SCHEDULE OF CONSTRAINT VIOLATION PENALTY FACTORS

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about constraint equation relaxation procedure, as at the date of publication.

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CONTENTS

VERSION RELEASE HISTORY

Version	Date	Notes
4.0	15/11/2017	Added note in Section 2 about amendment of CVP factors during real-time operation Edited Items 23,30 and 31 to amend CVPs for RERT constraints. Edited Items 24 and 29 to amend CVPs for Direction constraints.
3.0	11/09/2013	Added AEMO-Entered Non-Scheduled Market Unit Direction constraint and AEMO-Entered Non-Scheduled Market Unit Direction – *"What-If"* constraint to the CVP list in items 6 and 7
2.0	02/08/2013	• Revised the proposed implementation dates in item 2 • Replaced "Interconnector Ramping constraint" with "Interconnector Outage (Hard) Ramping constraint" in item 3
1.0	18/06/2013	Initial creation

1. INTRODUCTION

The National Electricity Market dispatch engine (NEMDE) is a linear programming (LP) solver that employs constraint violation variables, with different Constraint Violation Penalty (CVP) prices associated with each type of constraint, to ensure that NEMDE arrives at a physically feasible dispatch solution by violating conflicting constraints in a pre-defined priority order based on their relative CVP prices.

All CVP prices (in $ per MWh) are set at values above the Market Price Cap (MPC) to ensure that all available energy and FCAS resources, regardless of their price, are used prior to violating constraints. If the CVP price was set below the MPC, then the relevant constraint would incorrectly violate in preference to dispatching available resources offered at a price above that CVP price.

Given that the MPC is periodically subject to change, CVP prices for each type of constraint are represented as an MPC multiplier, known as a CVP factor, as follows:

CVP factor = CVP price / MPC

Hence NEMDE calculates the cost (in $) of violating a constraint as follows:

CVP factor x MPC x Violation degree

Where:

MPC: Market Price Cap ($/MWh)

Violation degree: the amount of power (MW) by which the constraint is violated

CVP prices (or CVP factors) are assigned to each constraint type based upon the following criteria:

1. To achieve a pre-defined priority order for resolving potential dispatch conflicts between different constraint types. The higher the CVP price, the higher the priority that the LP solver associates with complying with the right hand side value of that constraint type, compared with other lower priority (or lower CVP price) constraint types.

2. To ensure that there is sufficient differentiation between CVP prices of different constraint types so that the pre-defined violation priority order is maintained within the dispatch solution.

2. APPLICATION OF CVP FACTORS

This document provides a schedule of constraint types and the associated CVP factors that are used in AEMO's Constraint Relaxation Procedure (https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/2016/Constraint-Relaxation-Procedure-v2.pdf). It includes current and old CVP factors and the various rules to establish the relative priority order for resolving dispatch conflicts between different constraint types within NEMDE.

As reflected in the Constraint Relaxation Procedure, AEMO may from time to time need to modify the CVP factors set out in this document in order to resolve unreasonable dispatch outcomes that arise in real-time operation.

3. SCHEDULE OF CONSTRAINT TYPES AND ASSOCIATED CVP FACTORS

The following table provides a full list of all constraint types used in NEMDE and their associated CVP factors. The column “Current and Old CVP Factors” provides the current CVP factors in bold and the old factors in brackets(). The “Comment” column provides how the current CVP factors were derived for the dispatch process. The table is ordered by the current CVP factors in descending order.

Item	Constraint Name	Formulation Equation	Current and Old CVP Factors	Comment (Dispatch)
1	Unit and Interconnector Zero constraint (Energy and FCAS)	N/A	**1160** (360)	**Form of Constraint** ▪ Unit <= 0 MW ▪ Interconnector <= 0 MW and Interconnector >= 0 MW **CVP Ranking** ▪ CVP > Ramp Rate CVP **Function and Dispatch** ▪ Ensure zero Energy and FCAS targets for a planned outage where the unit or interconnector is out of service.
2	AEMO-Entered Unit, MNSP & Regulated DC Interconnector Dispatch Conformance constraint (Non-conformance constraint)	N/A	**1160** (360)	**Form of Constraint** ▪ Unit/MNSP/Regulated DC Interconnector = Initial MW (ConstraintID prefixed by NC_) Currently the only MNSP is Basslink while Regulated DC interconnectors consist of VIC-SA (Murraylink) and NSW-QLD (Terranora) **CVP Ranking** ▪ CVP > Ramp Rate CVP **Function and Dispatch** ▪ Represents limits on the ability of a generating unit (or load)/MNSP/Regulated DC Interconnector to move from one level of MW to another within a specified time period. ▪ Normally there is no conflict between non-conformance (NC) constraints and Unit Ramp Rate constraints because NC constraints set the unit/interconnector to its initialMW and Ramp Rates are bound around the initialMW. However, if a fast start unit with zero MaxAvail and zero target generates at non-zero levels a NC constraint is triggered to set the unit to its initialMW. At the same time, the fast start unit is re-committed (every DI) due to zero MaxAvail and the non-zero target in pass 1 which

				ignores the FS Inflexible Profile. The NC constraint is violated due to lower CVP (existing) than sum of CVPs of Unit Ramp Rate constraint and MaxAvail constraint. The current CVP value is chosen to ensure that the NC constraint is not violated in this circumstance.
3	Unit Ramp Rate constraint *(variables DeficitRampRate and SurplusRampRate)*	(8.1)(8.1a), (8.4), (8.4a), (8.2), (8.2a), (8.5), (8.5a)	**1155** (440)	**Form of Constraint** ▪ NEMDE variables: DeficitRampRate and SurplusRampRate **CVP Ranking** ▪ CVP < Non-Conformance constraint CVP ▪ CVP > Energy Inflexible Offer constraint (Participant-Entered Unit Fixed Loading) : to *ensure that units are brought to their fixed loadings at the appropriate rate* ▪ CVP > Interconnector Capacity Limit constraint CVP **Function and Dispatch** ▪ Represents limits on the ability of a generating unit (or load) to move from one level of MW to another within a specified time period.
4	MNSPInterconnector Ramp Rate constraint *(variables MNSPRUPDeficit and MNSPRDNSurplus)*	(4.1.14), (4.1.15), (4.1.18)	**1155** (440)	**Form of Constraint** ▪ NEMDE variables: MNSPUPDeficit and MNSPDNSurplus **CVP Ranking** ▪ CVP same as Unit Ramp Rate CVP **Function and Dispatch** ▪ Represents limits on the ability of a MNSPInterconnector to move from one level of MW to another within a specified time period.
5	Interconnector Capacity Limit constraint *(variables FlowDeficit and FlowSurplus)*	(4.1.1), (4.1.2)	**1150** (380)	**Form of Constraint** ▪ NEMDE variables: FlowDeficit and FlowSurplus **CVP Ranking** ▪ CVP < Ramp Rate CVP ▪ CVP < Non-conformance CVP ▪ CVP > Satisfactory Network Limit CVP ▪ CVP > Unscheduled Reserve Contract Activation Intervention constraint **Function and Dispatch** ▪ Represents interconnector flow limits.

6	AEMO-Entered Unscheduled Reserve Contract Activation **-** Intervention constraint *(invoked as a pair with Unscheduled Reserve Contract Activation - "What-If" constraint)* *or* AEMO-Entered Non-Scheduled Market Unit Direction constraint *(invoked as a pair with Non-Scheduled Market Unit Direction - "What-If" constraint)*	N/A	**1145** (440)	**Form of Constraint** ▪ Invoked as a pair with "AENO-Entered Unscheduled Reserve Contract Activation - "What-If" constraint" ▪ General form: Unit >= X MW ▪ Invoked as a pair with Non-Scheduled Market Unit Direction - "What-If" constraint ▪ Unit = 0MW (directing unit on/off) **CVP Ranking** ▪ CVP < Interconnector Capacity Limit CVP, MNSPInterconnector Ramp Rate CVP ▪ CVP > What-If CVP – *to ensure that the Intervention constraint overrides the What-If constraint (noting that under the current design both the Intervention & What-If constraints co-exist in the Target run)* **Function and Dispatch** ▪ After activation of contracted reserves from an unscheduled unit, the Intervention constraint maintains a zero MW dispatch target for the dummy scheduled load (for both unscheduled load and unscheduled generator) ▪ Intervention constraint only applies to the Target (Physical) run only during intervention
7	AEMO-Entered Unscheduled Reserve Contract Activation or Unscheduled Market Unit Direction - "What-If" constraint Or AEMO-Entered Non-Scheduled Market Unit Direction - "What-If" constraint	N/A	**1140** (360)	**Form of Constraint** ▪ Invoked as a pair with "AENO-Entered Unscheduled Reserve Contract Activation - Intervention constraint" ▪ dummy unit = X MW (activation MW amount) ▪ Invoked as a pair with "AEMO-Entered Non-Scheduled Market Unit Direction constraint" ▪ Dummy_Generator unit = MW directed off (directing a unit off) ▪ Dummy_Load unit = MW directed on (directing a unit on) **CVP Ranking** ▪ CVP > (MaxAvail CVP, Energy Inflexible Offer CVP, Total Band MW Offer CVP) : *CVP greater than MaxAvail CVP to ensure that in the What-If (Pricing) run, the What-If constraint overrides the dummy unit's zero MaxAvail constraint and constrains-on that unit's "what-if" dispatch to the activation amount. Therefore there is no need for AEMO to rebid the dummy unit's MaxAvail to the activation level after invoking the reserve activation constraints* *Assumptions: Dummy unit has unrestricted ramp rates in energy offer, no FCAS offers and is not subject to any other generic constraints* **Function and Dispatch** ▪ After activation of contracted reserves from an unscheduled unit, the What-If constraint constrains-on the dispatch target of the dummy scheduled load in the What-If (Pricing) run to its activation level. ▪ Currently applies to both the Target and What-If runs during intervention.

				▪ The constraint is effective in the What-if run, but overridden by the Unscheduled Reserve Contract Activation Intervention constraint in the Target (Physical) run.
8	Total Band MW Offer constraint *(variable DeficitOfferMW)*	(4.5.3), (4.5.5)	**1135** (80)	**Form of Constraint** ▪ NEMDE variable: DeficitOfferMW **CVP Ranking** ▪ CVP < Unscheduled Reserve Contract Activation "What-If" CVP ▪ CVP > FSIP, Unit Direction CVP, UIGF CVP and Fixed Loading CVP **Function and Dispatch** ▪ Prevents dispatch beyond the sum of all offered bands (which must add up to equal or greater than (as designed) the registered maximum capacity). Therefore, it has higher priority than Unit Direction, UIGF and Fixed Loading constraints.
9	Total Band MW Offer constraint - MNSP only *(variable MNSPOfferDeficit)*	(4.1.10)	**1135** (80)	**Form of Constraint** ▪ NEMDE variable: MNSPOfferDeficit **CVP Ranking** ▪ CVP same as CVP of Total Band MW constraint (higher priority than FSIP, Unit Direction, UIGF and Fixed Loading constraints) **Function and Dispatch** ▪ Prevents dispatch beyond the sum of all offered bands (which must add up to equal or greater than (as designed) the registered maximum capacity).
10	Fast Start Inflexible Profile constraint *(variables ProfileDeficitMW and ProfileSurplusMW)*	(9.2.1-1), (9.2.1-2), (9.3.1-1), (9.3.1-2), (9.4.1-1), (9.4.1-2)	**1130** (75)	**FORM OF CONSTRAINT** ▪ NEMDE variables ProfileDeficitMW and ProfileSurplusMW **CVP Ranking** ▪ CVP > Unit Direction > MaxAvail ▪ CVP > Unit Direction CVP + MaxAvail CVP (when non-zero MaxAvail MW is less than Directed MW) **Function and Dispatch** ▪ Fast Start Inflexible Profile T1, T2, T3 & T4 Mode constraints ▪ It is required the directed unit to rebid to non-zero MaxAvail to avoid the fast start pre-processing reset the current mode to zero or Mode 4 of the FS unit.
11	AEMO-Entered Unit Direction System Security constraint (Energy or FCAS)	N/A	**755** (360)	**Form of Constraint** ▪ Generic Constraint. ConstraintID prefixed by # ▪ General form: Unit >= X MW **CVP Ranking** ▪ CVP high enough to direct a fast start unit (modes 1 or 2) above MaxAvail or UIGF ▪ CVP < FS Inflexible Profile CVP

				▪ CVP > (MaxAvail + 4xFCAS xxEnablementMax) (to override the cumulative CVP effect of multiple FCAS EnablementMaxes that are lower than the direction level) ▪ CVP > (Fixed loading CVP + 4xFCAS xxEnablementMax limits CVP) ▪ CVP > (Fixed loading CVP + MaxAvail CVP) **Function and Dispatch** ▪ Direction is likely to occur when power system conditions are tight and there is a need to restore power system security. ▪ AEMO may need to direct a unit's loading for power system security reasons or to reflect the actual loading of a non-compliance unit. The high CVP is required to ensure that AEMO direction overrides the cumulative effect of a participant-entered fixed loading and unit's FCAS xxEnablementMax limits.
12	Unconstrained Intermittent Generation Forecast (UIGF) *(variable UIGFSurplus)*	(4.10.0)	**385** (200)	**Form of Constraint** ▪ NEMDE variable: UIGFSurplus **CVP Ranking** ▪ CVP > (Energy Inflexible Offer constraint) Unit fixed loading CVP **Function and Dispatch** ▪ To ensure maximum dispatch level of semi-scheduled unit does not exceed the Unconstrained Intermittent Generation Forecast (UIGF) value.
13	Energy Inflexible Offer constraint (Participant-entered Unit Fixed Loading)	N/A	**380** (100)	**Form of Constraint** ▪ Unit = X MW (Participant Offer, ConstraintID prefixed by $) **CVP Ranking** ▪ CVP > MaxAvail CVP ▪ CVP < Unconstrained Intermittent Generation Forecast (UIGF) – *to ensure maximum dispatch level of semi-dispatch unit does not exceed the Unconstrained Intermittent Generation Forecast (UIGF) value* **Function and Dispatch** ▪ Participant Bid and it a higher priority than Unit MaxAvail constraint since this is set by participant due to technical reasons, which is taken to override the previous bid capacity. However it cannot override a lower priority Unit MaxAvail for FS unit during modes 1, 2 and 3 (cumulative CVP) to ensure that target complies with FS Inflexibility Profile. ▪ Lower priority than RampRate limits so that units are brought to their fixed loadings at a reasonable rate.
14	Unit MaxAvail constraint *(Variables - DeficitTraderEnergyCapacity (Energy MaxAvail) and DeficitEnergy (Daily Energy limit - Pre-Dispatch only))*	(4.9.0), (4.9.1), (11.1), (11.3)	**370** (70)	**Form of Constraint** ▪ NEMDE variables: DeficitTraderEnergyCapacity (Energy MaxAvail) and DeficitEnergy (Daily Energy limit - Pre-Dispatch only) **CVP Ranking** ▪ CVP > Satisfactory Limit CVP

				Function and Dispatch ▪ Represents Participant Bid ▪ Can be overridden by Energy Inflexible Offer constraint (Participant-entered fixed loading)
15	MNSP Availability Constraint *(variable MNSPCapacityDeficit)*	(4.1.11), (4.1.18)	**365** (70)	**Form of Constraint** ▪ NEMDE variable MNSPCapacityDeficit **CVP Ranking** ▪ CVP > Satisfactory Network Limit CVP **Function and Dispatch** ▪ Represents Participant Bid ▪ Can be overridden by Energy Inflexible Offer constraint (Participant-entered fixed loading)
16	MNSP Losses constraint *(variables MNSPForwardLossesDeficit/Surplus, MNSPReverseLossesDeficit/Surplus)*	(4.1.12), (4.1.13)	**365** (70)	**Form of Constraint** ▪ NEMDE variables MNSPForwardLossesDeficit/Surplus, MNSPReverseLossesDeficit/Surplus **CVP Ranking** ▪ CVP = MNSP Availability constraint CVP **Function and Dispatch** ▪ MNSP losses constraints represent intra-regional flows on MNSP using a pair of variables at each end of the MNSP. ▪ The constraints are designed to avoid dispatching non-physical circulating flows in both MNSP flow offer directions at once (Refer to NEMDE equation 4.1.13)
17	Satisfactory Network Limit constraint	N/A	**360** (360)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP < MaxAvail CVP and MNSP Availability CVP - *due to fully co-optimised constraints which contain a mixture of interconnector and generator terms on LHS* ▪ CVP > Regional Energy Demand Supply Balance CVP – *to ensure that a Satisfactory network limit is not violated before Region Deficit (Region Load shedding)* **Function and Dispatch** ▪ Represents limits to operate within the satisfactory operating state ▪ Represents maximum post-contingency plant safety type limits ▪ Does not include zero flow network disconnection (islanding) limits, which is represented using “Unit and Interconnector Zero constraint” ▪ Load shedding would be used in order to remain within these limits ▪ Applies to both inter-regional and intra-regional network elements.

18	FCAS MaxAvail constraint *(variable xxDeficit)*	(5.1), (5.0b)	**155** (70)	**Form of Constraint** ▪ NEMDE variable: xxDeficit - *where 'xx' is replaced with 'R6SE', 'R60S', 'R5MI', 'R5RE','L6SE', 'L60S', 'L5MI','L5RE'* **CVP Ranking** ▪ CVP > associated FCAS xx Requirement CVP ▪ CVP > Energy Demand Supply Balance CVP **Function and Dispatch** ▪ Offered FCAS xxMaxAvail Limit constraint ▪ Region Deficit constraint should be violated in preference to FCAS xxMaxAvail constraint because FCAS xxMaxAvail represents the physical limit of FCAS which violated would pose to system security threat ▪ Associated FCAS xx requirement constraint should be violated ahead of Unit FCAS xxMaxAvail
19	FCAS Joint Ramping constraint *(variables R5REJointRampDeficit/Surplus,* *L5REJointRampDeficit/Surplus)*	(5.8a), (5.9a), (5.8b), (5.9b)	**155** (70)	**Form of Constraint** ▪ NEMDE variables: R5REJointRampDeficit/Surplus and L5REJointRampDeficit/Surplus **CVP Ranking** ▪ CVP same as FCAS MaxAvail CVP **Function and Dispatch** ▪ Represents joint ramping for Energy and Regulation services
20	Regional Energy Demand Supply Balance constraint *(variable DeficitGen) - Region Load Shedding*	(4.5.1)	**150** (65)	**Form of Constraint** ▪ NEMDE variable: DeficitGen (Region Load Shedding) **CVP Ranking** ▪ CVP < FCAS MaxAvail CVP ▪ CVP < Satisfactory Network Limit CVP ▪ CVP > 4 x Secure Network Limit Stability and Other ▪ CVP > sum of the four FCAS Raisexx CVPs **Function and Dispatch** ▪ Represents ability to meet scheduled demand ▪ Lower priority than FCAS xxMaxAvail because FCAS xxMaxAvail represents the physical limit of FCAS if violated would pose to system security threat ▪ All 4 FCAS Raise services (sum CVP 28) should be violated in preference to dispatch of demand shedding (i.e. dispatch of Region DeficitGen) thereby preventing constraining-off of energy dispatch below Unit FCAS raisexx EnablementMax ▪ The proposed CVP of 150, which is greater than 5 x sum CVP 28, allows all 4 FCAS Raise services of 5 units to be violated ahead of violation of Demand Supply Balance constraint.

21	Regional Energy Demand Supply Balance constraint *(variable SurplusGen) - Excess Generation*	(4.5.1)	**150** (65)	**Form of Constraint** ▪ NEMDE variable: SurplusGen (Excess Generation) **CVP Ranking** ▪ CVP < FCAS MaxAvail CVP ▪ CVP < Satisfactory Network Limit CVP ▪ CVP > 4 x Secure Network Limit Stability and Other ▪ CVP > sum of the four FCAS Lowerxx CVPs **Function and Dispatch** ▪ Represents ability to back down to scheduled demand ▪ Lower priority than FCAS xxMaxAvail because FCAS xxMaxAvail represents the physical limit of FCAS if violated would pose to system security threat ▪ All 4 FCAS Lower services (sum CVP 28) should be violated in preference to dispatch of excess generation (i.e. dispatch of Region SurplusGen) thereby preventing constraining-on energy dispatch above Unit FCAS Lowerxx EnablementMax. ▪ The proposed CVP of 150, which is greater than 5 x sum CVP 28, allows all 4 FCAS Lower services of 5 units to be violated ahead of violation of Demand Supply Balance constraint.
22	FCAS EnablementMin/FCAS EnablementMax constraint *(variables xxLowerSurplus, xxUpperDeficit)*	(5.2), (5.3) (5.10a), (5.11a), (5.10b), (5.11b)	**70** (70)	**Form of Constraint** ▪ NEMDE Variables: xxUpperDeficit and xxLowerSurplus - *where xx is one of the contingency FCAS categories (R6, R60, R5, L6, L60, L5) and regulation FCAS categories (R5RE, L5RE)* **CVP Ranking** ▪ CVP < Regional Energy Demand Supply Balance CVP **Function and Dispatch** ▪ Represents Offered FCAS xxEnablementMin/Max Limit constraint ▪ Lower priority order than Regional Energy Demand Supply Balance constraints (Deficit and Surplus) and FCAS xxMaxAvail because it represents energy limit of FCAS trapezium and should be untrapped (violated) before violating Regional Demand Supply Balance constraints ▪ Allows up to 2 trapped FCAS EnablementMax Limits (2 services) before a Region Deficit is reported.
23	AEMO-Entered Scheduled Reserve Contract Dispatch Intervention constraint *(invoked as a pair with Scheduled Reserve Contract Dispatch - "What-If" constraint)*	N/A	**65** (55)	**Form of Constraint** ▪ The constraint should be invoked as a pair with “AEMO-Entered Scheduled Reserve Contract Dispatch "What-If" constraint” ▪ General form: Unit >= X MW ▪ Applies to the Target (Physical) run only during intervention **CVP Ranking** ▪ CVP > AEMO-Entered Scheduled Reserve Contract Dispatch "What-If" constraint CVP – *to override "What-If" constraint in the Target run* ▪ CVP > Unit Mandatory Restriction Offer constraint higher-end CVP – *to ensure NEMDE can constrain-on unit above its MR offer constraint level*

				▪ CVP > AEMO-Entered Unit FCAS Direction Intervention constraint – *to ensure NEMDE does not constrain off a Directed unit's energy dispatch below minimum load to enable more raise FCAS and meet FCAS intervention constraint.* **Function and Dispatch** ▪ Applies to the Target (Physical) run only during intervention ▪ Constrains-on the dispatch of contracted reserves from a scheduled unit Intervention constraint only applies to the Target (Physical) run during interventio
24	AEMO-Entered Unit Energy Direction Intervention constraint *(invoked as a pair with Unit Energy "What-If" constraint)*	N/A	**65** (55)	**Form of Constraint** ▪ The constraint should be invoked as a pair with "AEMO-Entered Unit Energy "What-If" constraint" ▪ General form: Unit = X MW ▪ Applies to the Target run only during intervention **CVP Ranking** ▪ CVP > AEMO-Entered Unit Energy Direction "What-If" constraint CVP – *to override "What-If" constraint in the Target run because both Intervention and What-If constraints are included in Target run (Physical run)* ▪ CVP > Unit Mandatory Restriction Offer constraint higher-end CVP – *to ensure NEMDE can constrain-on unit above its MR offer constraint level* **Function and Dispatch** ▪ Applies to the Target run only during intervention ▪ Set unit greater than or equal to the required minimum dispatch level (typically the advised technical minimum) ▪ Assumes that the unit has subsequently rebid to full Unit Energy Availability as part of direction with no lower fixed loadings When AEMO constrains on/off a directed unit, it is possible that this can cause a secure network limit constraint violated. However, directing a unit is to resolve security issues based on Contingency Analysis study. It is not likely the intervention constraint causes a security issue.
25	AEMO-Entered Unit FCAS Direction Intervention constraint *(invoked as a pair with Unit FCAS "What-If" constraint)*	N/A	**60** (60)	Form of Constraint ▪ The constraint should be invoked as a pair with "AEMO-Entered Unit FCAS "What-If" constraint" ▪ General form: Unit = X MWApplies to the Target run only during intervention CVP Ranking ▪ CVP < FCAS xxEnablementMin/Max CVP Function and Dispatch ▪ Applies to the Target run only during intervention ▪ Assumes that the unit has subsequently rebid to full Unit FCAS Availability as part of direction

				▪ If the unit is initially outside the FCAS enablement limits, the constraints would be accompanied by Intervention Energy constraint to bring energy dispatch within FCAS Enablement limits. The Intervention Energy constraints are in the form of o Unit Energy Dispatch <= FCAS EnablementMax, or o Unit Energy Dispatch >= FCAS EnablementMin
26	Secure Network Limit Stability and Other constraint	N/A	**35** (20)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > Secure Network Limit Thermal CVP **Function and Dispatch** ▪ Non-thermal Secure Network Limit constraints such as voltage, transient and oscillation stability limit constraints, etc. ▪ Higher priority order than Secure Network Limit Thermal constraint because Secure Network Limit Thermal constraint is usually time-based well above 5 minutes. Therefore, Secure Network Limit Thermal constraint should be violated ahead of Secure Network Limit Other constraint.
27	Interconnector Outage (Hard) Ramping constraint	N/A	**35** (20)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP <= Source outage CVP ▪ CVP >= Secure Network Limit Thermal CVP **Function and Dispatch** ▪ Specifies the minimum steps to take to reach the required level within the maximum time allowed. Ramping at a slower rate than Soft ramping constraint. ▪ Can be invoked for a short notice outage (less than 30mins) ▪ May be invoked for managing network outages involving FCAS constraints
28	Secure Network Limit Thermal constraint	N/A	**30** (20)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > 1 – *to avoid the risk that NEMDE may choose to violate this constraint in preference to dispatching high price offers* ▪ CVP > MR higher-end CVP – *to prevent one Secure Network Limit Thermal being violated before dispatching above unit MR offers constraints* **Function and Dispatch** ▪ Includes thermal Secure Network Limits

29	AEMO-Entered Unit Energy Trader "What-If" constraint	N/A	**29** (50)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP < AEMO-Entered Unit Energy Direction CVP **Function and Dispatch** ▪ Used to prevent economic dispatch to other than the Unit's pre-direction (What-If) dispatch level Currently applies to both the Target (Physical) run and What-If runs during intervention. The constraint is effective in the What-if run, but overridden by the Direction Intervention constraint in the Target run
30	AEMO-Entered Scheduled Reserve Contract Dispatch "What-If" constraint	N/A	**29** (50)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP < AEMO-Entered Scheduled Reserve Contract Dispatch CVP – *to ensure the "What-If" is overridden by the intervention when both intervention and what-if constraints co-exist in the Target run* ▪ CVP < Secure Network Limit Thermal constraint and Secure Network Limit Stability constraints – *to ensure RERT unit is dispatched above its minimum load before dispatching other generation above the Secure Network Thermal or Stability limits to avoid load shedding.* **Function and Dispatch:** ▪ Used to prevent economic dispatch other than the Unit's pre-direction (What-If) dispatch level The constraint is effective in What-If run but overridden by the Scheduled Reserve Contract Dispatch Intervention constraint in the Target(Physical) run
31	AEMO-Entered Unit Energy Counteraction (Direction) Intervention constraint	N/A	**27** (48)	**Form of Constraint** ▪ Unit <= (pre-intervention level - [min required - pre-intervention] of directed unit) **CVP Ranking** ▪ CVP < AEMO-Entered Unit Energy Direction CVP – *to avoid overriding Unit Energy Direction constraint in case there is a confliction of these two)* **Function and Dispatch** ▪ Applied to plant selected to be an affected participant as a result of direction (to counter-balance the amount of directed energy) Applies to target run only during intervention.

32	Planned Network Outage (Hard) Ramping constraint (Associated with “Secure Network Limit Thermal constraint”, “Secure Network Limit Stability and Other constraint” or “Satisfactory Network Limit constraint”)	N/A	**26** (20)	**Form of Constraint** ▪ No specific form. **CVP Ranking** ▪ Hard Ramping CVP + soft Ramping CVP < Source outage CVP – *to avoid conflict between source outage constraint and ramping constraints which remain few DIs after the outage happens. This is designed to ensure that in case of short delay in outage the flow is still at the final level for the outage to take place (e.g. Source outage constraint CVP can be 30 if it is a Secure Network Limit Thermal constraint)* **Function and Dispatch** ▪ Specifies the minimum steps to take to reach the required level within the maximum time allowed. Ramping at a slower rate than Soft ramping constraint. ▪ The ramping constraint is created based on the outage constraint in pre-dispatch timeframe. In other words, the ramping constraint is invoked at least 30 minutes before the outage start time.
33	Unit Mandatory Restriction (MR) Offer constraint	N/A	**12 to 25** (6 to 19)	**Form of Constraint** ▪ Unit Energy Dispatch ≤ RHS Where RHS = (Unit bid maximum energy availability minus Accepted MR Offer Capacity plus/minus subsequent adjustment to Accepted MR Offer Capacity) The coefficient of unit term on LHS is always 1 **CVP Ranking** ▪ Lower-end CVP > max(FCAS requirement CVPs) - *ensure that a FCAS requirement violates before constraining-on unit's energy dispatch above its MR offer constraint* ▪ Higher-end CVP < Secure Network Limit Thermal CVP - *All Unit MR Offer constraints should be violated (i.e. all MR Offer Capacity dispatched) ahead of violating Secure Network Limit Thermal constraint)* ▪ Higher-end CVP + Unit Direction What-If CVP < AEMO-Entered Unit Energy Direction Intervention CVP- *In order to direct a MR unit for security reason* The cumulative effect of FCAS constraints is not considered in deciding the MR CVP values to keep the CVP values small. MR is not a common event. Further, while MR constraints could potentially conflict with FCAS requirements that constrain-on a unit's energy dispatch to provide more FCAS, this scenario is unlikely as MR typically apply during high demand periods whereas the need to constrain-on for extra FCAS typically would occur in low demand periods. **Function and Dispatch** ▪ CVP spacing between MR units is calculated based on the number of accepted MR units. The system can take the maximum of 28 units in the range.

34	AEMO-Entered Unit FCAS Direction "What-If" constraint	N/A	**12** (6)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R6/L6 CVP ▪ CVP > FCAS RREG/LREG CVP ▪ **Function and Dispatch** ▪ Used during Intervention Pricing ("What-If") run ▪ Higher priority than any FCAS Requirement constraints so that FCAS Requirement constraints get violated before constraining-on unit above its FCAS What-If level.
35	FCAS RREG Requirement constraint	N/A	**10** (2)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R6/L6 CVP ▪ CVP > default Negative Residue Management CVP **Function and Dispatch** ▪ Represents ability to control of frequency for “normal” variations in demand ▪ Higher priority than default NRM constraint because FCAS requirement constraints are invoked to maintain system security, whereas NRM constraint is only used to maintain the market outcome.
36	FCAS LREG Requirement constraint	N/A	**10** (2)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R6/L6 CVP ▪ CVP > default Negative Residue Management CVP **FUNCTION AND DISPATCH** ▪ Represents ability to control of frequency for “normal” variations in demand ▪ Higher priority than default NRM constraint because FCAS requirement constraints are invoked to maintain system security, whereas NRM constraint is only used to maintain the market outcome.
37	FCAS R6 Requirement constraint	N/A	**8** (5)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R60/L60 CVP ▪ CVP < FCAS RREG/LREG CVP

				▪ **Function and Dispatch:** Represents ability to maintain frequency control within “tolerance band” following a credible generation loss contingency ▪ Relaxation of this constraint indicates that frequency restoration to within the tolerance band would take longer than 6 seconds
38	FCAS L6 Requirement constraint	N/A	**8** (5)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R60/L60 CVP ▪ CVP < FCAS RREG/LREG CVP **Function and Dispatch** ▪ Represents ability to maintain frequency control within “tolerance band” following a credible load loss contingency ▪ Relaxation of this constraint indicates that frequency restoration to within the tolerance band would take longer than 6 seconds
39	FCAS R60 Requirement constraint	N/A	**6** (4)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R5/L5 CVP ▪ CVP < FCAS R6/L6 CVP **Function and Dispatch** ▪ Represent ability to restore frequency to within “tolerance band” following a credible generation loss contingency ▪ Relaxation of this constraint indicates that frequency restoration to within the tolerance band would take longer than 60 seconds
40	FCAS L60 Requirement constraint	N/A	**6** (4)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > FCAS R5/L5 CVP ▪ CVP < FCAS R6/L6 CVP **Function and Dispatch** ▪ Represent ability to restore frequency to within “tolerance band” following a credible load loss contingency ▪ Relaxation of this constraint indicates that frequency restoration to within the tolerance band would take longer than 60 seconds

41	FCAS R5 Requirement constraint	N/A	**4** (3)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > NRM constraint CVP ▪ CVP < FCAS R60/L60 CVP **Function and Dispatch** ▪ Represent ability to return frequency to within “normal band” within 5 minutes following a credible generation loss contingency.
42	FCAS L5 Requirement constraint	N/A	**4** (3)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP > NRM constraint CVP ▪ CVP < FCAS R60/L60 CVP **Function and Dispatch** ▪ Represent ability to return frequency to within “normal band” within 5 minutes following a credible load loss contingency.
43	Negative Residue Management (NRM) constraint	N/A	**2 – default value, variable** (variable)	**Form of Constraint** ▪ No specific form **CVP Ranking** ▪ CVP < Secure Network Limit Thermal constraint CVP ▪ CVP < Lowest FCAS Constraint CVP **Function and Dispatch** ▪ The proposed descending priority order is Secure Network Limit, FCAS Constraints (contingency services), Negative Residue Management NRM The CVP may be increased to a higher number at times if the default CVP value of 2 does not effectively stop the negative residue accumulation and the increased CVP does not present any risk to the power system security.

44	Planned Network Outage (Soft) Ramping constraint (associated with Secure Network Limit Thermal constraint)	N/A	**0.0002 to 1** (0.0002 to 1)	**Form of Constraint** ▪ Planned Network Outage Ramping constraint set: Outage LHS ≤ RHS (soft) @CVP=SoftCVP, and Outage LHS ≤ RHS (hard) @CVP=HardCVP (for ≤ and = type source constraints) or Outage LHS ≥ RHS (soft) @CVP=SoftCVP, and Outage LHS ≥ RHS (hard) @CVP=HardCVP (for ≥ type source constraint) Where: RHS = Calculated RHS value for current DS ramping DI Note: The ramping constraint is not applied for FCAS constraints. **CVP Ranking** ▪ Network Outage: SoftCVP = Min{1, Max([K x ABS(V)] / MPC, 0.0002)} Where: K: Fixed scaling factor (initially = 1) V: Marginal value of the source constraint from the latest PD run at the time when the source constraint set is being ramped. Once the ramping constraint is created, the Soft CVP value will remain unchanged even though new PD results (i.e. new marginal values) would be available after the ramping constraint set creation. Note: HardCVP = 20 * VoLL **Function and Dispatch** ▪ The aim of the soft constraint would be to achieve the ramping faster while allowing constraint to violate (small CVP) rather than result in significant price spikes or dips, whereas the hard constraint is to ensure that ramping would be completed regardless of pricing outcomes.

45	Interconnector Outage (Soft) Ramping constraint (associated with Secure Network Limit Thermal constraint)	N/A	**8.4E-10 to 1.184 formula with MPC 13,100** (same formula)	**Form of Constraint** ▪ Interconnector outage ramping constraint set: Interconnector Flow ≤ Final Outage Level @CVP=SoftCVP if initial Interconnector flow > 0 (ramping positive flow down) or Interconnector Flow ≥ Final Outage Level @CVP=SoftCVP if initial Interconnector flow < 0 (ramping negative flow down) Note: The ramping constraint is not applied for FCAS constraints. **CVP Ranking** ▪ Interconnector: SoftCVP = Max{0, [C x PPDi] / MPC} Where C = Fixed Scaling Factor, initially 1.1 PPDi = Pre-dispatch Price Difference for Interconnector i Once the ramping constraint is created, the Soft CVP value will remain unchanged even though new PD results (i.e. new marginal values) would be available after the ramping constraint set creation. Note: existing HardCVP = Secure Network Limit CVP 20 * MPC ▪ **Function and Dispatch** The aim of the soft constraint would be to achieve the ramping faster while allowing constraint to violate (small CVP) rather than result in significant price spikes or dips, whereas the hard constraint is to ensure that ramping would be completed regardless of pricing outcomes.
46	Non-Physical Loss Oscillation Control constraint	N/A	**0.0001** (0.0001)	**Form of Constraint:** ▪ Interconnector = target "Total Cleared" MW of the DI prior to DI flagged as "Non Physical Losses Invoked" (e.g. Quick constraint for energy #V-S-MNSP1_I_E) **CVP Ranking** ▪ The constraint CVP should be small so that the constraint will not override security network limit constraint and can be violated when the system changes. **Function and Dispatch** ▪ Applied to Murraylink and/or Terranora interconnectors if the oscillation (from one direction to the other in alternate dispatch cycles) on these interconnectors are deemed to be causing a Power System Security issue ▪ If the constraint continues to violate over successive dispatch intervals, then it should be revoked and replaced with a security constraint and ≥ operator ▪ The constraint should be revoked immediately the NPL runs cease or Pre-dispatch indicates that the VIC-SA or QNI interconnector is going to bind for the next interval

47	Tie-Break constraint *(variables TBSlack1, TBSlack2)*	(10.1)	**1.00E-06** (1.00E-06)	**Form of Constraint** ▪ NEMDE slack variables: TBSlack1 and TBSlack2 The variables are used in a NEMDE constraint to solve the problem so that the price-tied bands in the same region are dispatched in proportion to the MW sizes of the respective bands. **CVP Ranking** ▪ CVP is sufficiently small so that it will not cause any violation of any other security constraints, nor impact the use of other competitively priced bids and offers ▪ CVP = 1x10-6 (default value) ▪ **Function and Dispatch** ▪ The constraint is used to separate energy capacity bid/offered at same price ▪ If the prices(adjusted by intra-regional loss factors) of two bids or offer bands of the same type of load bids or energy offers in a region are within 1x10-6 of one another, they are deemed price-tied. ▪ In the NEM market, tie-breaking model is by default enforced only for energy bids and offers, not for the FCAS offers. Please note that FCAS price-tied offers will be dispatched randomly over dispatch intervals based on how the LP optimization process in NEMDE approached that solution.