.84% (84.62)
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.	53	331% (349.33)	44.91% (64.08)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
V::N_SMF2_V2	Out = South Morang F2 500/330kV txfmr, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.	87	240% (222.74)	28.02% (60.7)
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	5	177% (351.47)	114.74% (258.23)
N_X_MBTE2_A	Out= two Directlink cables, NSW to Qld limit	59	133.75% (11.8)	21.32% (4.46)
V::N_SMF2_SD2	Out = South Morang F2 500/330kV txfmr, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, SA decelerates, YPS G1 on 500kV. Constraint active for SA flows above 500 MW VIC to SA only, swamped otherwise.	3	110.36% (309.78)	48.83% (154.3)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

S>NWBCB6225_TX1: Investigated and no improvement can be made to the constraint equation at this stage.

V::N_SMF2_V2: Investigated and no improvement can be made to the constraint equation at this stage.

V::N_SMF2_SD2: Investigated and no improvement can be made to the constraint equation at this stage.

V^SML_BAWB_3: Investigated and no improvement can be made to the constraint equation at this stage.

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_MBTE2_A: 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 September 2017.

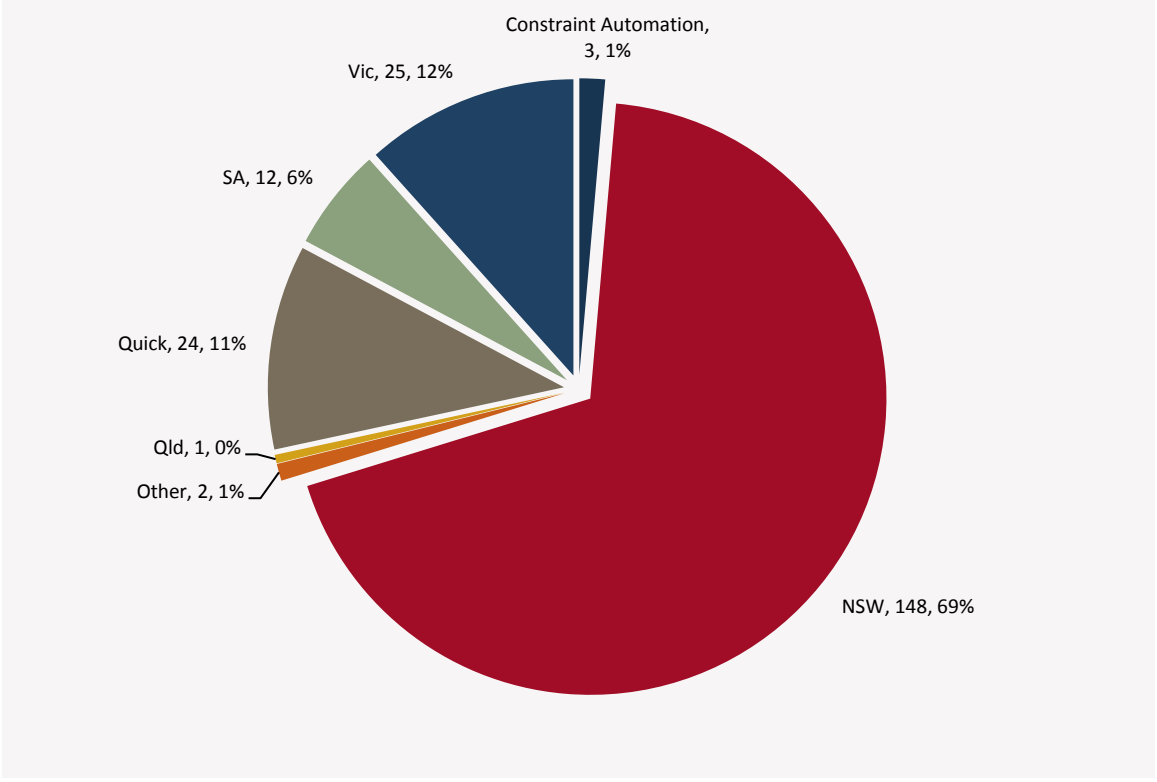
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Deer Park Terminal Station	11 September 2017	Victoria	The Deer Park 220 kV Terminal Station was commissioned at 2115 hrs. Market Notice 59167 issued.
Deer Park Terminal Station	14 September 2017	Victoria	Deer Park B2 and B4 220/66 kV transformers and the 66 kV bus bars were commissioned.

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