MONTHLY CONSTRAINT REPORT - JANUARY 2018

FOR THE NATIONAL ELECTRICITY MARKET

PUBLISHED **FEBRUARY 2018**

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.

Disclaimer

AEMO has made every effort to ensure the quality of the information in this report but cannot guarantee its accuracy or completeness. Any views expressed in this report are those of AEMO unless otherwise stated, and may be based on information given to AEMO by other persons.

Accordingly, to the maximum extent permitted by law, AEMO and its officers, employees and consultants involved in the preparation of this report:

- make no representation or warranty, express or implied, as to the currency, accuracy, reliability or completeness of the information in this report; and
- are not liable (whether by reason of negligence or otherwise) for any statements or representations in this report, or any omissions from it, or for any use or reliance on the information in it.

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

This report details constraint equation performance and transmission congestion related issues for January 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	2531 (210.91)	09/11/2017
I_CTRL_ISSUE_TE	DC Link Control Issue Constraint for Terranora	742 (61.83)	21/12/2012
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.	611 (50.91)	06/06/2016
T>T_NIL_110_1	Out = NIL, avoid pre-contingent O/L of the Derby to Scottsdale Tee 110 kV line, feedback	292 (24.33)	05/03/2014
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	274 (22.83)	20/12/2016
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.	235 (19.58)	25/11/2015
N^N_KKLS_1	Out= Koolkhan to Lismore (967), avoid voltage collapse on trip of Coffs Harbour to Lismore (89), swamp out when all 3 Directlink O/S	224 (18.66)	21/08/2013
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	201 (16.75)	13/09/2016
T>T_X_BWLF_PMWA110_4	Out= Bridgewater to Lindisfarne or Bridgewater to Waddamana AND Palmerston to Waddamana 110kV lines, avoid O/L Tungatinah to Meadowbank Tee 1 110kV line on trip of Tungatinah to Meadowbank Tee 2 to New Norfolk 110kV lines, Feedback	175 (14.58)	03/01/2018
N_MBTE1_B	Out= one Directlink cable, Qld to NSW limit	168 (14.0)	25/11/2013

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
V>>V_NIL_1A	Out = Nil, avoid O/L Murray to Dederang No.1 330kV line (flow MSS to DDTS) for loss of the parallel No.2 line, DBUSS-Line control scheme enabled, 15 min line ratings, feedback	339,932	19/01/2018
T>T_NIL_110_1	Out = NIL, avoid pre-contingent O/L of the Derby to Scottsdale Tee 110 kV line, feedback	277,898	05/03/2014
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.	184,574	11/12/2017
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	157,744	18/04/2017
S_HPRG1_E	Out= Nil, Hornsdale Battery generation energy target <= 30 MW	150,616	13/12/2017
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	146,287	09/11/2017
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	115,323	12/04/2016
F_I+LREG_0120	NEM Lower Regulation Requirement greater than 120 MW	115,042	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	96,172	12/04/2016
V^SML_NSWRB_2	Out = NSW Murraylink runback scheme, avoid voltage collapse for loss of Darlington Pt to Buronga (X5) 220kV line	95,835	01/05/2017

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
I_CTRL_ISSUE_TE	DC Link Control Issue Constraint for Terranora.	27 (2.25)	21/12/2012
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	12 (1.0)	12/04/2016
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	10 (0.83)	12/04/2016
N>LSDU_LSDU	Constraint Automation, O/L 9U7/L @LISM132 for CTG LN9X on trip of LISM132-DUNOON 9U6/L 132KV LINE. Generated by RTCA[EMS]	9 (0.75)	01/02/2018
S>>BG6246_BGPR_HUWT	Out= Bungama 132kV CB6246, avoid O/L Hummocks-Waterloo 132kV line on trip of Bungama-Port Pirie 132kV line (this offloads Snowtown-Bungama 132kV line), Feedback	5 (0.41)	02/09/2016
N^N_KKLS_1	Out= Koolkhan to Lismore (967), avoid voltage collapse on trip of Coffs Harbour to Lismore (89), swamp out when all 3 Directlink O/S	4 (0.33)	21/08/2013
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
N>N-KKLS_TE_2	Out= Koolkhan to Lismore (967), avoid O/L Glen Innes to Tenterfield (96R) on trip of Coffs Harbour to Lismore (89), swamp out when all 3 directlink O/S, Feedback, TG formulation on PD & ST	2 (0.16)	21/08/2013
F_T+LREG_0050	Tasmania Lower Regulation Requirement greater than 50 MW, Basslink unable to transfer FCAS	2 (0.16)	29/01/2015
S>NIL_HUWT_STBG	Out = Nil; Limit Snowtown WF generation to avoid Snowtown - Bungama line OL on loss of Hummocks - Waterloo line.	2 (0.16)	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
I_CTRL_ISSUE_TE	Constraint violated for 27 DIs last month, 26 of which were consecutive. Max violation of 8.4 MW occurred on 19/01/2018 at 1940 hrs. Constraint equation violated due to competing requirement with Terranora interconnector import limit set by N_MBTE1_B.
F_T+NIL_WF_TG_R6	Constraint violated for 12 DIs last month. Max violation of 11.37 MW occurred on 07/01/2018 at 1855 hrs. Constraint equation violated due to Tasmania raise 6 sec service availability less than requirement.
F_T+NIL_MG_R6	Constraint violated for 10 DIs last month. Max violation of 132.75 MW occurred on 23/01/2018 at 0045 hrs. Constraint equation violated due to Tasmania raise 6 sec service availability less than requirement.
N>LSDU_LSDU	Constraint violated for 9 DIs last month, 7 of which were consecutive. Max violation of 8.46 MW occurred on 13/01/2018 at 2210 hrs and 2215 hrs. Constraint equation violated due to competing requirement with Terranora interconnector import limit set by I_CTRL_ISSUE_TE
S>>BG6246_BGPR_HUWT	Constraint violated for 5 DIs last month. Max violation of 10.13 MW occurred on 13/01/2018 at 0805 hrs. Constraint violated due to Snowtown wind farm being limited by its ramp down rate.
N^N_KKLS_1	Constraint violated for 4 DIs last week. Max violation of 15 MW occurred on 19/01/2018 at 1105 hrs. Constraint equation violated due to competing requirement with Terranora interconnector import limit set by I_CTRL_ISSUE_TE.

Constraint Equation ID (System Normal Bold)	Description
T_TAMARCCGT_GCS	Constraint violated for 3 DIs on 22/01/2018 at 0805 hrs and 1530 hrs and on 23/01/2018 at 0045 hrs. Max violation of 37.57 MW occurred on 23/01/2018 at 0045 hrs. Constraint equation violated due to reduction in load armed by the Tamar GCS (generator control scheme) and Tamar Valley CCGT being limited by its ramp down rate.
N>N-KKLS_TE_2	Constraint violated for 2 DIs on 18/01/2018 at 1515 hrs and 1525 hrs. Max violation of 56 MW occurred on 18/01/2018 at 1525 hrs. Constraint equation violated due to competing requirement with Terranora interconnector import limit set by QNTE_ROC.
F_T+LREG_0050	Constraint violated for 2 DIs on 19/01/2018 at 1315 hrs and 22/01/2018 at 1115 hrs. Max violation of 50 MW occurred on 19/01/2018 at 1315 hrs. Constraint equation violated due to Tasmania lower regulation service availability less than requirement.
S>NIL_HUWT_STBG	Constraint violated for 2 DIs on 12/01/2018 at 0920 hrs and 0940 hrs. Max violation of 6.56 MW occurred on 12/01/2018 at 0940 hrs. Constraint violated due to Snowtown windfarm 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	2521 (210.08)	-433.13 (-964.83)
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	1067 (88.92)	-392.56 (-477.99)
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	1001 (83.42)	-286.54 (-477.99)
I_CTRL_ISSUE_TE	N-Q-MNSP1 Export	DC Link Control Issue Constraint for Terranora	708 (59.0)	-2.49 (44.6)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	591 (49.25)	-11.43 (478.0)
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	339 (28.25)	-459.15 (-477.99)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	292 (24.33)	101.87 (478.0)
F_T++RREG_0050	T-V-MNSP1 Import	Tasmania Raise Regulation Requirement greater than 50 MW, Basslink able transfer FCAS	246 (20.5)	-420.38 (-477.61)
F_MAIN++NIL_MG_R60	T-V-MNSP1 Export	Out = Nil, Raise 60 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	226 (18.83)	-112.77 (478.0)
V_T_NIL_FCSPS	T-V-MNSP1 Import	Basslink limit from Vic to Tas for load enabled for FCSPS	216 (18.0)	-432.68 (-475.91)

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

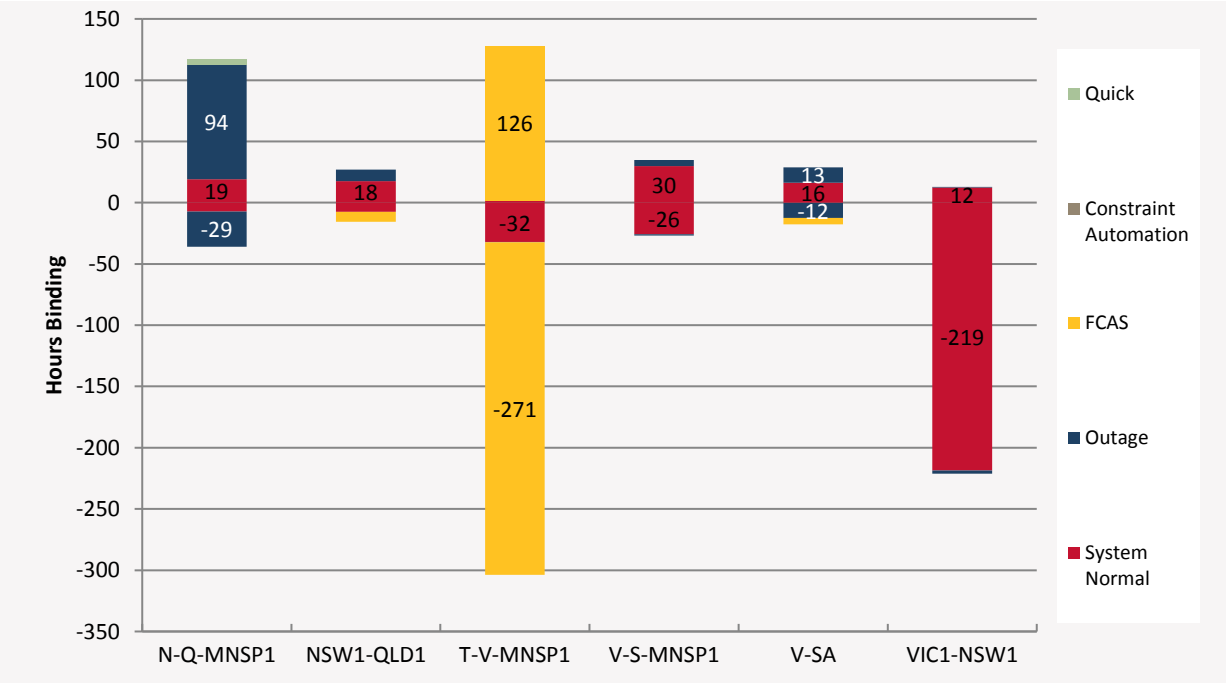
Non-real time constraint automation was not used.

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.

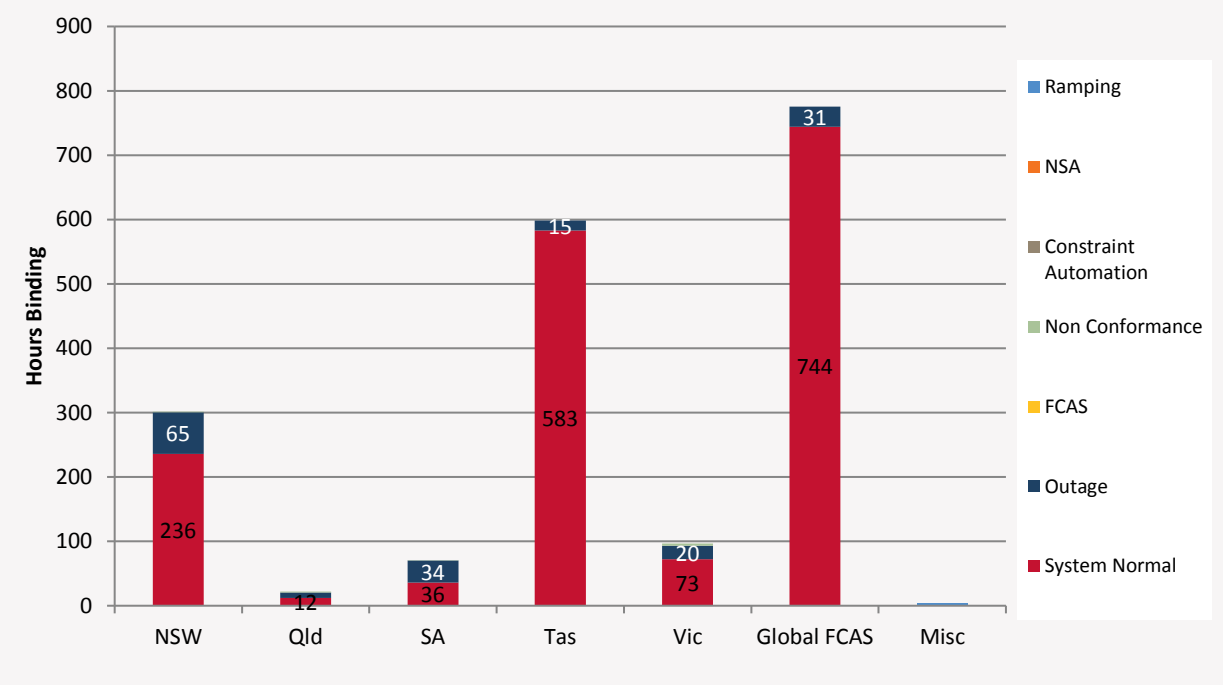
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

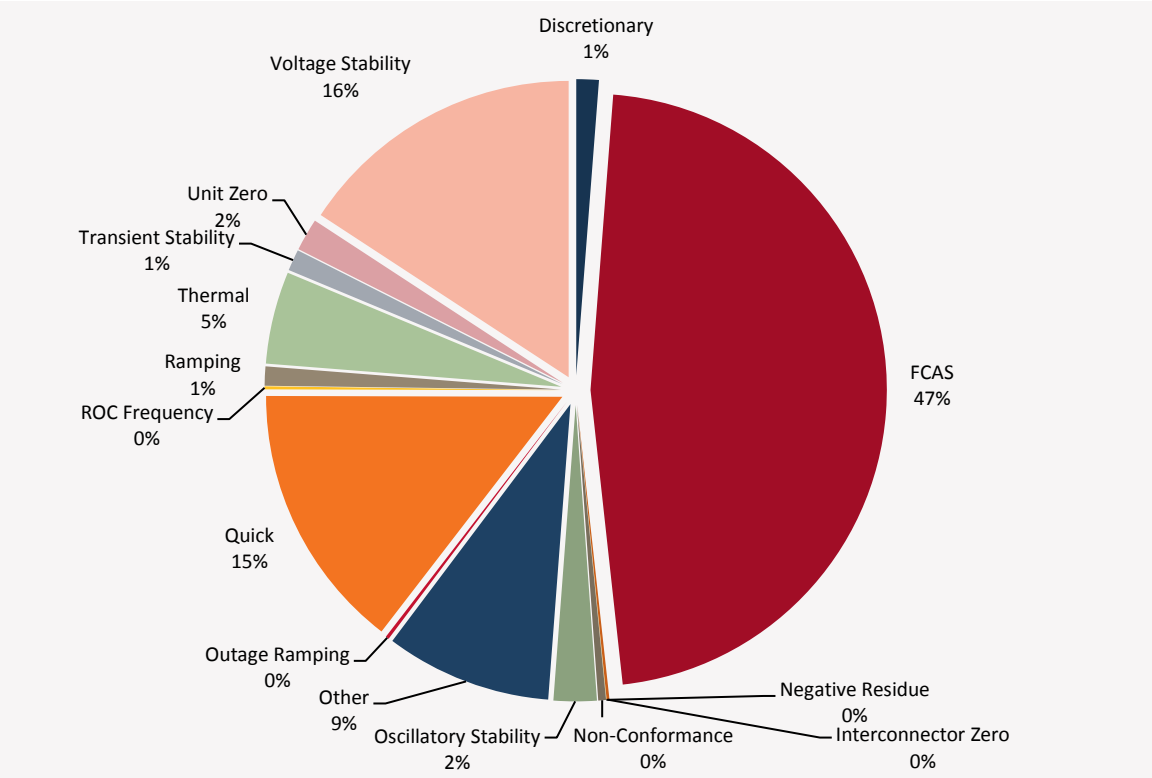
Figure 2-2 — Regional binding dispatch hours



2.7. Binding Constraint Equations by Limit Type

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

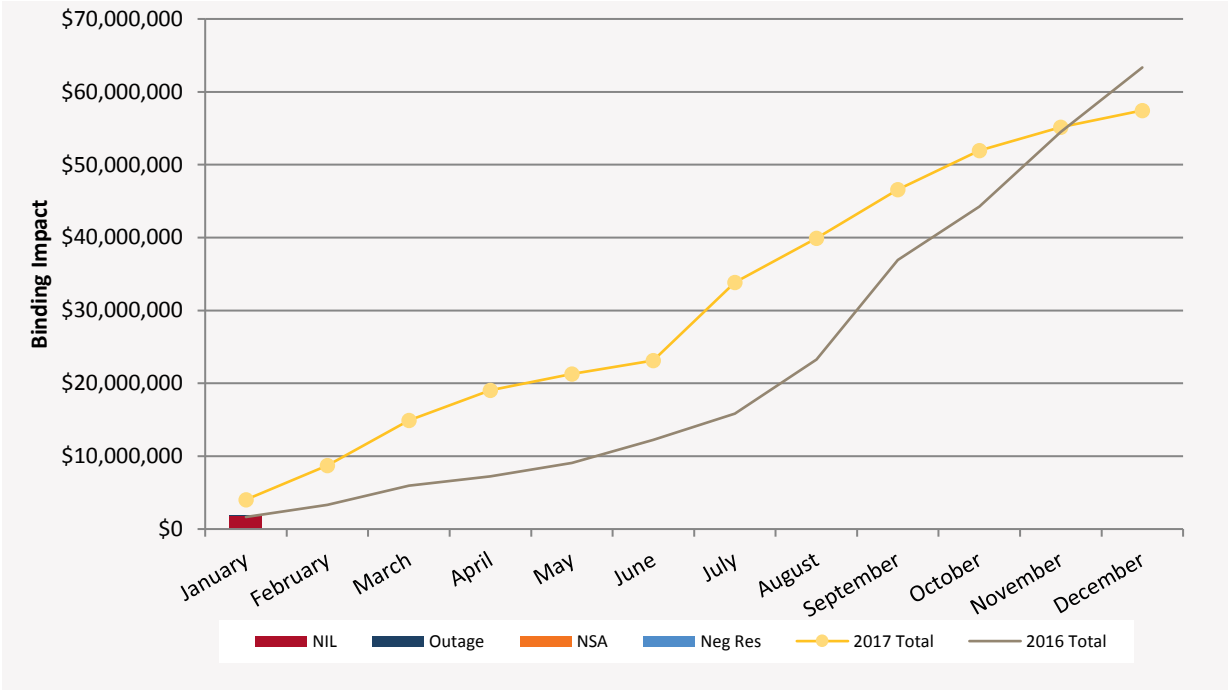
Figure 2-3 — Binding by limit type



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
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	3	426% (34.85)	230% (27.18)
N>>N-NIL__3_OPENED	Out= Nil, avoid O/L Liddell to Muswellbrook (83) using 15 mins rating on trip of Liddell to Tamworth (84) line, Feedback	18	299% (893)	92.98% (252.56)
V>SML_NSWRB_10	Out = NSW Murraylink runback scheme, avoid O/L of Kerang to Wemen 220 kV line section for loss of Balranald to Darlington Point (X5/1) 220 kV line, feedback	11	290% (379.13)	142.25% (223.19)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
N>N-NIL_LSDU	Out = Nil, avoid overloading Lismore to Dunoon line (9U6 or 9U7) on trip of the other Lismore to Dunoon line (9U7 or 9U6), Feedback	34	256% (126.35)	46.67% (24.54)
V>>V_NIL_8	Out = Nil, avoid O/L DDTS to WOTS 330kV line for trip of LowerTumut-Wagga (051) + (991,990,99P) or (990,99M,970) ex_Yass lines - status switched ; Feedback	3	174% (93.35)	157% (86.88)
V_T_NIL_FCSPS	Basslink limit from Vic to Tas for load enabled for FCSPS	66	162% (333.5)	38.76% (98.37)
N^^V_NIL_1	Out = Nil, avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	600	100.62% (321.9)	27.22% (93.97)
S>V_NIL_NIL_RBNW	Out = Nil, avoid overloading Robertstown-North West Bend #1 or #2 132kV lines for no contingencies, feedback	30	99.32% (172.57)	67.51% (114.88)
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.	7	98.33% (99.95)	84.4% (99.95)
S>>BG6246_BGPR_HUWT	Out= Bungama 132kV CB6246, avoid O/L Hummocks-Waterloo 132kV line on trip of Bungama-Port Pirie 132kV line (this offloads Snowtown-Bungama 132kV line), Feedback	6	93.46% (76.45)	47.13% (38.27)

2.9.1. Further Investigation

The following constraint equation(s) have been investigated:

S>>BG6246_BGPR_HUWT: Investigated and no improvement can be made to the constraint equation at this stage.

N>>N-NIL__3_OPENED: Investigated and constraint equation looks normal. The mismatch may be due to the local load distribution changes near Muswellbrook and Mitchell. Local load DFS when established can help with the PD performance.

V>SML_NSWRB_10: Investigated and no improvement can be made to the constraint equation at this stage.

N>N-NIL_LSDU: Investigated and the mismatch is due to modelling of DFS and SCADA value on Terranora load. DFS forecasting is being investigated to improve its performance. No improvements can be made to the constraint equation at this stage.

V>>V_NIL_8: 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.

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.

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

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 January 2018.

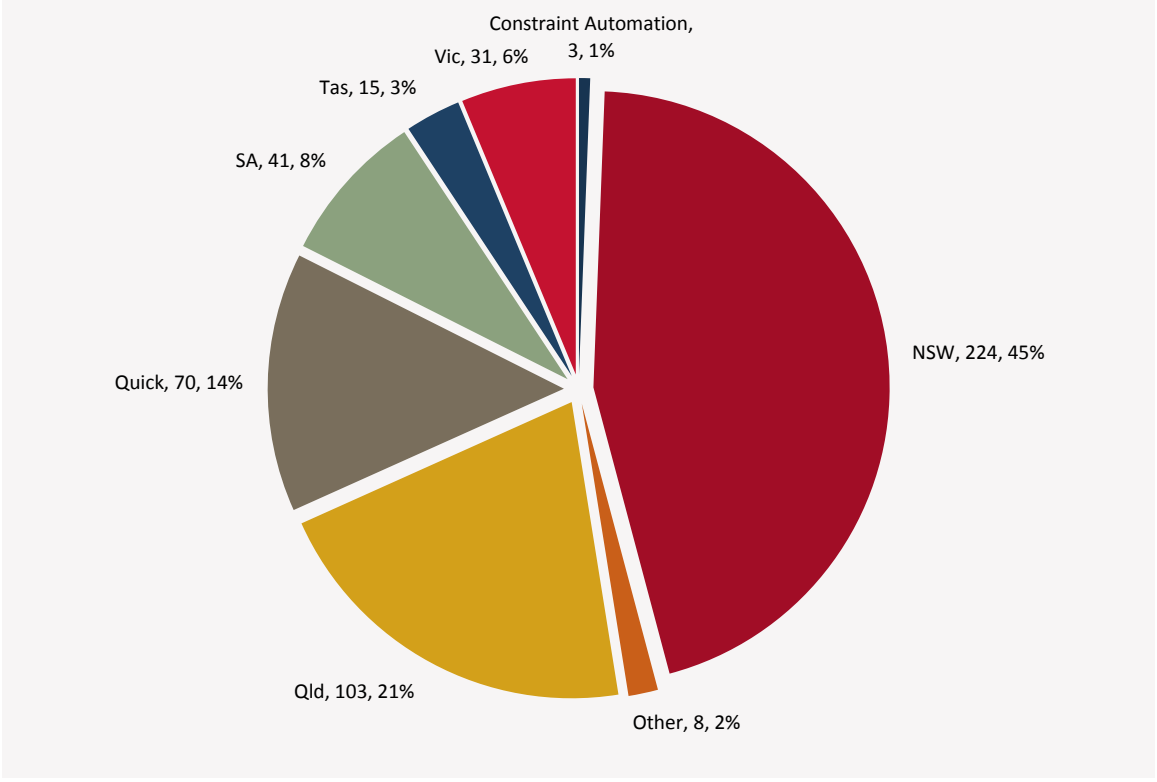
Table 3-1 – Generator and transmission changes

Project	Date	Region	Notes
Nil			

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