Monthly Constraint Report

August 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 August 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	5917 (493.08)	Voltage Stability
S>NIL_MHNW1_MHNW2	Out= Nil, avoid O/L Monash-North West Bend #2 132kV on trip of Monash-North West Bend #1 132kV line, Feedback	1449 (120.75)	Thermal
N^^N_NIL_3	Out= Nil, limit power flow on line X5 from Balranald to Darlington Point (X5) to avoid voltage collapse at Balranald for contingency trip of any major 220kV line in NW Victoria	1249 (104.08)	Voltage Stability
N>NIL_969	Out= Nil, avoid O/L Gunnedah to Tamworth (969) on trip of Nil, Feedback. Metering is used as specified in OM520	1088 (90.66)	Thermal
T::T_NIL_3	Out = NIL, prevent poorly damped TAS North - South oscillations following fault and trip of Palmerston to Sheffield 220 kV line. Swamp out when Basslink export or inertia of machines exporting through Sheffield < 1850 MWs.	848 (70.66)	Transient Stability
N>NIL_94T	Out= Nil, avoid O/L Molong to Orange North (94T) on trip of Nil, Feedback	846 (70.5)	Thermal
V^^N_NIL_1	Out = Nil, avoid voltage collapse around Murray for loss of all APD potlines	752 (62.66)	Voltage Stability
S>NIL_HUWT_STBG3	Out = Nil; Limit Snowtown WF generation to avoid Snowtown - Bungama line OL on loss of Hummocks - Waterloo line.[Note: Constraint Swamped when Wattle PT when generating >=60 MW)	750 (62.5)	Thermal
S_DVRB_270	Out = DV-BL 275kV line Or MK-RB 275kV line O/S, discretionary upper limit for North Brown Hill WF + Bluff WF + Willogolechie WF + Hallet Hill WF (i.e. generation + load component) <= 270 MW	736 (61.33)	Discretionary
V>>V_NIL_18	Out= Nil, avoid O/L Ararat to Waubra 220kV line on trip of Kerang to Bendigo 220kV line, Feedback	685 (57.08)	Thermal

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
S>NIL_MHNW1_MHNW2	Out= Nil, avoid O/L Monash-North West Bend #2 132kV on trip of Monash-North West Bend #1 132kV line, Feedback	1,097,646	Thermal
N>NIL_969	Out= Nil, avoid O/L Gunnedah to Tamworth (969) on trip of Nil, Feedback. Metering is used as specified in OM520	1,057,145	Thermal
N>NIL_94T	Out= Nil, avoid O/L Molong to Orange North (94T) on trip of Nil, Feedback	954,137	Thermal
N^^N_NIL_3	Out= Nil, limit power flow on line X5 from Balranald to Darlington Point (X5) to avoid voltage collapse at Balranald for contingency trip of any major 220kV line in NW Victoria	939,768	Voltage Stability
V>>V_NIL_18	Out= Nil, avoid O/L Ararat to Waubra 220kV line on trip of Kerang to Bendigo 220kV line, Feedback	599,808	Thermal
S_DVRB_270	Out = DV-BL 275kV line Or MK-RB 275kV line O/S, discretionary upper limit for North Brown Hill WF + Bluff WF + Willogolechie WF + Hallet Hill WF (i.e. generation + load component) <= 270 MW	586,878	Discretionary
S_ISLE_CRK_10	Discretionary upper limit on Cathedral Rocks windfarm<=10 MW when 2-4 syn cons I/S for SA is at risk of islanding or in islanded mode(Note: this equation is swamped when 0-1 sync cons are I/S)	547,691	Discretionary
S>NIL_HUWT_STBG3	Out = Nil; Limit Snowtown WF generation to avoid Snowtown - Bungama line OL on loss of Hummocks - Waterloo line. [Note: Constraint Swamped when Wattle PT when generating >=60 MW)	515,237	Thermal
S>>MKRB_TWPA_TPRS	Out= Mokota-Robertstown 275kV line, avoid O/L Templers-Roseworthy 132kV line on trip of Templers West-Para 275kV line, Feedback	507,184	Thermal
V_BANSF_BBD_60	Out = Nil, Limit Bannerton SF upper limit to 60 MW if Boundary Bend (BBD) loading is less than 10 MW, DS only. Swamp out if BBD loading is 10 MW or above.	367,603	Discretionary

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

[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.

(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)	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	19 (1.58)	Voltage Stability
F_I+NIL_APD_TL_L6	Lower 6 sec Service Requirement for the loss of APD potlines due to undervoltage following a fault on MOPS-HYTS-APD 500 kV line	13 (1.08)	FCAS
F_I+BIP_ML_L6	Out = Nil, Lower 6 sec requirement for a NEM Load Event, for loss of the largest Boyne Island potline.	13 (1.08)	FCAS
F_I+NIL_MG_R6	Out = Nil, Raise 6 sec requirement for a NEM Generation Event	13 (1.08)	FCAS
F_I+NIL_APD_TL_L60	Lower 60 sec Service Requirement for the loss of APD potlines due to undervoltage following a fault on MOPS-HYTS-APD 500 kV line	13 (1.08)	FCAS
F_I+BIP_ML_L60	Out = Nil, Lower 60 sec requirement for a NEM Load Event, for loss of the largest Boyne Island potline.	13 (1.08)	FCAS
F_I+GFT_TG_R6	Out = Nil, Raise 6 sec requirement for a Network Event - loss of Waubra, Ararat, Crowlands, Bulgana and Murra Warra wind farms due to operation of GFT following a trip of ARTS - WBTS - BATS 220kV line	13 (1.08)	FCAS
F_I+NIL_WF_TG_R6	Out= Nil, Global Raise 6 sec requirement for loss of a Smithton to Woolnorth or Norwood to Scotsdale tee Derby, Waddamana to Cattle Hill or Pieman to Granville Harbour line	13 (1.08)	FCAS
F_I+NIL_BB_TG_R6	Out= Nil, Global Raise 6 sec requirement for loss of a Bell Bay to George Town line	13 (1.08)	FCAS
F_I+TTS_TG_R6	Out = Nil, Raise 6 sec requirement for a Network Event - loss of Silverton WF, Broken Hill SF, Sunraysia SF, Limondale 1 SF and Darlington Point SF due to operation of Transfer Trip Scheme (TTS) following contingency trip of line 63	13 (1.08)	FCAS

2.3.1 Reasons for constraint equation violations

Table 4 Reasons for constraint equation violations

Constraint Equation ID (System Normal Bold)	Description
N^N-LS_SVC	Constraint equation violated for 19 non-consecutive DIs between 03/08/2022 0630 hrs and 15/08/2022 at 1815 hrs with a max violation of 75.53 MW occurring on 03/08/2022 at 0705 hrs. Constraint violated due to competing requirements with import limits on the DirectLink interconnector which were set by #R025806_002_RAMP_F, N_X_MBTE_3B.
F_I+NIL_APD_TL_L6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 3101.09 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation occurred due to an issue with an updated NEMDE version (see market notice 100839).
F_I+BIP_ML_L6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2964.24 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6.
F_I+NIL_MG_R6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2964.24 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6

Constraint Equation ID (System Normal Bold)	Description
F_I+NIL_APD_TL_L60	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2610.95 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6.
F_I+BIP_ML_L60	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2419.61 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6.
F_I+GFT_TG_R6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2368.84 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6
F_I+NIL_WF_TG_R6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2333.66 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6.
F_I+NIL_BB_TG_R6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2231.06 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6.
F_I+TTS_TG_R6	Constraint equation violated for 13 consecutive DIs between 10/08/2022 at 1135 hrs and 10/08/2022 at 1235 hrs with max violation of 2231.06 MW occurring on 10/08/2022 at 1135 hrs. Constraint equation violation due to same reason as F_I+NIL_APD_TL_L6.

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	5688 (474.0)	-70.48 (96.5)
S>NIL_MHNW1_MHNW2	V-S-MNSP1 Export	Out= Nil, avoid O/L Monash-North West Bend #2 132kV on trip of Monash-North West Bend #1 132kV line, Feedback	1347 (112.25)	164.35 (190.67)
F_MAIN++NIL_MG_R6	T-V-MNSP1 Export	Out = Nil, Raise 6 sec requirement for a Mainland Generation Event, Basslink able transfer FCAS	1147 (95.58)	-119.22 (-10.26)
N^^N_NIL_3	VIC1-NSW1 Export	Out= Nil, limit power flow on line X5 from Balranald to Darlington Point (X5) to avoid voltage collapse at Balranald for contingency trip of any major 220kV line in NW Victoria	1146 (95.5)	270.83 (1125.86)
T::T_NIL_3	T-V-MNSP1 Import	Out = NIL, prevent poorly damped TAS North - South oscillations following fault and trip of Palmerston to Sheffield 220 kV line. Swamp out when Basslink export or inertia of machines exporting through Sheffield < 1850 MWs.	845 (70.42)	-139.88 (-323.15)
N^^N_NIL_3	V-S-MNSP1 Import	Out= Nil, limit power flow on line X5 from Balranald to Darlington Point (X5) to avoid voltage collapse at Balranald for contingency trip of any major 220kV line in NW Victoria	785 (65.42)	119.41 (-161.78)
V^^N_NIL_1	VIC1-NSW1 Export	Out = Nil, avoid voltage collapse around Murray for loss of all APD potlines	612 (51.0)	894.8 (1475.71)
F_Q++ARTW_L6	NSW1-QLD1 Import	Out = Armidale to Tamworth (85 or 86) line, Qld Lower 6 sec Requirement	590 (49.17)	-267.58 (-505.4)

Constraint Equation ID (System Normal Bold)	Interconnector	Description	#DIs (Hours)	Average Limit (Max)
N>>LDNC_964_82	N-Q-MNSP1 Import	Out = Liddell to Newcastle (81) line, avoid O/L Port Macquarie to Herron Creek Tee (964/2) on trip of Liddell to Tomago (82) line, Swamps if 964 O/S, Feedback	578 (48.17)	30.09 (-174.15)
V^^N_DTKV_1	VIC1-NSW1 Export	Out = Dapto - Kangaroo Valley (18) 330kV line, avoid voltage collapse around Murray for loss of all APD potlines	574 (47.83)	740.97 (1388.58)

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 1 – Non-Real-Time Constraint Automation usage

Constraint Set ID	Date Time	Description
CA_SYDS_5206DEEE	11/08/2022 10:55 to 11/08/2022 11:00	Constraint Automation was created to manage overloading on Bungama Transformer for the loss of Para - Munno Para or Blyth West - Munno Para.
CA_SYDS_51FCB84F	03/08/2022 18:10 to 03/08/2022 18:35	Constraint Automation was created to manage overloading on Clare North - Brinkworth line during an unplanned outage of Brinkworth-Templer West 275 kV line with an existing outage of Mt Lock-Canowie-Robertstown.
CA_SYDS_51FCBFDD	03/08/2022 18:40 to 03/08/2022 19:05	Constraint Automation was created to manage overloading on Clare North - Brinkworth line on trip of Mokota – Robertstown line during an unplanned outage of Brinkworth-Templer West 275 kV line with an existing outage of Mt Lock-Canowie-Robertstown.
CA_BRIS_52155A1A	22/08/2022 10:35 to 22/08/2022 11:10	Constraint Automation. Continency violation was observed on the Elaine to Moorabool 220 kV line for loss of Ballarat to Moorabool No.2 220 kV line.

2.5.1 Further Investigation

CA_SYDS_5206DEEE: Constraint didn't bind and didn't resolve the issue. As an interim measure, Snowtown N+S total was reduced to 210 MW by invoking S-SNOW_N+S_210 at 10:55. This solved violation. At 11:15 the discretionary constraint on Snowtown was removed as the constraint builder built new thermal equation S>>CNRB_BWPA_BGTX and updated S-CNRB and S-S-CNRB_BC-2CP that should manage the ongoing and future violation issues.

CA_SYDS_51FCB84F: Auto Constraint invoked but it did not bind. The constraint builder built a multiple constraint S-X_CNRB+BRTW to manage the ongoing and future violation issues.

CA_SYDS_51FCBFDD: Auto Constraint invoked but it didn't work upon invocation. The constraint builder built a multiple constraint S-X_CNRB+BRTW to manage the ongoing and future violation issues.

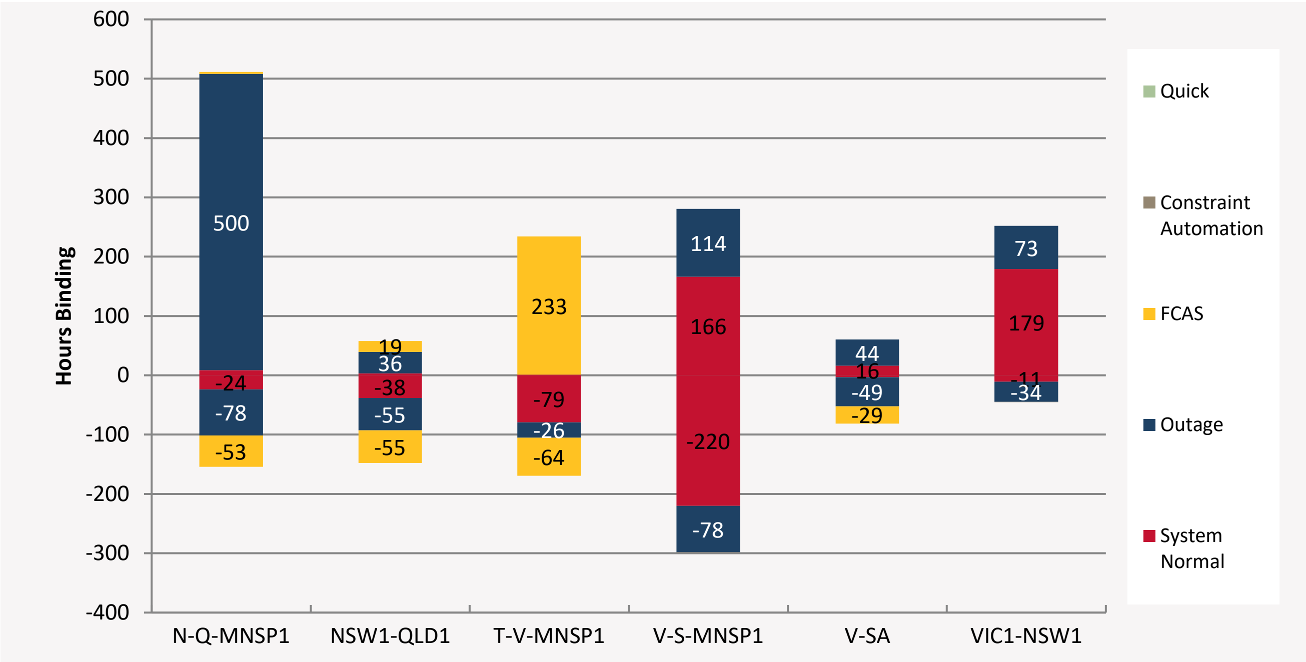
CA_BRIS_52155A1A: Automated constraint was created to manage this contingency violation. At 1110 hrs, a new system normal constraint equation was created and applied which replaced the automated constraint

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.

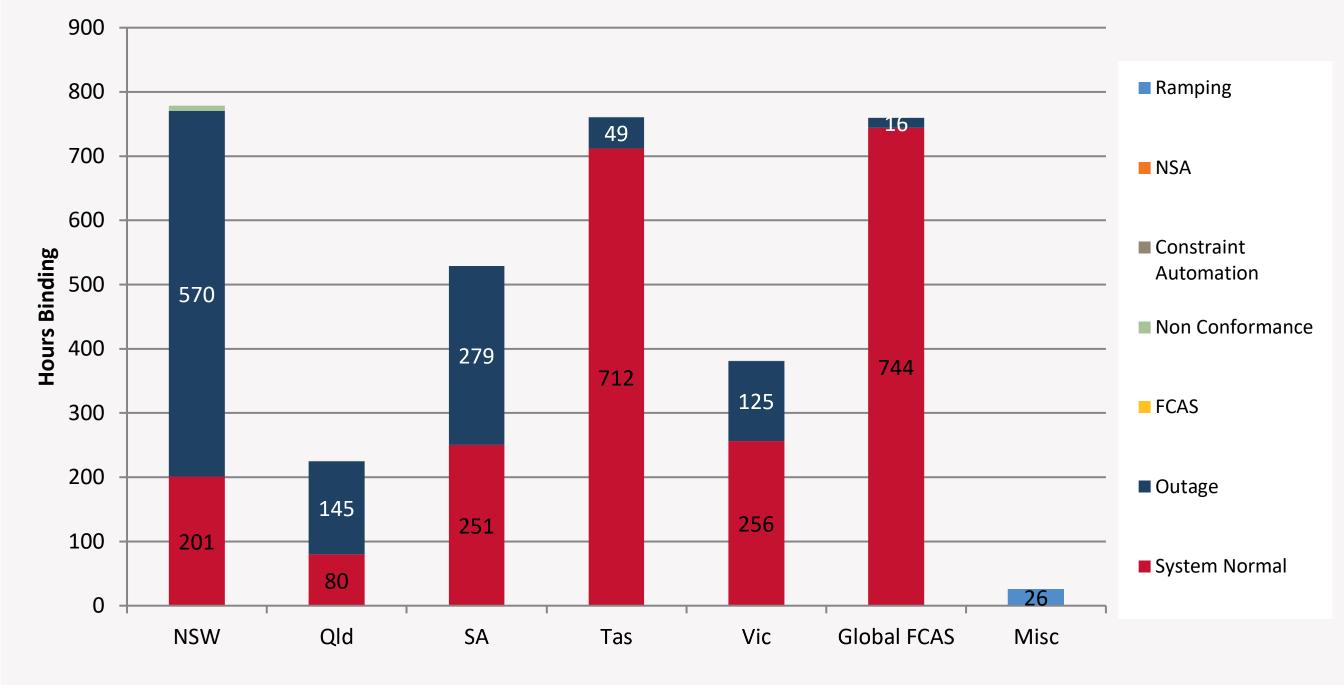
In the following graph the export binding hours are indicated as positive numbers and import with negative values.

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.

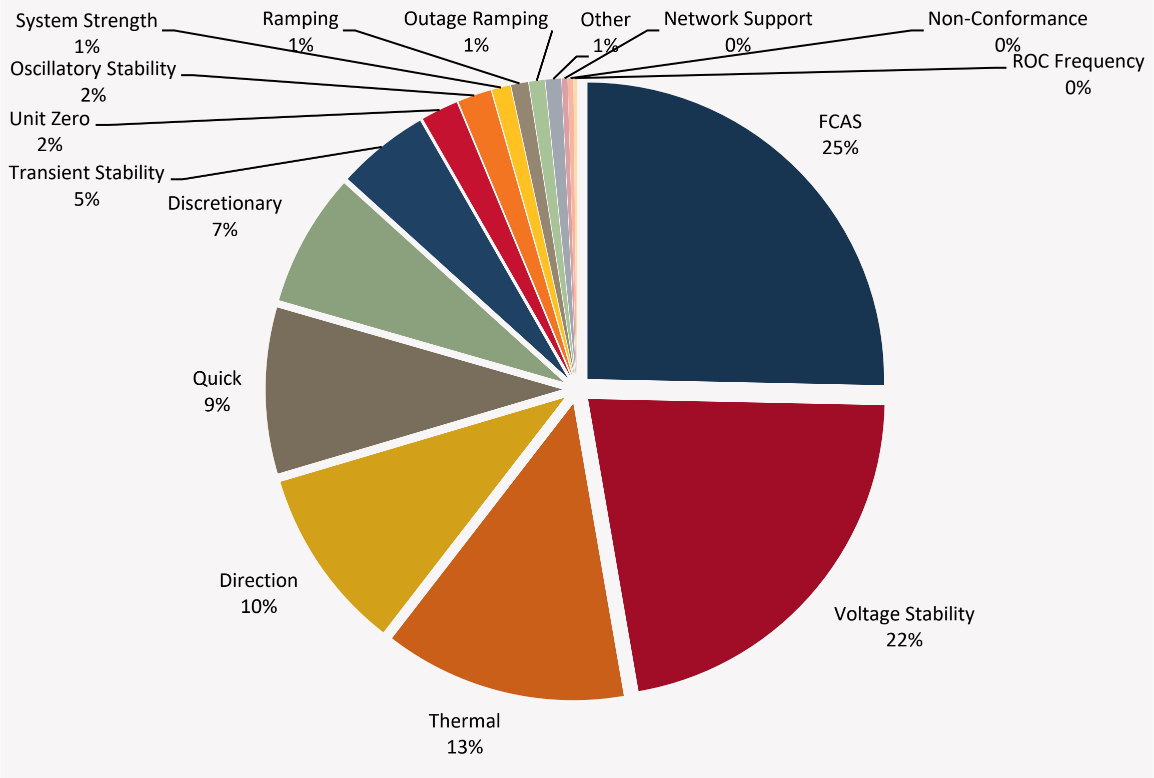
Figure 2 Regional binding dispatch hours



2.7 Binding Constraint Equations by Limit Type

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

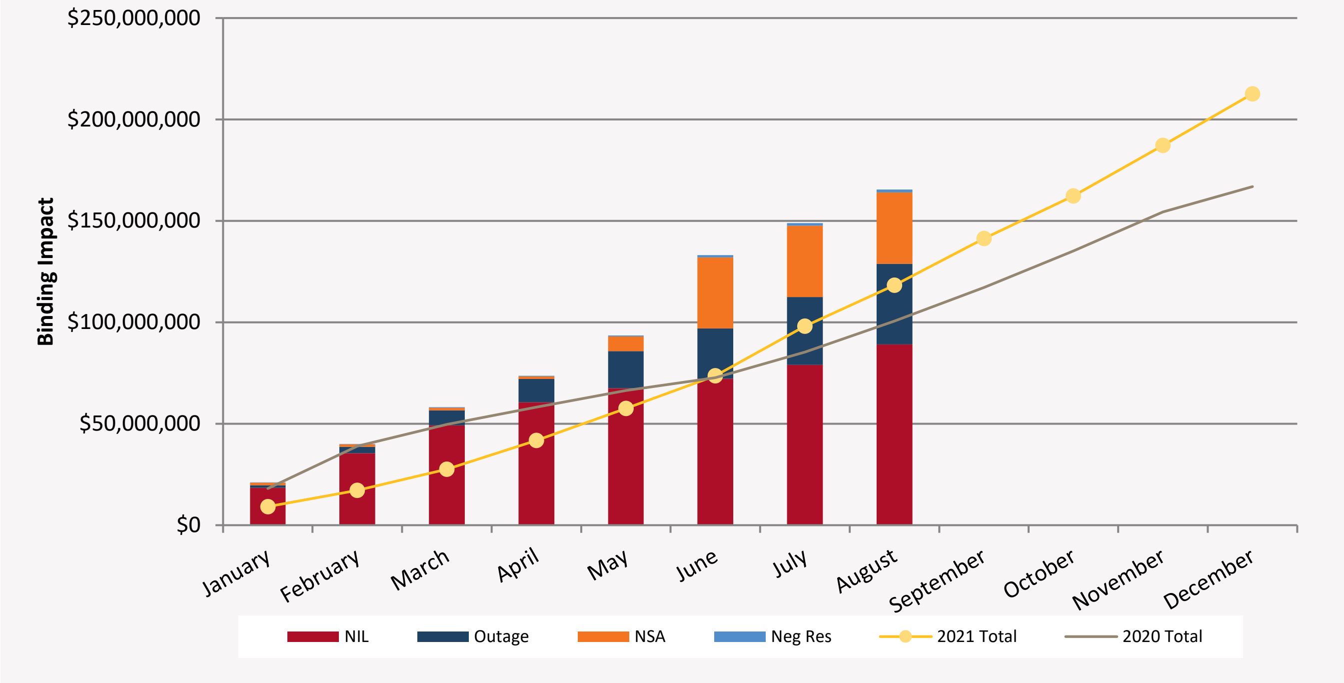
Figure 3 Binding by limit type



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
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	1074	14,199% (124.73)	107.41% (25.57)
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.	56	9,119% (257.03)	562% (71.15)
V::N_X_SMSC_V2	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 500kV.	29	5,154% (321.56)	642% (154.41)
V::S_NIL_MAXG_SECP_2	Out = Nil (NOTE: with both Black Range series capacitors O/S); Vic to SA transient stability limit (South East Capacitor OOS or not available for switching) for loss of SA largest generator.	15	1,691% (9,442)	242% (787)

Constraint Equation ID (System Normal Bold)	Description	#DIs	% + Max Diff	% + Avg Diff
Q^FNQ_MEWF_-60_-100	Nominated Offset= -60MW (Fdr7139 and Fdr7301 closed),-100 (Fdr7139 and Fdr7301 opened) Far North Qld Voltage Stability limit for loss of Mt Emerald Windfarm during system normal configuration (Fdr857+877 IS)	5	620% (2,655)	313% (2,332)
N^^V_SM_SCAP	Out = both South Morang 330 kV series capacitor banks, avoid voltage collapse at Southern NSW for loss of the largest Vic generating unit or Basslink	169	424% (516)	75.57% (177.7)
N^^V_CNCW_1	Out = Canberra-Capital (6) or Kangaroo Valley to Capital (3W) or Dapto-Kangaroo Valley (18), avoid voltage collapse at Darlington Point for loss of the largest Vic generating unit or Basslink	83	417% (640)	82.96% (173.33)
N_X_MBTE_3B	Out= all three Directlink cables, Terranora_I/C_import <= Terranora_Load	29	241% (22.2)	94.81% (11.15)
V^^SML_NSWRB_2	Out = NSW Murraylink runback scheme, VIC to SA transfer limit on Murraylink to avoid voltage collapse at Red Cliffs for the loss of either the Darlington Point to Balranald (X5) or Balranald to Buronga (X3) 220kV lines	9	126.77% (281.35)	113.91% (240.43)

2.9.1 Further Investigation

The following constraint equation(s) have been investigated:

Q^FNQ_MEWF_-60_-100: Investigated and no improvement can be made to the constraint equation at this stage.

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

N^N-LS_SVC: Investigated and constraint equation was updated on 27/08 to improve PD performance.

V::N_X_SMSC_O2: Investigated and no improvement can be made to the constraint equation at this stage.

V::N_X_SMSC_V2: Investigated and no improvement can be made to the constraint equation at this stage.

V::S_NIL_MAXG_SECP_2: Investigated and no improvement can be made to the constraint equation at this stage.

N^^V_CNCW_1: 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. The forecasting of the Terranora load has been improved in November 2018.

V^^SML_NSWRB_2: 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 2022.

Table 7 Generator and transmission changes

Project	Date	Region	Notes
Dr Enelx Q54	5 August 2022	QLD	New WDR unit has been commissioned
Dr Enelx Q50	9 August 2022	QLD	New WDR unit has been commissioned
Moorabool No. 2 100MVar 220kV Reactor	13 August 2022	VIC	The Moorabool No. 2 220 kV Reactor has been commissioned.
Uralla 330kV Terminal station	19 August 2022	NSW	Uralla cut in between Tamworth and Armidale 330kV terminal stations has been commissioned.

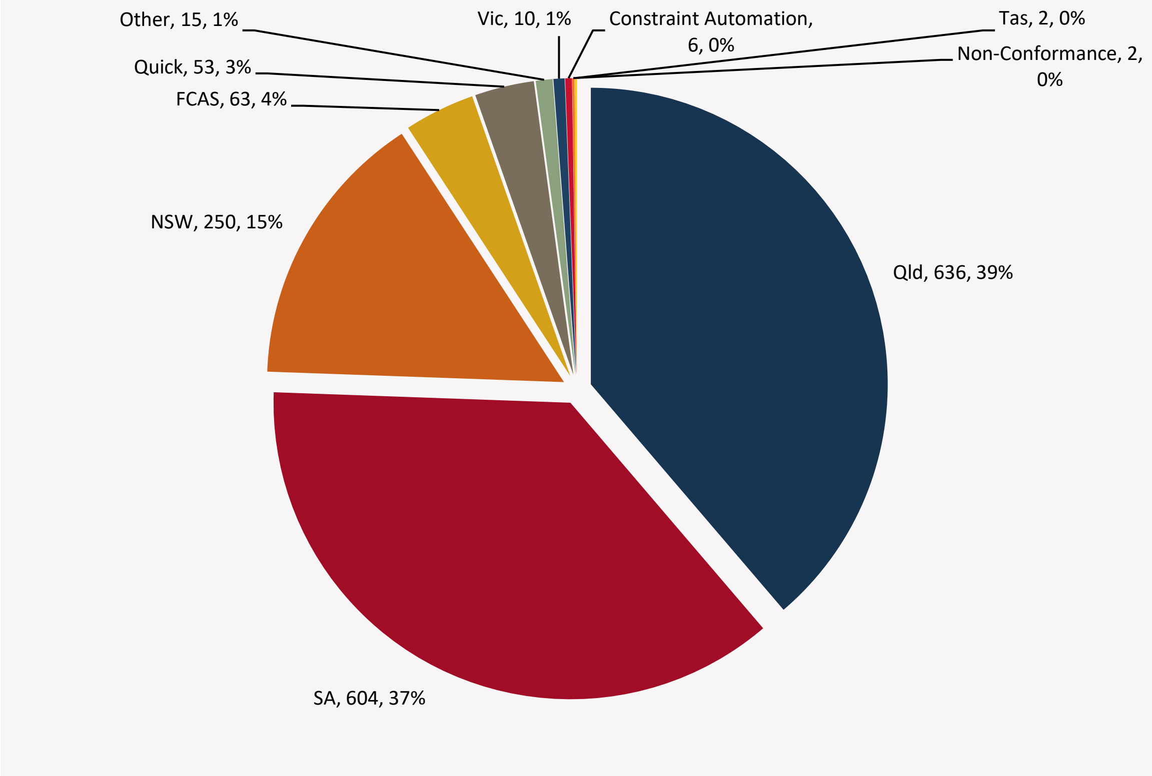
3.1 Constraint Equation Changes

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].

[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

Figure 5 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.

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