

# ESOPP GUIDE

## CONSTRAINT FREQUENTLY ASKED QUESTIONS (FAQ)

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3	30 December 2009	Ben Blake	AEMO rebranding
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## 2 Definitions

ABBREVIATION	DEFINITION
FCAS	Frequency Control Ancillary Services
LHS	Left Hand Side of a constraint equation
NEMDE	National Electricity Market Dispatch Engine
RHS	Right Hand Side of a constraint equation
TNSP	Transmission Network Services Provider
FCAS	Frequency Control Ancillary Services

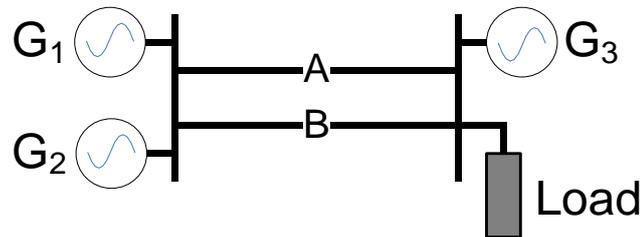
## 3 Frequently Asked Questions (FAQ)

### 3.1 Why was the constraint equation binding?

A constraint equation is binding when NEMDE or PASA targets the summation of the LHS terms to be equal with the constraint RHS value. For network constraint equations this indicates the power system is being operated near or at a design limit (thermal, voltage stability or transient stability). For FCAS constraint equations, binding indicates the constraint equation is setting the FCAS requirement for the service indicated for regions on the LHS.

This is indicated in the constraint results as a non-zero value in the Marginal Value field.

Consider the following system:



The limit on lines A and B is defined by the following:

$$Flow_{AB} \leq Limit_{AB}$$

This limit could be a voltage collapse or transient stability limit or the rating of one line for the trip of the other.

The flow on the 2 lines is only supplied by the two generators  $G_1$  and  $G_2$  so:

$$Flow_{AB} = G_1 + G_2$$

Therefore the constraint equation would look like this:

$$G_1 + G_2 \leq Limit_{AB}$$

When the constraint equation is binding the LHS is equal to the RHS

$$G_1 + G_2 = Limit_{AB}$$

Finally, to supply the load  $G_3$  would need to be dispatched to make up the shortfall due to the limitation on lines A and B.

### 3.2 Why was the constraint equation violating?

A constraint equation is violating when NEMDE or PASA is unable to target the summation of the LHS terms below the RHS value. From the example in 3.1:

$$G_1 + G_2 > Limit_{AB}$$

This is indicated in the constraint results as a non-zero value in the Violation Degree field.

### 3.3 Why does the constraint equation bind and then not bind?

This can indicate that something has changed in the power system that changes the inputs to the limit equation (whether this is a LHS or RHS term). This could be due to a range of factors including:

- A generator trip (such as  $G_1$  or  $G_2$  in 3.1).
- a capacitor bank or synchronous condenser was switched on which raised a voltage collapse limit
- A generator on the LHS of the constraint equation rebid
- The demand changed
- The line/transformer rating changed. Dynamically calculated ratings can change due to weather conditions. Other ratings can change from daytime to night-time or seasonally (summer / winter / spring / autumn). See the Transmission Equipment Ratings for more information: <http://www.aemo.com.au/electricityops/170-0011.html>.

### 3.4 Why does the constraint equation exist?

Each constraint equation models a particular system limit for a system configuration. This information is included in the GENCONDATA table in the main Description field and the Impact, Limit Type and Reason fields (see SO\_OP3709<sup>1</sup> section 9.4.3).

For example the constraint equation F\_I+ML\_L5\_0370 has the description: “*Out = Nil, Lower 5 min requirement for a NEM Load Event, ML = 370*”

The “Out = Nil” indicates this is a system normal (i.e. Nil or no outages) constraint equation and is generally always invoked (there are exceptions to this where there are multiple configurations for system normal like the radial/parallel modes in Victoria). If this were for an outage condition the item of plant out would be in place of the “Nil”. E.g. *Out = Georgetown No.3 22/110kV transformer*.

The remaining text details the system condition the constraint equation is used for; in this case it is for the FCAS requirements for loss of a 370 MW load.

### 3.5 Why was the constraint equation changed / why was the new constraint equation added?

Constraint equations are changed or added to for a number of reasons including:

- A new limit equation was provided by the TNSP
- An item of plant (for example a generator, interconnector, transmission line, reactive power device or transformer) was commissioned or decommissioned
- Adjustments were made to improve the performance of the constraint equation
- Power system studies identified a new condition that needs to be managed by a constraint equation
- A new FCAS requirement was identified
- A new Network Support Agreement was notified to AEMO

### 3.6 What changed in the new version of the constraint equation

What changed in the constraint equation is indicated:

- In the weekly “NEM Constraint Library Changes” AEMO Communication
- In the Modifications field in GENCONDATA

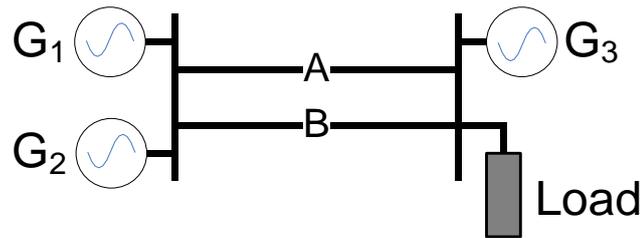
### 3.7 Why is my unit being reduced yet my bid indicates it should not be reduced?

This can be due to a binding constraint equation reducing your generator MW output to avoid exceeding a power system limit. This is known as being “constrained off”. Considering the simple power system example from 3.1 if the power flow across A and B needs to be reduced then NEMDE will target  $G_1$  or  $G_2$  (or both) to reduce this flow.

### 3.8 Why is my unit being increased yet my bid indicates this is against the price?

Similarly to 3.7 this can be due to a binding constraint equation increasing your generator MW output to avoid exceeding a power system limit. This is known as being “constrained on”. Consider the simple power system example from 3.1:

<sup>1</sup> <http://www.aemo.com.au/electricityops/3709.html>



In 3.1 the constraint equation was defined in terms of  $G_1$  and  $G_2$  and these were constrained so the flow on line A and B remains below the limit. However, the constraint equation could have been defined in terms of  $G_3$ :

$$Flow_{AB} \leq Limit_{AB}$$

$$Flow_{AB} = G_1 + G_2 = Load - G_3$$

Therefore the constraint equation would look like this:

$$-G_3 \leq Limit_{AB} - Load$$

In this case  $G_3$  would be constrained on to reduce the flow on lines A and B.

Note: Constraint equations may not necessarily be formulated as in the simple examples in 3.1 and 3.8. AEMO has rules defining what appears on the LHS and RHS of constraint equations. Please refer to the Network and FCAS Constraint Formulation Policy<sup>2</sup> for more information.

### 3.9 What is the difference between the Left Hand Side and Right Hand Side of a constraint equation?

The Left Hand Side (LHS) contains the market variables NEMDE or PASA can dispatch. This includes:

- scheduled generating units and scheduled loads (energy)
- ancillary service generating units and ancillary service loads (FCAS)
- Interconnectors and MNSPs
- Regional FCAS requirements

The Right Hand Side (RHS) contains everything else that makes up the limit equation (e.g. line rating, line flows, generator MVAR, on/off status of plant, operating margins, confidence intervals etc). The RHS is pre-calculated and then presented to NEMDE as a constant value.

### 3.10 How is the constraint RHS value in Dispatch/Predispatch related to the power system limit?

In general the constraint equation RHS value is not equivalent to the power system limit. There are several reasons for this:

- Many of the limit equations contain market quantities (Generators, Interconnectors and Regional FCAS) that can be added to the LHS of a constraint equation. AEMO receives limit advice from TNSPs either in the form of a limit equation for stability limits or a rating for lines or transformers. These limit equations are translated into quantities that can be used by NEMDE. For example to manage a line flow in NSW the post contingent line flow is calculated on the RHS, while the LHS contains the contribution terms from the generators and interconnectors in NSW.
- Constraint equations (generally ones for thermal overloads) are built in dispatch to only target the LHS units to within the headroom available for the limit (these are known as Feedback constraint equations). For example:

<sup>2</sup> <http://www.aemo.com.au/electricityops/170-0040.html>

$$G_1 + G_2 - G_3 + I_1 \leq \text{Rating} - \text{Line flow}$$

$$+ \text{Initial value of } (G_1 + G_2 - G_3 + I_1)$$

- Terms in the limit equation are moved to the LHS or RHS of the constraint equation to comply with the Network and FCAS Constraint Formulation Policy<sup>3</sup>. For example a limit equation defined by a TNSP as a limit on a single interconnector will have as part of conversion to a constraint equation any of the other interconnectors and generators moved from the RHS to the LHS (as long as their relative factor sizes comply with AEMO's constraint formulation policy).

### 3.11 How are the Constraint Equation and Constraint Set IDs labelled?

This is documented in the Constraint Naming Guidelines on the AEMO website:

<http://www.aemo.com.au/powersystemops/200-0141.html>

### 3.12 How do I determine which constraint equations are binding?

The DispatchConstraint (and PreDispatchConstraint) tables include the results for all constraint equations for a dispatch interval (and a trading interval). The binding constraint equations are those which have a non-zero value in MarginalValue field.

### 3.13 How do I determine which constraint equations are violating?

Similarly to 3.12, the violating constraint equations are those in the DispatchConstraint (and PreDispatchConstraint) tables which have a non-zero value in ViolationDegree field.

### 3.14 Where can I find information on planned network outages?

The Network Outage Schedule is published on the AEMO website:

<http://www.aemo.com.au/electricityops/NOS.html>

### 3.15 What is the marginal value?

The marginal value is the marginal cost of the constraint equation. This value is capped at VOLL x (constraint equation CVP). Put another way, if there was a change in the constraint equation RHS by 1 MW the marginal value represents the change in cost to the objective function.

### 3.16 What is the violation degree?

This is the difference between the constraint equation LHS summation and the RHS.

### 3.17 Why do binding constraint equations have different marginal values and what does it mean?

Constraint equations have different marginal values as there is a different cost for a change in the RHS value (see 3.15). Note that it is very likely that different constraint equations have different factors and terms on the LHS.

<sup>3</sup> <http://www.aemo.com.au/electricityops/170-0040.html>

### **3.18 How does NEMDE determine how much each LHS term is moved by when relieving a binding constraint equation?**

NEMDE will set the target of a LHS term of a constraint equation to minimise the objective function, so long as that movement does not violate any of the other constraint equations (this includes constraint equations internal to NEMDE such as the regional energy balance) in NEMDE.

### **3.19 How does NEMDE deal with equal unit bids in the scenario described in 3.18?**

If two LHS terms have the same coefficients and have the same marginal cost, these LHS terms will be dispatched in proportion to the MW sizes of the respective marginal bid bands through the tie-breaking constraint equation created for that pair of price-tied bands. Note that this is subject to the costs and restrictions imposed by other constraint equations in NEMDE.

The tie-breaking constraint equations only apply to energy bids and not FCAS.

### **3.20 How can I convert a constraint equation and the IDs used on the LHS and RHS to a more human readable form?**

There is a conversion tool available via the MMS Web portal that will convert a constraint equation into a more human readable or "Plain English" form. This changes the IDs used on the LHS and RHS of the constraint equation to a description and reverse polish notations (RPN) used on the RHS are converted into conventional algebraic form.

For example the SPD ID "Q\_DIRLK\_H31MDNR\_TRFMR" is converted to "MW flow on Molendinar 275/110kV transformer"

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