# Limits Advice Guidelines

## February 2025

A report for the National Electricity Market on the provision of limits advice from Network Service Providers to the Australian Energy Market Operator.

# Important notice

## Purpose

This publication has been prepared by the Australian Energy Market Operator (AEMO) for the purpose of providing information to network service providers (NSPs) about constraint equations, further requesting that network limit equations, ratings and diagrams are provided to AEMO from NSPs. The engineering data and limits advice supplied by NSPs is crucial in facilitating network congestion management in the National Electricity Market (NEM).

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## Version control

| Version | Release date | Changes |
|---|---|---|
| 2 | 5th February 2025 | Format: Convert document to current AEMO template.<br>Information: Update content according to current requirements and national electricity rules.<br>Reviews: AEMO and NSPs both reviewed this document. |
| 1 | 30th March 2012 | Initial version |

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# 1 Introduction

This document intends to provide Network Service Providers (NSPs) participating in the National Electricity Market (NEM), with information about the requirement for AEMO to receive limits advice in accordance with this guide. AEMO requires single line diagrams, plant ratings, and network limits to be formulated by NSPs defining the technical envelope of their power system. AEMO is reliant on NSPs to provide this expert advice regarding the limitations of their network for system normal, outages and credible contingency cases. AEMO operates the network considering thermal overload, voltage, transient and oscillatory stability and system strength limits and does this by deploying constraint equations within its market systems.

## 1.1 Background

A constraint equation produced by AEMO is embedded within market management systems to operate the power system within its limits, considering an operating margin, and equipment maximum physical capability. These equations interface with the NEM dispatch engine (NEMDE) and influence the dispatch solution. AEMO has a continuous program of work to build constraint equations that accurately reflect the current power system configuration and then as augmentation work, and plant movements occur makes the necessary updates to these equations. In addition, AEMO manages a due diligence process where ongoing studies are conducted to assess constraint equation performance and identify gaps. In this process any conservative limits leading to over constrained power flow effecting market outcome would be flagged triggering a review process. As would power flow violating limits leading to a risk for power system security remedial action would be taken.

Transmission network service providers (TNSPs) participating in the NEM, plan, design, maintain and operate transmission networks within their region and interconnectors enabling inter regional transfer. Distribution network service providers (DNSPs) build, maintain and operate the distribution networks linking transmission to end user. Collectively NSPs provide the infrastructure to transfer power from the generators to end users. The NEM is under a constant state of change even more prevalent in recent times with higher levels of, inverter-based resources (IBR), distributed energy resources (DER), utility scale renewable energy sources (RES) and battery energy storage systems (BESSs). These are often connected to the grid away from traditional generation centres therefore changing power flow and network dynamics. Network limit equations formulated by NSPs are created and updated for, the addition of new transmission lines, transformers, reactive power infrastructure, changes to network topology, generator connections, optimisation, and the rising influence of consumer energy resources (CER) must also be in aggregate factored into network capability and provided to AEMO.

## 1.2 Significance

AEMO is reliant on limits advice from NSPs to maintain power system security whilst solving the optimal electricity market outcome. This is achieved by operating all plant and equipment within normal or emergency limits with considering potential constraints in dispatch of generation and ancillary services. This document together with other relevant AEMO publications referenced in 1.3, are developed under requirements of the National Electricity Rules (NER) Chapter 3 Market Rules. Not limited to chapter 3 If there is any inconsistency between this document and the entire NER, the NER will prevail to the extent of that inconsistency.

## 1.3 Other AEMO publications

AEMO publishes information for congestion and constraint building in:

1. The Congestion Information Resource [1] provides a consolidated source of information relevant to the understanding and management of transmission network congestion (constraint) risk.
2. Constraint Naming Guidelines [2] defines how AEMO labels the constraint equations. Each constraint equation has a unique identifier.
3. Constraint Formulation Guidelines[3] sets out the principles for translating or formulating the physical restrictions in the power system into constraint equations.
4. Constraint Implementation Guidelines[4] examples of constructed constraint equations in accordance with the formulation guidelines.
5. Schedule of Constraint Violation Penalty Factors[5] provides a schedule of constraint types and associated CVP factors that are used in AEMOs constraint relaxation procedure.
6. Confidence Levels, Offsets and Operating Margins[6] describes the responsibilities, usage, and process for applying statistical and operating margins used in constraint equations.
7. Over-Constrained Dispatch Rerun Process[7] describes the process AEMO uses to rerun NEMDE for over-constrained dispatch.
8. AEMO timing requirements for the provision of information for connecting new plant and network changes.[8]

[1] AEMO, Congestion information resource: https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource

[2] AEMO, Constraint Naming Guidelines: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2016/constraint-naming-guidelines.pdf

[3] AEMO, Constraint Formulation Guidelines: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2023/constraint-formulation-guidelines-v12---final_1.pdf?la=en

[4] AEMO, Constraint Implementation Guidelines: https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/constraints-implementation-guidelines/final-constraint-implementation-guidelines-v3.pdf?la=en

[5] AEMO, Schedule of Constraint Violation Penalty Factors: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2024/schedule-of-constraint-violation-penalty-factors.pdf

[6] AEMO, Confidence Levels, Offsets and Operating Margins: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2016/confidence_levels_offsets_and_operating_margins.pdf

[7] AEMO, Over-Constrained Dispatch Rerun Process: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2016/over-constrained-dispatch-rerun-process.pdf

[8] AEMO timing requirements for the provision of information for connecting new plant and network changes: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/aemo-timing-requirements-for-the-provision-of-information

# 2 Responsibilities

NSPs are responsible for providing AEMO with a complete set of engineering data, single line diagrams, SCADA signals, limit equations, ratings, and information on control schemes for both system normal and outage conditions. NSPs are responsible for applying confidence levels or offsets in the limit equations provided to AEMO.

AEMO is responsible for modelling the network, conducting due diligence on these limit equations provided by the NSP and constructing the constraint equations based on the supplied limit equation in accordance with the constraint formulation guidelines[9]. AEMO applies operating margins as per the Operating Margins document.

# 3 Requirements

This document herein defines, how limits advice should be communicated, the timeframes to be observed for providing the information and technical requirements. An important first step upon receiving limits advice is confirming all the included terms are being modelled in AEMO systems. If not the first step is to bring all required data points online and include them in AEMO Energy Management System (EMS) and AEMO Modelling Platform (AMP).

- When a new limit term is to be modelled, additional time is needed to establish the ICCP link to AEMO for the new SCADA point/s and update the network model to include it.
- New terms are introduced by the NSP for various reasons such as, better network control and monitoring, a new connection, for example a generator or reactive power infrastructure and network augmentation.
- The NSP is responsible to provide all SCADA signals, plant and equipment ratings for their network allowing AEMO to perform accurate network modelling.

For limits advice where all terms are currently modelled in AEMO systems these limit equations can proceed directly to due diligence and constraint building using the current AEMO EMS model and AMP study cases.

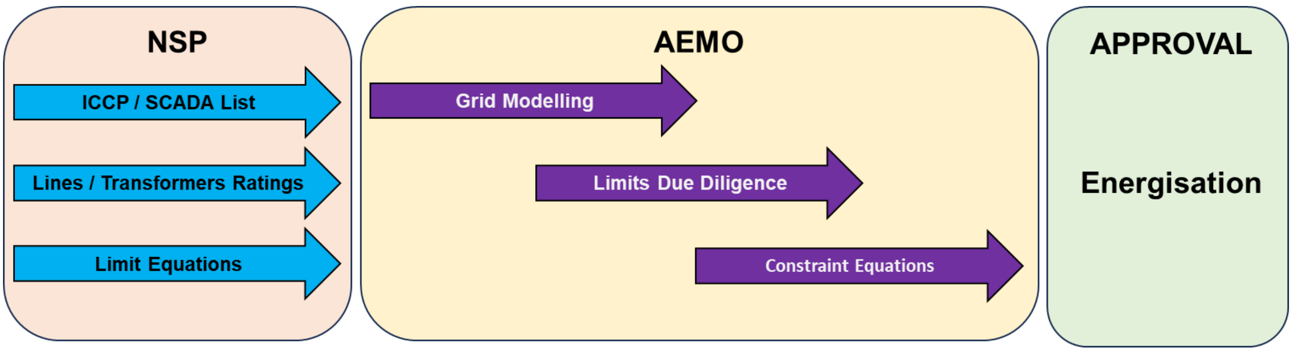


**Figure 1: Typical Limits Advice Process**

[9] AEMO, Constraint Formulation Guidelines: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2023/constraint-formulation-guidelines-v12---final_1.pdf?la=en

## 3.1 Communication

All limit advice is to be emailed to **limits.advice@aemo.com.au**. This email address is the primary repository used by AEMO for limit advice. The limit advice should clearly indicate whether it is draft or final and for major limit advice the final version should be formally signed off by the NSP.

## 3.2 Timeline

All limit advice must be provided 6 weeks in advance of the planned energisation date. During public holidays and the holiday season this lead time may be extended due to office closures. AEMO publishes a guide detailing lead time requirements for the provision of information[10]. This lead-time is a strict requirement to allow AEMO to fulfill its obligations in, grid modelling, limit due diligence, constraint equation construction, peer review and testing. In situations where AEMO believes these tasks will take longer, AEMO will discuss the timeframe for providing advice with the NSP. If the NSP requires the limit advice to be expedited this can be discussed with AEMO on a case-by-case basis.

In general, a wholesale revision of a complex system normal limit in most cases will take the full 6 weeks, however minor changes to existing limits may be shorter dependent on congestion modelling resourcing at the time and at the discretion of AEMO. In the case of short notice outages, the limits advice needs to be provided at least 4 business days ahead of the outage. If this is not possible, there is a risk that the due diligence cannot be completed in time, and the outage may need to be deferred.

## 3.3 Limit Types

For each limit type (thermal overload, voltage, transient, oscillatory stability and system strength) AEMO requires a limit equation or offset to an existing limit equation. Note: graphs or tables will not be accepted. The fault or tripped element(s) should be clearly identified along with all assumptions about the operating conditions (such as particular reactive plant being in or out of service).

### 3.3.1 Thermal Overload

For thermal limits *AEMO* requires:

- A list of the monitored and tripped lines/transformers/generators for which constraint equations need to be constructed. Lines and transformers need to include the direction of flow.
- The rating to use under no contingency (N) and contingency (N-1) cases.
    - Where two ratings can be used the NSP is to advise which rating to use and under which operating conditions.

[10] AEMO timing requirements for the provision of information for connecting new plant and network changes: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/aemo-timing-requirements-for-the-provision-of-information

- Where a very short time (< 15 minute) rating is to be used, detail is required on the control scheme or other approach that would be used to reduce flow(s) post contingency. If the rating is shorter than 10 minutes an automatically initiated response would be required.

- NSPs to ensure any line and transformer ratings (continuous, short-time or dynamic) required for the first dot point are provided to AEMO via the existing process to supply ratings to AEMO's EMS

*AEMO* will calculate the participation factors for thermal limits for the generators and interconnectors as per *AEMO*'s constraint formulation guidelines.

### 3.3.2 Voltage, Transient and Oscillatory Stability and System Strength

For stability and fault level limits AEMO requires limit equations for managing network flow to ensure,

- Voltages remain at acceptable levels after a credible contingency.
- Continued synchronism of all generators on the power system following a credible contingency.
- Damping of power system oscillations is adequate following a credible contingency.
- System strength fault level is adequate in both steady state and post fault.

### 3.3.3 Inverter and Turbine limits

In cases where there are limitations on plant with turbines or inverters the following terminology should be followed.

Disconnected – The inverters or turbines are physically disconnected from the power system through the opening of a circuit breaker or through the participant advising AEMO that the inverters are physically disconnected from the power system via some other means.

Blocked – The inverters or turbines enter a state where they will not respond to any power system changes and are essentially no longer operating/online. For the avoidance of doubt when an inverter or turbine is blocked it will provide no MWs or MVARs and will be prevented from firing and therefore does not impact system strength. When "Blocked" the inverter or turbine may remain physically connected to the power system. In the past AEMO has referred to this in the limit's advice as "Pause Mode"

Constrained to Zero – The inverter or turbines are constrained to 0 MW output via the local plant controller, or constraints and NEMDE.

## 3.4 Control Schemes

Information on the operation of control schemes, whether these are for generator runback or power system protection, is required so constraint equations can be modelled to consider control scheme actions. In particular, the following advice is required:

- Monitored element(s) and whether these elements only consider a particular direction of flow.

- The power system conditions needed to activate the control scheme action(s). This includes parameters and thresholds of the elements included in the control scheme. Examples include line ratings, line flows and generator outputs.

- Control scheme action(s). Examples include generator runback or tripping of load blocks.

- What action is to be taken when the control scheme is out of service.
- What actions are to be taken to reactivate the control scheme once it has operated and any restrictions on its reactivation.

## 3.5 Limit Equations

All terms in the limit equation are to be clearly defined (such as what constitutes the Southeast or Armidale load). The values specified also need to be made available to AEMO via SCADA. The limit equation should be for either thermal overload or stability and strength, combinations of these will be rejected.

The LHS of constraint equations can only accept linear terms in MW quantities. AEMO would prefer that scheduled generators and interconnectors are not included in non-linear calculations (such as quadratic calculations).

The RHS is constructed by AEMO for Dispatch, Pre-dispatch, ST PASA and MT PASA timeframes. Outside Dispatch AEMO needs to use estimates of terms in the limit equation. Guidance from NSPs as to how to estimate these terms at times of high load and high transfer is required. Cases should include status of reactive plant or units on-line at aggregated units.

Limit equations need to include the effect of DER and be applicable for an increasing range of loads (from a peak winter night peak demand to a very low demand on a midday in summer).

# 4 Ongoing Review

NSPs should conduct regular review and where required update limit equations for both system normal and planned outages and advice provided to AEMO for,

- Expanding influence of DER into networks.
- Changing load profiles.
- Increased electrification of systems.
- Expansion of networks and new infrastructure.
- Inclusion of new technologies such as grid forming inverters, virtual synchronous machines, etc.
- New operating strategies of large grid connected plant: such as BESS and synchronous condensers.

# Glossary

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

| Term | Definition |
|---|---|
| **AEMC** | Australian Energy Market Commission |
| **AER** | Australian Energy Regulator |
| **AEMO** | Australian Energy Market Operator |
| **NSP** | Network Service Provider |
| **TNSP** | Transmission Network Service Provider |
| **DNSP** | Distribution Network Service Provider |
| **NEL** | National Electricity Law |
| **NER** | National Electricity Rules |
| **NEM** | National Electricity Market |
| **NEMDE** | National Electricity Market Dispatch Engine |
| **EMS** | Energy Management System |
| **AMP** | AEMO Modelling Platform |
| **SCADA** | Supervisory Control and Data Acquisition. Information such as line flows and generator outputs are delivered via SCADA. |
| **ICCP** | Inter Control Centre Protocol |
| **FCAS** | Frequency Control Ancillary Services |
| **Limit equation** | These are the mathematical expressions describing a limitation on a part of the transmission or distribution network. These are provided to AEMO by Network Service Providers (NSPs) |
| **Constraint equation** | These are the mathematical representations that AEMO uses to model power system limitations and FCAS requirements in the National Electricity Market Dispatch Engine (NEMDE). |
| **LHS** | Left Hand Side of a constraint equation. This consists of the variables that can be optimised by NEMDE. These terms include Scheduled Generators, Semi-Scheduled Generators, scheduled loads, regulated Interconnectors, Market Network Service Providers (MNSPs) or regional FCAS requirements. |
| **RHS** | Right Hand Side of a constraint equation. The RHS is pre-calculated and presented to the solver as a constant; these terms cannot be optimised by NEMDE. |
| **System normal** | The configuration of the power system where:<br>• All transmission elements are in service, or<br>• The network is operating in its normal network configuration. |
| **PASA** | Projected Assessment of System Adequacy |
| **DER** | Distributed Energy Resource |
| **CER** | Consumer Energy Resource |
| **RES** | Renewable Energy Source |
| **BESS** | Battery Energy Storage System |
| **IBR** | Inverter Based Resources |