Monthly Constraint Report

June 2022

A report for the National Electricity Market on Constraint results.

Important notice

Purpose

This publication has been prepared by AEMO 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 June 2022. 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 1 Top 10 binding network constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Limit Type
N^N-LS_SVC	Out= Lismore SVC O/S or in reactive power control mode, avoid Voltage collapse on Armidale to Coffs Harbour (87) trip; Swamp out when three directlink cables are O/S; TG formulation only	5374 (447.83)	Voltage Stability
Q_STR_7C2K_HASF_5	No limit to Haughton Solar Farm if Stan>=2+(Stan+Cal)>=3+Glad>=2+(Stan+Cal+Glad) >=7+Kar>=2,NQLD>350&370(AVG),Ross_FN>150&170(AVG),Haughton Syncon is ON, Zero otherwise.	2528 (210.66)	System Strength
Q_STR_7C2K_HASF_4	No limit to Haughton Solar Farm if Stan>=2+Cal>=1+Glad>=2+(Stan+Cal+Glad) >=7+Kar>=2,NQLD>350&370(AVG),Ross_FN>150&170(AVG),Haughton Syncon is ON, Zero otherwise.	2116 (176.33)	System Strength
N_CG4_ZERO_E	Direction to zero for Colongra #4 for Dispatch and Predispatch and NOT PASA	2052 (171.0)	Other
N_CG2_ZERO_E	Direction to zero for Colongra #2 for Dispatch and Predispatch and NOT PASA	2052 (171.0)	Other
N_CG3_ZERO_E	Direction to zero for Colongra #3 for Dispatch and Predispatch and NOT PASA	2052 (171.0)	Other
N_URANQ11_ZERO_E	Direction to zero for Uranquinty #1 for Dispatch and Predispatch and NOT PASA	2040 (170.0)	Other
N_URANQ12_ZERO_E	Direction to zero for Uranquinty #2 for Dispatch and Predispatch and NOT PASA	2040 (170.0)	Other
N_URANQ14_ZERO_E	Direction to zero for Uranquinty #4 for Dispatch and Predispatch and NOT PASA	2040 (170.0)	Other
N_URANQ13_ZERO_E	Direction to zero for Uranquinty #3 for Dispatch and Predispatch and NOT PASA	2040 (170.0)	Other

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 Top 10 binding impact network constraint equations

Constraint Equation ID (System Normal Bold)	Description	∑ Marginal Values	Limit Type
Q^^NIL_QNI_SRAR	Out = Nil, limit QLD to NSW on QNI to avoid voltage instability on trip of Sapphire - Armidale (8E) 330 kV line	8,809,577	Voltage Stability
S_TORRB3_ZERO_E	Direction to zero for Torrens Island B #3 for Dispatch and Predispatch and NOT PASA	8,790,091	Other
N_SITHE01_ZERO_E	Direction to zero for Sithe for Dispatch and Predispatch and NOT PASA	7,935,494	Other
V^^N_NIL_1	Out = Nil, avoid voltage collapse around Murray for loss of all APD potlines	7,491,316	Voltage Stability
S_TORRB2_ZERO_E	Direction to zero for Torrens Island B #2 for Dispatch and Predispatch and NOT PASA	7,085,534	Other
S_PPCCGT_ZERO_E	Direction to zero for Pelican Point for Dispatch and Predispatch and NOT PASA	7,038,417	Other
S^NIL_CRK+MTM_95	Out= Nil, upper limit for Cathedral Rocks WF + Mt Millar WF <= 95 MW to maintain voltage stability limits	6,878,706	Voltage Stability
N^N-LS_SVC	Out= Lismore SVC O/S or in reactive power control mode, avoid Voltage collapse on Armidale to Coffs Harbour (87) trip; Swamp out when three directlink cables are O/S; TG formulation only	6,474,543	Voltage Stability
N_URANQ11_ZERO_E	Direction to zero for Uranquinty #1 for Dispatch and Predispatch and NOT PASA	6,188,873	Other
N_URANQ14_ZERO_E	Direction to zero for Uranquinty #4 for Dispatch and Predispatch and NOT PASA	6,177,816	Other

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 3 Top 10 violating constraint equations

Constraint Equation ID (System Normal Bold)	Description	#DIs (Hours)	Limit Type
S_TORRB3_ZERO_E	Direction to zero for Torrens Island B #3 for Dispatch and Predispatch and NOT PASA	1980 (165.0)	Other
S_TORRB2_ZERO_E	Direction to zero for Torrens Island B #2 for Dispatch and Predispatch and NOT PASA	1980 (165.0)	Other
N_URANQ11_ZERO_E	Direction to zero for Uranquinty #1 for Dispatch and Predispatch and NOT PASA	1651 (137.58)	Other
N_URANQ13_ZERO_E	Direction to zero for Uranquinty #3 for Dispatch and Predispatch and NOT PASA	1629 (135.75)	Other
N_URANQ14_ZERO_E	Direction to zero for Uranquinty #4 for Dispatch and Predispatch and NOT PASA	1572 (131.0)	Other
N_URANQ12_ZERO_E	Direction to zero for Uranquinty #2 for Dispatch and Predispatch and NOT PASA	1561 (130.08)	Other
N_SITHE01_ZERO_E	Direction to zero for Sithe for Dispatch and Predispatch and NOT PASA	1515 (126.25)	Other
S_PPCCGT_ZERO_E	Direction to zero for Pelican Point for Dispatch and Predispatch and NOT PASA	1494 (124.5)	Other
T_V_BL_ZERO_E	Direction to zero for Basslink (Tas to Vic) for Dispatch and Predispatch and NOT PASA	1296 (108.0)	Other
V_NPS_ZERO_E	Direction to zero for Newport for Dispatch and Predispatch and NOT PASA	862 (71.83)	Other

2.3.1 Reasons for constraint equation violations

Table 4 Reasons for constraint equation violations

Constraint Equation ID (System Normal Bold)	Description
S_TORRB3_ZERO_E	Constraint violated for 1980 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 200 MW occurring on multiple DIs. Constraint violated due to the management of directions during market suspension.
S_TORRB2_ZERO_E	Constraint violated for 1980 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 190 MW occurring on multiple DIs. Constraint violated for the same reason as above.
N_URANQ11_ZERO_E	Constraint violated for 1651 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 166 MW occurring on multiple DIs. Constraint violated for the same reason as above.
N_URANQ13_ZERO_E	Constraint violated for 1629 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 166 MW occurring on multiple DIs. Constraint violated for the same reason as above.
N_URANQ14_ZERO_E	Constraint violated for 1527 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 166 MW occurring on multiple DIs. Constraint violated for the same reason as above.
N_URANQ12_ZERO_E	Constraint violated for 1561 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 166 MW occurring on multiple DIs. Constraint violated for the same reason as above.
N_SITHE01_ZERO_E	Constraint violated for 1515 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 120 MW occurring on multiple DIs. Constraint violated for the same reason as above.
S_PPCCGT_ZERO_E	Constraint violated for 1494 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 500 MW occurring on multiple DIs. Constraint violated for the same reason as above.
T_V_BL_ZERO_E	Constraint violated for 1296 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 478 MW occurring on multiple DIs. Constraint violated for the same reason as above.

Constraint Equation ID (System Normal Bold)	Description
V_NPS_ZERO_E	Constraint violated for 862 non-consecutive DIs between 16/06/2022 and 23/06/2022 with a max violation of 510 MW occurring on multiple DIs. Constraint violated for the same reason as above.

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 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 5 Top 10 binding interconnector limit setters

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
N^N-LS_SVC	N-Q-MNSP1 Export	Out= Lismore SVC O/S or in reactive power control mode, avoid Voltage collapse on Armidale to Coffs Harbour (87) trip; Swamp out when three directlink cables are O/S; TG formulation only	5219 (434.92)	-87.87 (83.46)
T_V_BL_ZERO_E	T-V-MNSP1 Export	Direction to zero for Basslink (Tas to Vic) for Dispatch and Predispatch and NOT PASA	1295 (107.92)	0.0 (0.0)
SVML^NIL_MH-CAP_ON	V-S-MNSP1 Import	Out=NIL, SA to Vic on ML upper transfer limit to manage voltage collapse at Monash (Note: applies when capacitor banks at Monash are available and I/S for switching.)	1112 (92.67)	-154.47 (-185.75)
#T-V-MNSP1_E_O_E	T-V-MNSP1 Import	T-V-MNSP1.ENERGY * 1 >= 150 (Wt = 65)	1017 (84.75)	329.08 (100.0)
Q^^NIL_QNI_SRAR	NSW1-QLD1 Import	Out = Nil, limit QLD to NSW on QNI to avoid voltage instability on trip of Sapphire - Armidale (8E) 330 kV line	1014 (84.5)	-1019.95 (-1107.12)
F_MAIN++NIL_MG_R5	T-V-MNSP1 Export	Out = Nil, Raise 5 min requirement for a Mainland Generation Event, Basslink able transfer FCAS	997 (83.08)	372.51 (439.02)
V^^N_NIL_1	VIC1-NSW1 Export	Out = Nil, avoid voltage collapse around Murray for loss of all APD potlines	943 (78.58)	925.08 (1458.79)
SVML_ZERO	V-S-MNSP1 Import	SA to Vic on ML upper transfer limit of 0 MW	776 (64.67)	0.0 (0.0)
N_NIL_TE_B	N-Q-MNSP1 Import	Out=Nil, Terranora Interconnector Qld to NSW flow overall limits	596 (49.67)	-184.66 (-201.6)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	470 (39.17)	324.33 (439.01)

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

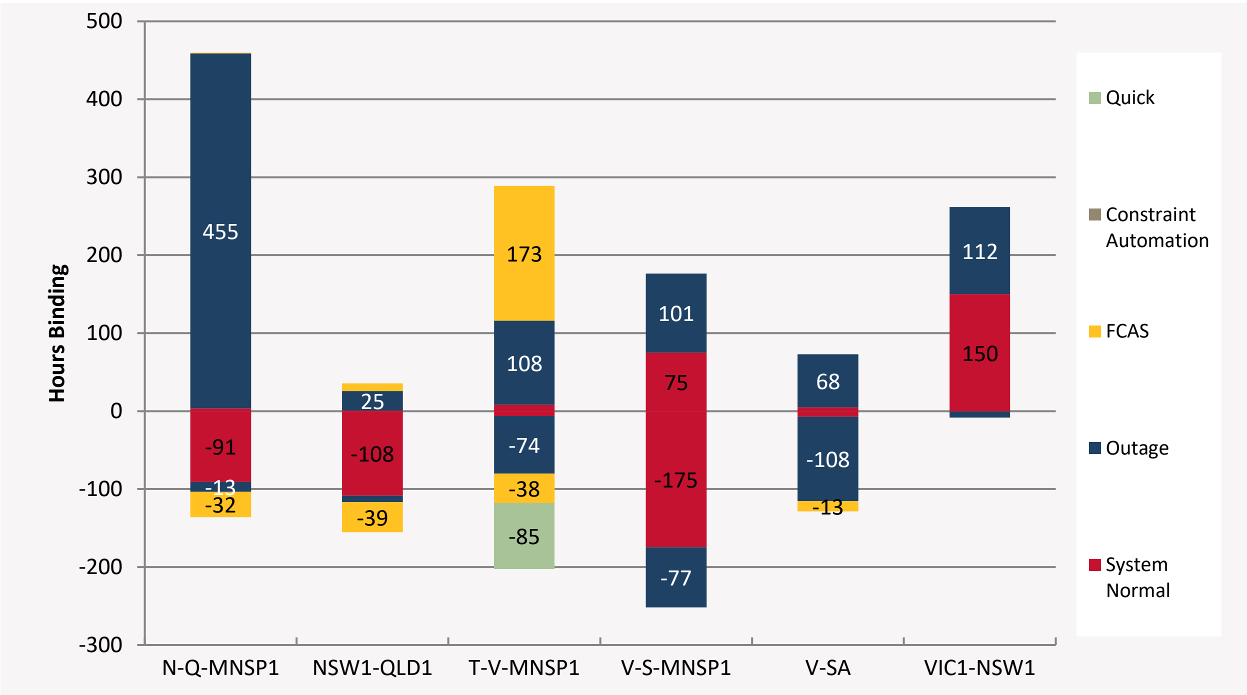
Non-real time constraint automation was not used.

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.

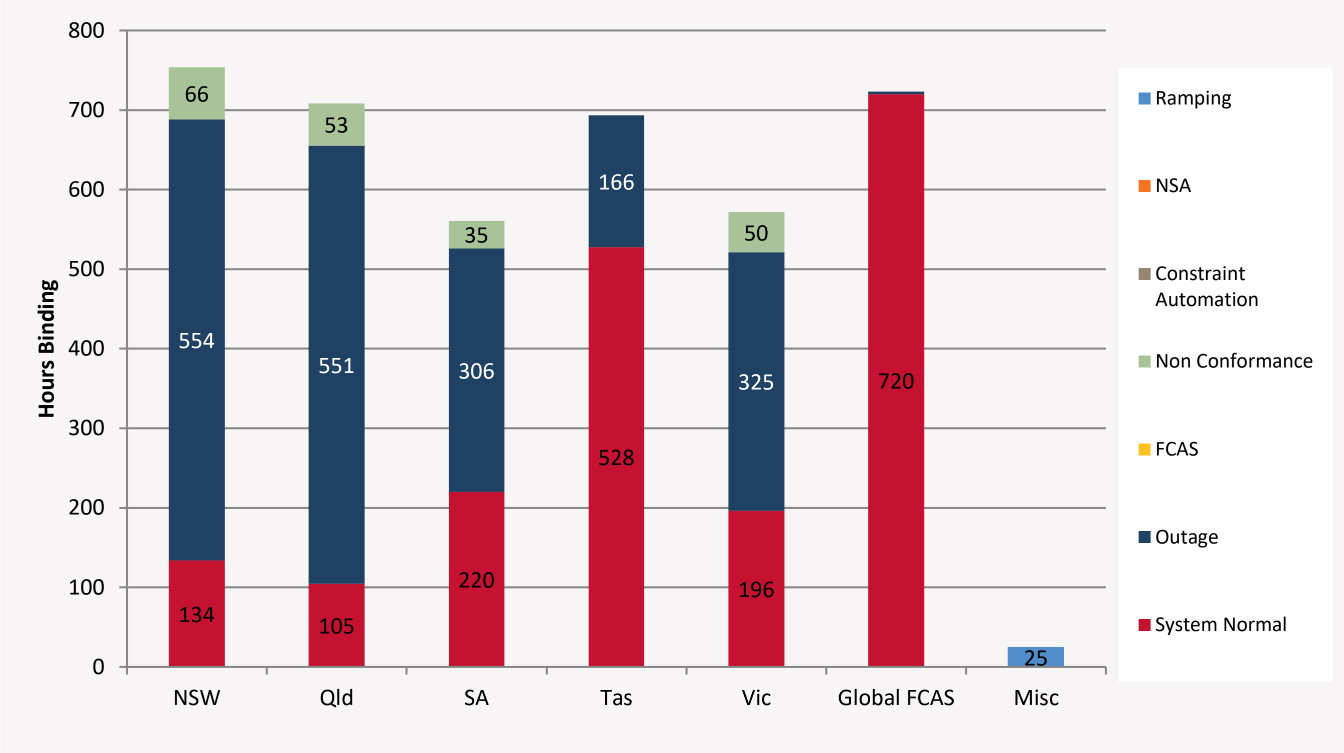
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

Figure 1 Interconnector binding dispatch hours



The regional comparison graph below uses the same categories as in Figure 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.

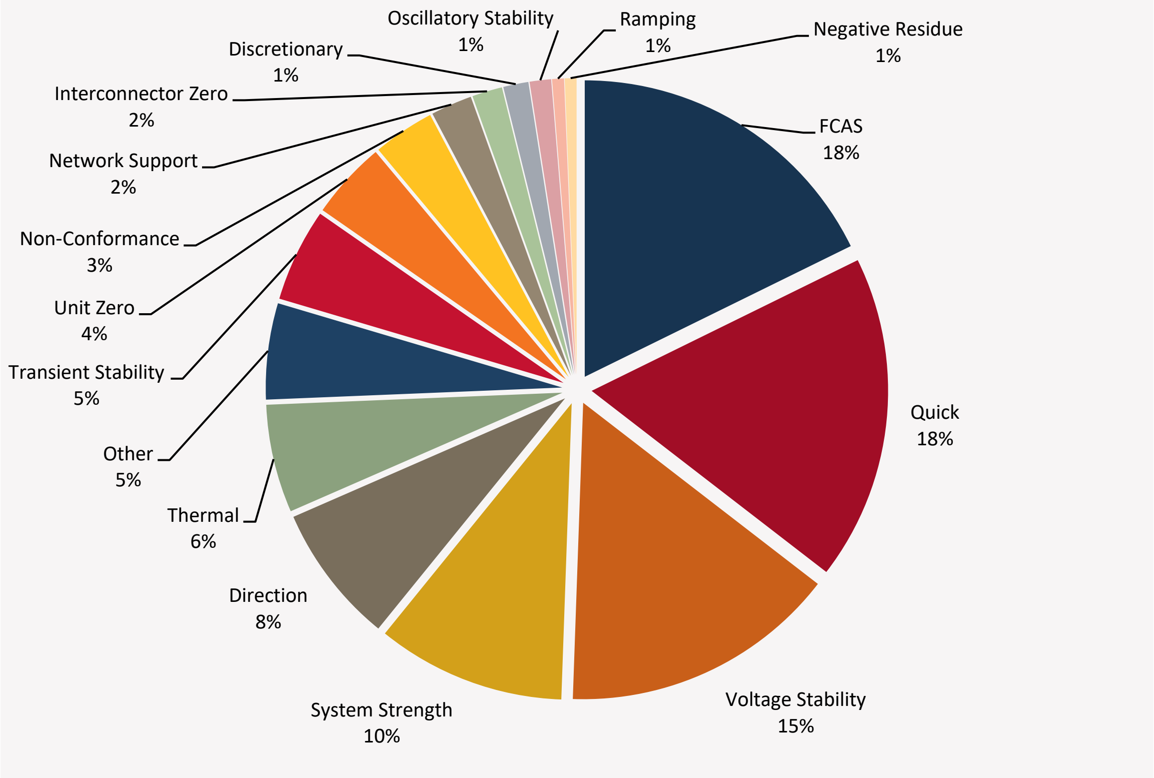
Figure 2 Regional binding dispatch hours



2.7 Binding Constraint Equations by Limit Type

The following pie charts show the percentage of dispatch intervals for June 2022 that the different types of constraint equations bound.

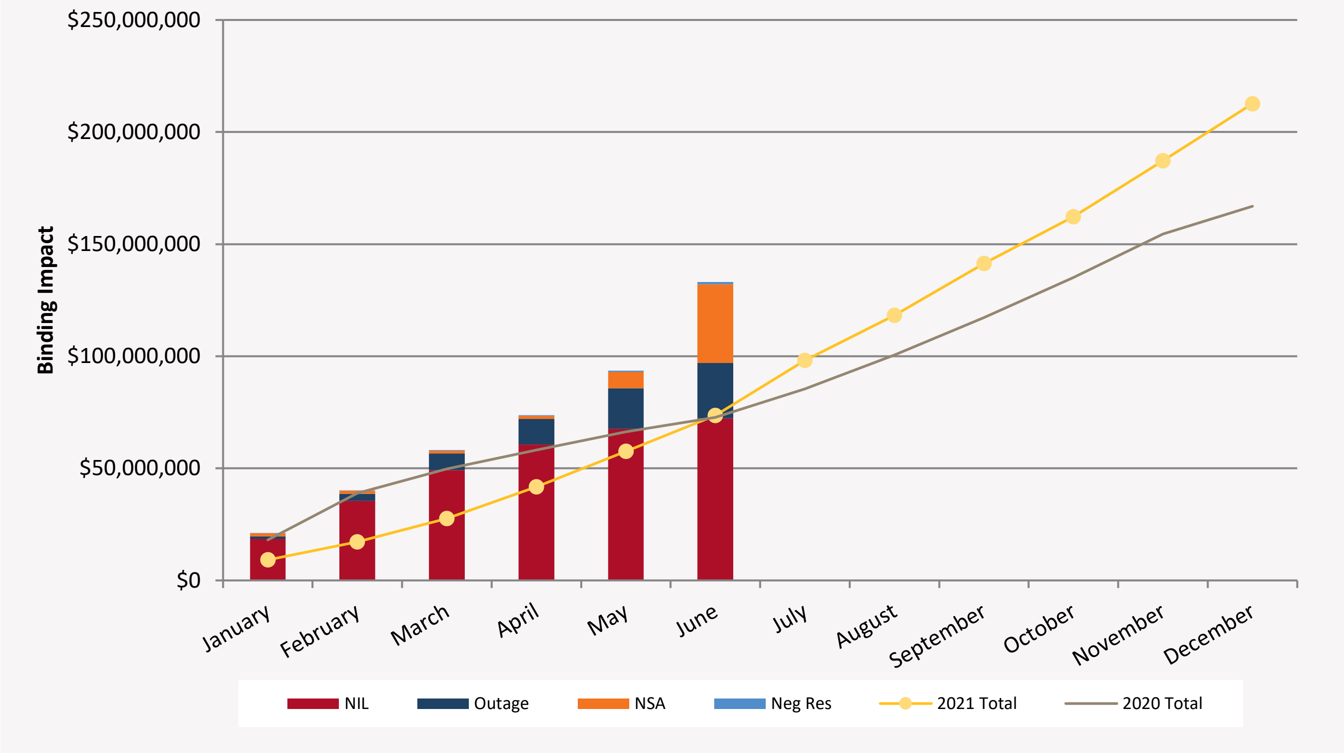
Figure 3 Binding by limit type



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 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 6 Top 10 largest Dispatch / Pre-dispatch differences

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
V::N_DDSM_V1	Out = Dederang to South Morang 330kV line, prevent transient instability for fault and trip of the parallel Dederang to South Morang 330kV line, VIC accelerates, Yallourn W G1 on 220 kV.	45	44,059% (209.73)	1,541% (82.48)
N^N-LS_SVC	Out= Lismore SVC O/S or in reactive power control mode, avoid Voltage collapse on Armidale to Coffs Harbour (87) trip; Swamp out when three directlink cables are O/S; TG formulation only	958	27,481% (113.24)	89.27% (23.66)
NSA_S_POR01_ISLD	Network Support Agreement for Port Lincoln Units 1 and 2 to meet local islanded demand for the planned outage.	159	19,772% (16.2)	171% (4.59)
V::N_X_SMSC_V1	Out = both South Morang 330 kV series capacitor banks, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates. Yallourn W G1 on 220kV.	102	8,059% (514)	299% (170.89)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
V::N_DDSM_V2	Out = Dederang to South Morang 330kV line, prevent transient instability for fault and trip of the parallel Dederang to South Morang 330kV line, VIC accelerates, Yallourn W G1 on 500 kV.	83	5,922% (183.61)	247% (71.54)
V::N_X_SMSC_O1	Out = both South Morang 330 kV series capacitor banks, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, Other than VIC accelerates. Yallourn W G1 on 220kV.	55	3,546% (408.48)	256% (145.76)
V>>V_DDSM_1	Out= Dederang to South Morang 330kV line, avoid O/L Ballarat to Bendigo 220kV line on trip of the remaining South Morang to Dederang 330kV line, Feedback	111	3,254% (231.16)	169% (91.99)
V::N_X_SMSC_O2	Out = both South Morang 330 kV series capacitor banks, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, Other than VIC accelerates. Yallourn W G1 on 500kV.	45	1,665% (359.1)	155% (148.42)
S::V_TBSE_TBSE	Out = one Tailembend-South East 275kV line (Note: with both Black Range series caps I/S); SA to VIC Transient Stability limit for loss of other Tailembend-South East 275kV lines.	115	776% (23.39)	70.42% (6.6)

2.9.1 Further Investigation

The following constraint equation(s) have been investigated:

S::V_TBSE_TBSE: Investigated in July 2022 and no improvement can be made at this stage.

V::N_DDSM_V1: Investigated in May 2022 and no improvement can be made at this stage.

N^N-LS_SVC: Investigated in May 2022 and no improvement can be made at this stage.

NSA_S_POR01_ISLD: Investigated in June 2022 and no improvement can be made at this stage.

V::N_X_SMSC_V1: Investigated in May 2022 and no improvement can be made at this stage.

V::N_DDSM_V2: Investigated in May 2022 and no improvement can be made at this stage.

V::N_X_SMSC_O1: Investigated in May 2022 and no improvement can be made at this stage.

V>>V_DDSM_1: Investigated in June 2022 and no improvement can be made at this stage.

V::N_X_SMSC_O2: Investigated in May 2022 and no improvement can be made at this stage.

V::N_X_SMSC_V2: Investigated in May 2022 and no improvement can be made 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 June 2022.

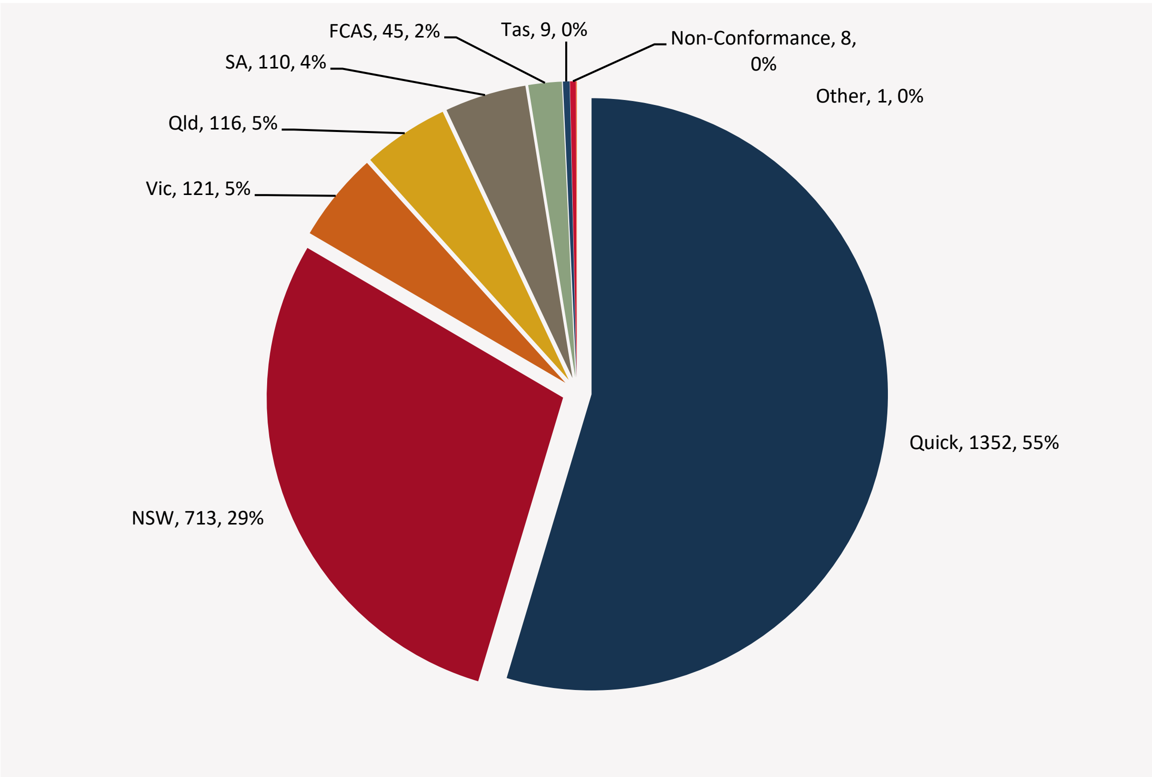
Table 7 Generator and transmission changes

Project	Date	Region	Notes
Columboola Solar Farm	14 June 2022	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 5 Constraint equation changes



[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: https://www.aemo.com.au/energy-systems/market-it-systems/nem-guides/wholesale-it-systems-software

The following graph compares the constraint equation changes for the current year versus the previous two years. The current year is categorised by region.

Figure 6 Constraint equation changes per month compared to previous two years