RELIABILITY STANDARD IMPLEMENTATION GUIDELINES

~~FINAL~~
~~October 2016~~
DRAFT
16 June 2017
Version 1.~~3~~4

Effective 1 November 2017

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

This document has been prepared by AEMO as required by clause 11.78.4 (a) of the National Electricity Rules (Rules), and has effect only for the purposes set out in the Rules.

Disclaimer

This document or the information in it may be subsequently updated or amended. This document might also contain information which is provided for explanatory purposes. This document does not constitute legal or business advice, and should not be relied on as a substitute for obtaining detailed advice about the Rules, or any other applicable laws, procedures or policies. AEMO has made every effort to ensure the quality of the information but cannot guarantee its accuracy or completeness or its suitability for particular purposes.

To the maximum extent permitted by law, AEMO and its officers, employees and consultants involved in the preparation of this report:

- make no representation or warranty, express or implied, as to the currency, accuracy, reliability or completeness of the information in this document; and
- are not liable (whether by reason of negligence or otherwise) for any statements or representations in this document, or any omissions from it, or for any use or reliance on the information in it.

Version release history

Version	Publication date	Details
V1.0	18 December 2015	Final report following consultation.
V1.1	2 June 2016	Initial draft – Update RSIG in accordance with Schedule 2 of the National Electricity Amendment (Energy Adequacy Assessment Projection timeframes) Rule 2016 No. 3.
V1.2	9 September 2016	Includes amendments suggested by the Consulted Persons during first stage of consultation.
V1.3	10 October 2016	Accepted all changes made in V1.2.
V1.4	16 June 2017	Proposed changes related to MT PASA – Reliability Assessment Methodology following the recommended solution proposed by Ernst & Young (EY) and submissions from Stage one of the RSIG consultation.. Updated intermittent generation and network constraint approach used in ESOO.

CONTENTS

TABLES

1. INTRODUCTION

1.1 Purpose and scope

These are the *reliability standard implementation guidelines* (RSIG or Guidelines) made under clause 3.9.3D of the National Electricity Rules (NER). They outline current processes that evaluate the market against the *reliability standard*.

These Guidelines have effect only for the purposes set out in clause 3.9.3D of the NER. The NER and the *National Electricity Law* prevail over these Guidelines to the extent of any inconsistency.

The Guidelines set out how the *Australian Energy Market Operator* (AEMO) implements the *reliability standard*, and the approach and assumptions AEMO uses to implement the *reliability standard* in relation to:

- Demand for electricity.
- *Reliability* of existing and future *generation.*
- *Intermittent generation.*
- *Energy constraints.*
- The treatment of extreme weather events.
- *Network constraints.*
- Factors considered in determining whether additional *Energy Adequacy Assessment Projection (EAAP)* reporting is required.

1.2 Related documents

Table 1 Related documents

Reference	Title	Location
Demand Forecasting	Load Forecasting SO_OP3710	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation
Directions	Intervention, Direction and Clause 4.8.9 Instructions SO_OP3707	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation
EAAP	Energy Adequacy Assessment Projection	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Energy-Adequacy-Assessment-Projection
ESOO	NEM Electricity Statement of Opportunities (ESOO) web page	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities
MT PASA	MT PASA Process Description	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Dispatch-information/Policy-and-process-documentationhttps://www.aemo.com.au/-/media/Files/Electricity/NEM/Data/MMS/2016/MT_PASA_Process_Description.pdf
MRL	ROAM Consulting Final Report for Operational MRLs – 2010 MRL Recalculation	http://www.aemo.com.au/Datasource/Archives/Archive1135
MT PASA capacity reserves	Assessing Reserve Adequacy in the NEM	http://www.aemo.com.au/Datasource/Archives/Archive1417
Network constraints	Constraint Implementation Guidelines	http://www.aemo.com.au/Datasource/Archives/Archive1055http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/Constraint-Implementation-Guidelines.pdf
Network constraints	Constraint Formulation Guidelines	http://www.aemo.com.au/Datasource/Archives/Archive1053http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/Constraint_Formulation_Guidelines_v10_1.pdf

Reference	Title	Location
Reserve contracts – dispatch and activation	Procedure for the Dispatch and Activation of Reserve Contracts SO_OP3717	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation
Reserve contracts – procuring reserve contracts	Procedure for the Exercise of Reliability and Emergency Reserve Trader (RERT) at the AEMO web page	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Emergency-Management
Short term weather events	Power system security guidelines SO_OP3715	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation
ST PASA	Short Term Reserve Assessment SO_OP3703	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation
ST PASA	ST PASA Process Description	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Dispatch-information/Policy-and-process-documentation

1.3 The reliability standard

The *reliability standard* is a measure of the effectiveness, or sufficiency, of installed capacity to meet demand. It is defined in clause 3.9.3C of the NER as the maximum expected *unserved energy* (USE), as a percentage of total energy, in a region over a financial year, and is currently set at 0.002%. USE is measured in gigawatt hours (GWh).

The USE that contributes to the *reliability standard* is defined in clause 3.9.3C (b) of the NER and excludes power system security events, network outages not associated with inter-regional flows and industrial action or acts of God.

The NER does not give specific direction to AEMO on how to implement the *reliability standard*, but it does require AEMO to perform the following functions in accordance with the RSIG:

1. Clause 3.7.2 MT PASA

(f)(6) Identify and quantify any projected failure to meet the *reliability standard* as assessed in accordance with the RSIG.

2. Clause 3.7.3 ST PASA

(h)(5) Identify and quantify any projected failure to meet the *reliability standard* as assessed in accordance with the RSIG.

3. Clause 4.2.7 Reliable operating state

(c) Assess whether the *power system* meets, and is projected to meet, the *reliability standard*, having regard to the RSIG.

4. Clause 4.3.1 Responsibility of AEMO for power system security

(l) Monitor demand and *generation* capacity in accordance with the RSIG and, if necessary, initiate action in relation to a *relevant AEMO intervention event.*

(m) Publish as appropriate, information about the potential for, or the occurrence of, a situation which could significantly impact, or is significantly impacting, on *power system security*, and advise of any *low reserve* condition for the relevant periods determined in accordance with the RSIG.

5. Clause 4.8.4 Declaration of conditions

(a) AEMO may declare a *low reserve* condition when it considers that the balance of *generation* capacity and demand for the period being assessed does not meet the *reliability standard* as assessed in accordance with the RSIG.

(b) AEMO may declare a *lack of reserve level 1, 2 or 3* to advise whenever *capacity reserves* reduce below the level required to manage *credible contingency events.*

1.4 AEMO's process for managing low reserve or lack of reserve conditions

If AEMO declares a *lack of reserve (LOR)* or *low reserve* condition (LRC), *AEMO* will follow the processes set out in clauses 4.8.5A and 4.8.5B. This includes publishing ~~of~~ any foreseeable circumstances that may require *AEMO* to implement an *AEMO intervention event*.

The ~~objective~~aim of implementing an AEMO *intervention event* is to maintain the reliability of supply and power system security where practicable, over the period *low reserve* or lack *of reserve* condition exists. *AEMO intervention event*s include:

(a) Issuing an instruction or direction in accordance with clause 4.8.9; or

(b) Exercising the reliability and emergency reserve trader in accordance with rule 3.20.

Details on these can be found in the Intervention, Direction and Clause 4.8.9 Instructions document and the Procedure for the Dispatch and Activation of Reserve Contracts SO_OP3717 document listed in section 1.2.

2. RELIABILITY STANDARD IMPLEMENTATION PROCESSES

AEMO implements the *reliability standard* using forecasts and projections over different timeframes. AEMO uses the following processes:

1. Electricity *Statement of Opportunities* (ESOO) to provide market information over a ten~~-~~-year projection to assist planning by existing and potential generators and market participants.
2. *Energy Adequacy Assessment Projection* (*EAAP*) to forecast USE for *energy* constrained scenarios over a two~~-~~-year projection.
3. Medium Term Projected Assessment of System Adequacy (MT PASA) to forecast ~~peak *capacity reserve* conditions~~ USE over a two~~-~~-year projection.
4. Short Term Projected Assessment of System Adequacy (ST PASA) to forecast *capacity reserve* over a six~~-~~-day projection.

Detailed information about each ~~of these processes~~process and ~~the~~ methodologies applied~~ in them~~ can be found on AEMO's website, as listed in section 1.2.

This section of the Guidelines describes how each ~~of the processes~~process evaluates key components that contribute to AEMO's forecast of reliability. Different assumptions used under the various processes reflect the study ~~time frame~~timeframe and hence level of uncertainty in the inputs.

Table 2 explains the processes AEMO undertakes to forecast *reliability*, inform *Market Participants* and *Network Service Providers* if the *reliability standard* is likely to be breached, and intervene where necessary.

Table 2 Summary of processes that AEMO uses to implement the reliability standard

Process	Study Time Frame/Publication Frequency[1]	Assessment Method	Primary Action	Second Action	Assumption for Potential Breach of Reliability Standard
ESOO	10 year/Annually	USE	Inform		Forecast USE>0.002% in any forecast year
EAAP	2 year/Annually	USE	Inform	4.8.9 instruction, RERT ~~of~~or direction	Forecast USE>0.002% in any forecast year
MT PASA	2 year/~~monthly~~Weekly	~~Capacity~~USE	Inform	4.8.9 instruction, RERT ~~of~~or direction	~~Reserves fall short of the Minimum Reserve Level (MRL)~~Forecast USE>0.002% in any forecast year
ST PASA	6 day/2 hours	Capacity	Inform	4.8.9 instruction, RERT ~~of~~or direction	LOR2 or LOR3

2.1 Electricity Statement of Opportunities

AEMO is required to publish an ~~Electricity Statement of Opportunities (~~ESOO~~)~~ annually under clause 3.13.3(q) of the NER. The ESOO provides information which can help stakeholders plan their operations over a ten-year outlook period, including information about the future supply demand balance.

The ESOO also indicates when *generation* or demand management capacity or augmentation of the *power system* is required to meet the *reliability standard*, using probabilistic modelling to determine the regional USE at an hourly resolution. This involves using time-sequential, security-constrained optimal dispatch simulations, incorporating Monte-Carlo simulations. AEMO compares the probability-weighted

[1] The frequencies shown in this table correspond with the NER and will be updated if changes are made to the underlying rules.

USE assessment against the *reliability standard*, and identifies potential future breaches. Detail on this approach and assumption can be found in the ESOO methodology document.[2]

AEMO then publishes details of any forecast LRC where the *reliability standard* may be breached. AEMO generally does not take any further action to ensure a response to any potential breaches of the *reliability standard* identified in the ESOO.[3]

The following sub-sections outline some key inputs to the ESOO model. A detailed description of the ESOO modelling methodology is available on the ESOO webpage as listed in section 1.2.

2.1.1 ESOO generation capacity

For the generation component of the ESOO assessment, AEMO uses the total of current generation capacity plus any committed future generation[4] and withdrawals, obtained from operators of generating plant in the ~~NEM.~~National Electricity Market (NEM).[5] AEMO does not assume or forecast any further new generation capacity. Generic annual planned outages are scheduled and optimised in lower demand periods, and forced outages are stochastically modelled using probabilities derived from historical performance or expert advice where historical information is not available.

2.1.2 ESOO intermittent generation

For *intermittent* generation, AEMO prepares ten~~-~~-year *intermittent* generation profiles based on historical performance, where available~~-~~, and/or meteorological data for new or committed generation. At least five different *intermittent* generation profiles are developed for each generator, based on historical weather traces, and sampled as part of the Monte-Carlo simulations. These generation profiles are ~~a deterministic input~~linked to the ~~Monte-Carlo simulations.~~ corresponding demand trace based on that same historical weather pattern to ensure any correlation between intermittent generation and demand is preserved. Detail on this approach and assumptions can be found in the ESOO methodology document.

~~As a matter of priority, AEMO is seeking a way to adopt a more probabilistic approach for modelling intermittent generation. Any future change in methodology will be communicated to stakeholders before it is applied, and highlighted in the ESOO methodology document.~~

2.1.3 ESOO energy constraints

The ESOO process accounts for projected *energy constraints* via inputs to the ESOO model. Any *energy constraint*, such as low water levels of dams used by hydroelectric *Generators,* is an input to the model as total *energy* available for the particular *Generator*. These assumptions are based on historical observations, and long-term average hydroelectric yields assessed by AEMO in consultation with relevant stakeholders. The same principle applies for any other *energy* limitation affecting a *Generator* in the model.

2.1.4 ESOO forecast demand

For the forecast demand component of the ESOO, AEMO uses the most recent National Electricity Forecasting Report (NEFR).[6] The NEFR projects *energy* and *maximum demand* forecasts for the

[2] See AEMO ESOO web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

[3] Unless the breach is identified in the National Transmission Network Development Plan (NTNDP) as an *NSCAS gap* and will not be met by the relevant *Transmission Network Service Provider*.

[4] Committed future generators represent generation that is considered to be proceeding based on AEMO's commitment criteria. For more detail see the AEMO Generation Information page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information.

[5] See ESOO Methodology, available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

[6] See AEMO NEFR web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Electricity-Forecasting-Report.

~~National Electricity Market (~~NEM~~)~~. AEMO converts the *energy* and *maximum demand* forecasts into hourly, or
half-hourly, demand profiles based on historical ~~demand~~weather patterns. The demand profile also incorporates NEFR assumptions on future distributed energy resources (DER), such as rooftop photovoltaic (PV ~~and~~), battery storage penetration~~.~~ and electric vehicles (EV).

Extreme weather events are considered ~~through the use of~~by using demand profiles derived from the 10% *probability of exceedance*[7] (10% POE) *maximum demand* forecasts. At a minimum, a combination of ~~both~~ 50% POE and 10% POE demand profiles from at least five historical reference years are ~~used~~sampled probabilistically in the Monte-Carlo simulations to develop the expected USE. At AEMO's discretion, more POE demand profiles (such as 90% POE) may be included, if USE outcomes are expected to be materially different from 50% POE outcomes.

2.1.5 Network constraints

AEMO continues to update and refine *network constraints* through its modelling projects ~~throughout~~during the year. ~~The~~ ESOO ~~implements~~uses the latest version of ~~pre-dispatch~~ST PASA formulation constraints~~,~~ as ~~well as the~~ a base set, with additional customised constraints, and *network* constraints ~~associated with~~ to model future ~~planned~~ *network* and generation upgrades. ~~Pre-dispatch constraints consider feedback terms in the right hand side of the equations, using the previous periods' dispatch to help formulate the current periods' limits.~~ .

Given the ten-year outlook period, ESOO constraint equations need to make assumptions on the future ~~inertia of the system, and whether reactive plants are in service~~status of the network. Such assumptions are made using long term averages or estimates based on demand levels.

Detailed information on *network constraints* can be found in the network constraints documents listed in section 1.2.

2.2 Energy Adequacy Assessment Projection

~~The Energy Adequacy Assessment Projection~~The *EAAP* implements the *reliability standard* over a two-year timeframe. ~~In addition to~~As well as the demand outlook, generation capacity availability and network constraints, the *EAAP* particularly focuses on the impact of potential *energy constraints*, such as water shortages during drought conditions, and identifies and reports forecast USE that exceeds the *reliability standard*.

AEMO is required to publish an *EAAP* in accordance with NER clause 3.7C. The *EAAP* makes available to the market an analysis that quantifies the impact of potential *energy constraints* on *energy* availability for a range of scenarios, specified in the *EAAP guidelines*. AEMO identifies potential periods of USE and quantifies projected annual USE that may breach the *reliability standard*.

The *energy constraints* that AEMO considers for the *EAAP* are defined in the *EAAP guidelines*. AEMO uses a market model to forecast two years at hourly resolution for these *energy constraint* scenarios. This involves using time-sequential Monte-Carlo market dispatch simulations. It uses a probability-weighted USE assessment to identify any potential *reliability standard* breaches.

The following sub-sections outline~~ some~~ key inputs to the *EAAP* model and factors for additional *EAAP* reporting. A detailed description of *EAAP* modelling is available on AEMO's website as listed in section 1.2.

2.2.1 *EAAP* generation capacity

Generation capacity is an input to the *EAAP* model. AEMO uses the most recent MT PASA offers to derive total capacity and planned outage information.

[7] Probability of exceedance is the chance that the observed value is greater than the reported value. A 10% probability of exceedance means there is a 10% chance that the outcome is greater than the reported value.

2.2.2 *EAAP* intermittent generation

Intermittent generation forecasts are the same generation profiles used in ESOO, which are based on historical performance where available or meteorological data for new or committed generation.

The semi-scheduled *intermittent generation* forecasts are aggregated per region and then added to the scheduled generation capacity of the associated region. Semi-scheduled *intermittent generation* is added to scheduled *generation* to make up the total *generation* dispatched by the *central dispatch* mechanism.

The non-scheduled *intermittent generation* forecasts are aggregated per region and then subtracted from the associated regional demand forecast. Non-scheduled *intermittent generation* is subtracted from demand because it is not dispatched by the *central dispatch* mechanism and thereby appears as negative demand.

2.2.3 *EAAP* energy constraints

AEMO's approach is to model *EAAP* scenarios that reflect credible *energy constraints*, as identified in the *EAAP guidelines*. The energy constraint information is provided to AEMO by participants through the *Generator Energy Limitation Framework* (GELF).[8]

2.2.4 *EAAP* demand

AEMO converts the most recent NEFR *energy* and *maximum demand* forecasts into an hourly demand profile based on historical demand patterns. The simulations assess both 50% and 10% POE *maximum demand* profiles. Extreme weather events are considered using demand profiles derived from the 10% POE *maximum demand* forecasts.

2.2.5 Network constraints

The *EAAP* simulations model the network power transfer capability using system normal constraint equations only. Detailed information on the preparation of *EAAP network constraints* can be found in the *EAAP guidelines*. The *EAAP* currently uses the same constraint equations that are used for ST PASA, see section 2.3.2.6. AEMO is investigating whether it is feasible to use the more detailed ESOO constraint set for *EAAP* modelling in future. Any change in methodology will be communicated to stakeholders before it is applied, and highlighted in the *EAAP guidelines*.

2.2.6 Factors for additional *EAAP* reporting

Without limitation, AEMO will consider the following factors in determining whether it has an obligation to publish an additional *EAAP*:

- Hydro storage levels.
- A major transmission limitation.
- A prolonged interconnection outage that results in a major restriction in energy transfers between NEM regions ~~within the NEM~~.
- A prolonged power station outage or fuel supply interruption that results in a material energy constraint.
- The requirement for AEMO to exercise the *RERT* under rule 3.20.
- A major change in operational consumption.
- Any other events or emerging events that may materially impact reliability by way of energy limitations.

[8] See Rules 3.7C (b) (g) to (j).

AEMO will also consider publishing additional *EAAP*s if a Market Participant informs AEMO of an event or circumstances it considers may result in a material energy constraint.

2.3 Projected Assessment of System Adequacy

AEMO's projected assessment of system adequacy (PASA) processes collect, analyse, and publish information that will inform the market ~~regarding~~about forecasts of supply and demand.

PASA is administered in two timeframes:

1. *Medium-term PASA* (MT PASA) – a 24~~-~~-month projection reported at daily resolution~~.~~ (although modelled at a 30 minute resolution).
2. *Short-term PASA* (ST PASA) – a six~~-~~-day projection at 30 minute resolution.

~~For the PASA processes, AEMO determines *capacity reserve* levels to assess the reliability of future *generation*.~~ Separate reserve assessments are applied for ~~the~~ MT PASA and ST PASA processes. MT PASA identifies LRC ~~and~~while ST PASA identifies LOR[9] conditions based on determined *capacity reserve* levels.

AEMO's response to ~~a capacity shortfall[10],~~ an LRC or LOR, depends on the extent of the projected supply shortfall, and the timeframe in which it is projected to arise. AEMO's potential responses include:

- Notifications to the market via reports, data, or market notices.
- Intervening in the market via *directions*[11] under NER clause 4.8.9.
- Intervening in the market by *dispatching*[12] contracted *reserve.*[13]

AEMO assumes that if a period of LRC or LOR is identified, then there is a risk that the *reliability standard* may be breached.

2.3.1 Medium Term PASA (MT PASA)

AEMO implements the *reliability standard* over a two-year timeframe by providing ~~a *capacity reserve* assessment~~an estimate of expected annual USE as part of the MT PASA process, which is run at least weekly. ~~This component of the broader~~

MT PASA ~~process identifies potential capacity shortfalls known as~~ uses probabilistic modelling to estimate the likelihood and magnitude of USE in each half hour based on the availability that *Registered Participants* have offered, the expected demand estimated by AEMO, intermittent generation forecasts and estimated transmission constraints. This involves using time-sequential, security-constrained optimal dispatch simulations, incorporating Monte-Carlo simulations.

If the expected annual USE, averaged across the simulations, exceeds the maximum level specified by the *reliability standard*, a LRC is identified. The *reliability standard* is implemented by identifying, disclosing and responding to periods of forecast LRC.

~~AEMO declares a LRC if *capacity reserves* are projected to be inadequate on any given day. Capacity reserves are the difference between the PASA availability *participants* have offered and expected demand estimated by AEMO according to the PASA processes. To assess supply adequacy, these *capacity reserves* are compared against Minimum Reserve Levels (MRLs). This provides a fast and timely assessment of supply adequacy without needing to compute USE explicitly using a large number of Monte Carlo simulations.~~

[9] See AEMO procedure (section 6) Short Term Management SO_OP3703, on web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

~~[10] See Assessing Reserve Adequacy in the NEM, on web page: http://www.aemo.com.au/Datasource/Archives/Archive1417.~~

[11] See Intervention, Direction and Clause 4.8.9 Instructions SO_OP3707, on web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

[12] Procedure for the Dispatch and Activation of Reserve Contracts SO_OP3717, on web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

[13] See AEMO web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Emergency-Management.

MRLs represent the minimum level of *capacity reserves* that must be carried in each *region* to avoid exceeding 0.002% USE in a given financial year. They are calculated by AEMO through market modelling, taking into account *inter-regional* reserve sharing capability, network system normal constraints, and generation forced outage probabilities. Due to the time-consuming nature of the MRL analysis, MRLs are only updated at AEMO's discretion. The methodology for calculating MRLs is available on AEMO's website.

Applying MRL in the MT PASA assists to identify potential reserve shortfalls in the NEM. However, AEMO may apply probabilistic studies such as *EAAP* to confirm the LRC findings of MT PASA before intervening in response to projected shortfalls.

AEMO responses to projected LRCAEMO's response to projected LRC identified in MT PASA may be to take direct action in the form of directions – for example, directing a *Generator* to reschedule an outage – or using the *reliability and emergency reserve trader* (RERT). The RERT can only be used if the expected reserve shortfall is within the next nine months. AEMO's RERT role is scheduled to expire on 30 June 2016.*RERT*. The *RERT* currently allows AEMO to contract for reserves up to nine months ahead of a period where reserves are projected to be insufficient to meet the reliability standard (known as a projected reserve shortfall). AEMO is able to dispatch these reserves to manage power system reliability and, where practicable, security. From 1 November 2017, this period will reduce to ten weeks as the AEMC seeks to minimise the market distortionary effects of the RERT.

A detailed description of the MT PASA process is available on AEMO's website as listed in section 1.2.

2.3.1.1 MT PASA generation capacity reserve assessment

AEMO assesses *reserve* capacity[9] by comparing a two year daily peak capacity profile to the MT PASA daily peak demand profile. If a pre-determined *reserve* requirement, MRL, is breached then AEMO may take action to attempt to restore the required *reserve* capacity.

The daily peak capacity profile used in the MT PASA processAEMO uses the most recent MT PASA offers to derive total generation capacity and planned outage information on a half-hourly basis. The information is derived from several sources:

- Scheduled *Generators* are required to submit to AEMO a daily PASA availability.[14,15] The availabilities submitted represent the generation capacity that could be made available within 24 hours, taking into account the ambient weather conditions at the time of 10% POE demand.
- Intermittent *Generators* submit capacity information, which is then used in AEMO's process of forecasting available *intermittent* generation capacity (see section 2.3.1.22.3.1.22.3.1.2).
- Committed generation development generation and retirement projects are included in the capacity forecast by using expected commissioning and decommissioning timeframes and associated availabilities.

Forced outages are assessed probabilistically as part of the MRL.MT PASA modelling. The probability of forced outages is based on historical performance and consistent with ESOO and *EAAP* assumptions used at the time the MRLs were updated.or expert advice where historical performance is not available.

2.3.1.2 MT PASA intermittent generation

AEMO uses two models:

[14] For MT PASA see NER Clause 3.7.2(d) and for ST PASA see NER Clause 3.7.3(e)(2).

[15] PASA availability is a defined term in the NER: The physical plant capability (taking ambient weather conditions into account in the manner described in the procedure prepared under clause 3.7.2(g)) of a scheduled generating unit, scheduled load or scheduled network service available in a particular period, including any physical plant capability that can be made available during that period, on 24 hours' notice.

- One to forecast *intermittent* wind *generation* – Australian Wind Energy Forecasting System (AWEFS[16]).
- The other to forecast *intermittent* solar *generation* – Australian Solar Energy Forecasting System (ASFES[17]).

The semiModelling of intermittent generation is consistent with ESOO. Intermittent generation profiles are derived for each generator from at least five historical weather years. Meteorological data, historical correlations and geographic locations are used to estimate output from new or committed intermittent generation. The probabilistic model samples from these generation profiles, maintaining linkages between the sampled *intermittent generation* profile and the corresponding demand profile. This allows the model to capture the varying contributions of wind and solar output to total supply, which is particularly relevant at times of high demand.

Significant non-scheduled intermittent generation forecasts are based on 90% POE per facility and the (>30MW) is modelled explicitly as this generation can impact network constraints.Non significant non-scheduled intermittent generation forecasts are based on 90% POE and aggregated per region.is accounted for through adjustments to demand traces.

The *intermittent generation* forecasts are aggregated by *region* and then added to the *scheduled generation* capacity (*PASA availability* submitted by *Market Participants*) in the associated region.

2.3.1.3 MT PASA energy constraints

As part of the MT PASA process, *energy constrained Generators* submit weekly *energy* limits. The MT PASA process then allocates *energy constrained generation* according to the ratio of forecast demand to aggregated MT PASA *generation* availability.

AEMO's approach in the MT PASA timeframe is to allocate While these may represent the maximum energy available in any given week, units may not be capable of operating up to these weekly limits indefinitely. There may also be annual energy limits that are more constraining. Since the *reliability standard* is assessed annually, AEMO may also use information provided under the *GELF* or through generator surveys to -set relevant annual energy constraints for MT PASA modelling. MT PASA modelling then allocates energy constrained generation to periods where forecast demand is high with respect to available capacity. This maximises *capacity reserves* throughout the MT PASA period. AEMO assumes that this reflects a likely market outcome that appropriately minimises forecast capacity shortfalls to minimise USE over the year.

2.3.1.4 MT PASA demand

The MT PASA daily peak demand profile is a 24 month 10% POE forecast of daily *maximum demand* for each *region*. This forecast is based on the *maximum demand* forecast in the latest NEFR regional demand forecast. AEMO uses the seasonal peak demand forecasts from the NEFR, then calculates daily peak demands based on historical relationships between season peak demand and:

- Seasonal weather variations such as seasonal temperature.
- Day type profiles such as weekday, weekend, school holidays, public holidays, and daylight saving.
- Large industrial load (LIL) demand and consumption expectations.

The MT PASA solves using daily peak demands in all regions. The probability of peak demand diversity between joint regions is taken into account when developing the MRLs, i.e. MRLs are reduced by the expected ability to import surplus reserves from other regions.

[16] See AEMO AWEFS web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Solar-and-wind-energy-forecasting.

[17] ASEFS is the same AWEFS except solar irradiation is used as an input rather than wind speed.

For implementing the *reliability standard*, the forecast demand component of MT PASA is the same as used in the ESOO, with the exception that MT PASA uses "as generated" operational demand and ESOO uses "sent out" operational demand. The difference between "as generated" and "sent out" demand is the auxiliary load which is currently estimated by AEMO as part of the NEFR. AEMO will use "sent out" demand in future and calculate the auxiliary load directly within the MT PASA modelling, if more accurate information on auxiliary load as a percentage of "as generated" output is available.

AEMO converts the *energy* and *maximum demand* forecasts from the NEFR into at least five half-hourly demand profiles for each region, based on historical weather patterns. The demand profiles also incorporate NEFR assumptions on future DER such as rooftop PV, battery storage penetration and EV.

Extreme weather events are considered by using demand profiles derived from the 10% POE *maximum demand* forecasts. At a minimum, a combination of 50% POE and 10% POE demand profiles are sampled probabilistically in the Monte-Carlo simulations to develop the expected USE. At AEMO's discretion, more POE demand profiles (such as 90% POE) may be included, if USE outcomes are expected to be materially different from 50% POE outcomes.

2.3.1.5 Network constraints

~~*Capacity reserve* is assessed in accordance with the MT PASA process, which includes assumptions on reserve sharing based on interconnector capacities and constraints. The MRLs are initially calculated based on system normal pre-dispatch constraints, the same constraints that are used for ESOO.~~

~~Then MRLs are adjusted to the *interconnector* limiting *constraints* that apply in MT PASA (regional net import/export limit constraints) to more accurately reflect the reserve sharing capability of the *interconnector*. Detail on preparation of PASA network constraints can be found in the MT PASA process description available on AEMO's website.~~

MT PASA uses the latest version of ST PASA formulation constraints (see Section 2.3.2.6) as a base set, with additional customised constraints, and *network* constraints to model future (committed) *network* and generation upgrades. AEMO constructs system normal and outage constraint equations for the MT *PASA* time frame.

Information to formulate *network constraint equations* is provided to *AEMO* by Transmission Network Service Providers (TNSPs) via the Network Outage Scheduler (NOS)[18] and limit advice. Within *AEMO*'s market systems, *constraint equations* are marked as system normal if they apply for all plant in service. To model network or plant outages in the power system, separate outage *constraint equations* are formulated and applied alongside the system normal *constraint equations*.

Detailed information on *network constraints* can be found in the network constraints documents listed in section 1.2.

2.3.2 Short Term PASA (ST PASA)

AEMO implements the *reliability standard* over a six-day timeframe by providing a *capacity reserve* assessment as part of the ST PASA process. *Capacity reserves* are measured against *credible contingency events* to indicate if supply is sufficient to meet demand and thereby avoid USE. If necessary, AEMO declares a LOR in accordance with clause 4.8.4 of the NER. ~~There are~~The three levels of LOR~~ which~~ can all be found in this clause. In the ST PASA timeframe, it is not realistic to consider USE over a financial year in a six-day ST PASA timeframe. As ST PASA has access to short term weather and participant offer information, it ~~there is~~therefore has less input uncertainty than is the case for longer term forecasts such as MT PASA and ESOO. Given the proximity to operational timeframes, intervention decisions aim to minimise expected USE, with intervention being considered to address a forecast LOR2 or LOR3.

[18] http://nos.prod.nemnet.net.au/nos

A detailed description of the ST PASA process is available on AEMO's website.

2.3.2.1 ST PASA generation capacity reserve assessment

For the ST PASA six-day timeframe, AEMO assesses *capacity reserve*[19] using a deterministic reserve assessment. If the *reserve* level for any *region* is less than the LOR1 level for that region, AEMO advises the existence of LOR1 condition for that region to the market. If the *reserve* level indicates a LOR2 or LOR3 then, AEMO may take action to restore the required *reserve* capacity by implementing an *AEMO intervention event*.

2.3.2.2 ST PASA intermittent generation

AEMO uses the AWEFS and ASFES models to forecast ST PASA *intermittent generation*. The model outputs for ST PASA are a half-hourly generation contribution, based on 50% POE per facility.

The semi-scheduled *intermittent generation* forecasts are aggregated per region and then added to the scheduled *generation* capacity (participant PASA offers) of the associated region. Non-scheduled intermittent *generation* is subtracted from the associated regional demand forecast.

2.3.2.3 ST PASA scheduled generation capacity

The ST PASA draws information on scheduled *generation* from the *availability* data submitted with generators' market offers. When a *slow-start generating unit* plans to be off-line at a specific time but could operate had it received a direction 24 hours previously, the *PASA availability* of that unit will indicate what capacity AEMO can assume at that specific time.

2.3.2.4 ST PASA Demand

For the demand component, AEMO uses a 50% POE, 30 minute resolution, demand forecast[20] for each NEM region. This forecast is produced by AEMO's automated Demand Forecasting System[21] (DFS).

The main inputs to the DFS are:

- Half-hourly historical demand for NEM *regions*.
- Historical and forecast weather data.
- Non-scheduled wind generation forecasts from AWEFS.
- Non-scheduled solar generation forecasts from ASEFS.
- Calendar information such as weekday/weekend, school holidays, public holidays, and daylight savings information.

2.3.2.5 Energy constraints

As part of the ST PASA process, *energy c*onstrained generators submit daily *energy* availability forecasts. The ST PASA process then allocates this *energy* limited generation, over the forecast period, maximising *capacity reserves* throughout the PASA period.

AEMO's approach in the ST PASA timeframe is thereby to allocate *constrained generation* efficiently, usually to periods of high demand. AEMO assumes that this best reflects a likely market outcome that appropriately minimises forecast *capacity* shortfalls.

Capacity reserve is then assessed in accordance with the ST PASA process.

---

[19] See section 2.1.2 of AEMO Short Term PASA Process Description on the AEMO web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Dispatch-information/Policy-and-process-documentation.

[20] For further information about the ST PASA demand forecast see AEMO Load Forecasting procedure (SO_OP3710) on web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

[21] See Load Forecasting SO_OP3710 on web page: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

2.3.2.6 Network constraints

Capacity reserve is assessed in accordance with the ST PASA process. Even in the short ST PASA timeframe, assumptions similar to those made in the ESOO process need to be made in formulating ST PASA network constraint equations, to address uncertainty around future power system conditions. The difference between ST PASA and ESOO constraints is that ST PASA assesses half-hourly snapshots of *capacity reserves* without taking into account the previous period's dispatch. This means ST PASA cannot use certain types of data that are available to the dispatch and pre-dispatch systems, such as supervisory control and data acquisition (SCADA) terms. These terms provide previous period feedback in network constraints to reflect the real-time data collections. More detail on the preparation of PASA network constraints can be found in the ST PASA process description in section 1.2.

2.3.2.7 Extreme temperature events

Extreme ambient temperatures affect both generation availability and forecast demand in the ST PASA timeframe.

For *generation* availability, the capacity offered by *Generators* is based on a predetermined temperature. In the event of an anticipated extreme weather event, *Generators* are required to revise their availability offers, with respect to a revised forecast temperature covering the extreme weather event. The revised *generation* availability offers are then assessed in accordance with the ST PASA process.

When the forecast temperatures exceed the regional reference temperatures, *AEMO* publishes a market notice reminding *Generators* to review the *available capacities* in their *dispatch offers* consistent with the forecast extreme temperature conditions. Further details are available in the Short Term Reserve Assessment operating procedure in section 1.2.

For demand, the AEMO DFS is periodically updated with forecast weather over the six-day forecast. Therefore extreme temperature events are automatically incorporated into the DFS as the event moves into the six-day forecast timeframe.

2.4 Summary of assumptions

Table 3 Summary of assumptions

	ESOO	*EAAP*	MT PASA	ST PASA
How is reliability standard implemented?	Directly assess USE expectations based on probabilistic modelling.	Directly assess USE expectations based on probabilistic modelling.	~~Calculate minimum reserve levels to approximate the point at which USE would exceed 0.002%. Assess whether capacity less MRL exceeds demand across assessment period.~~Directly assess USE expectations based on probabilistic modelling.	Is any region in LOR 2 or LOR3?
Demand	Sampling 10% POE and 50% POE hourly profiles based on NEFR and historical weather patterns.	10% POE and 50% POE hourly profiles based on NEFR and historical weather patterns.	Sampling at least 10% POE ~~daily peak load~~and 50% POE half-hourly profiles based on NEFR and ~~past trends, day type and special events~~historical weather patterns.	50% POE half hour demand based on expected weather trends.
Intermittent generation	Sampling hourly profiles based on ~~historical data~~historic weather patterns.	~~Hourly, 90% POE~~Sampling hourly profiles based on ~~AWEFS and ASEFS.~~historic weather patterns	~~Daily, 90% POE~~Sampling half-hourly profiles based on ~~AWEFS and ASEFS~~historic weather patterns.	Half-hourly, 50% POE based on AWEFS and ASEFS.
Scheduled generation capacity and outages	Annual survey	MT PASA offers.	MT PASA offers.	Available capacity – PASA availability.
Energy constraints	Monthly inflow of water assumed for hydro plants based on historical observations.	Provided through *GELF*.	Weekly energy constraints submitted by participants. *GELF* information may also be used where appropriate to assist in modelling annual energy constraints.	Daily energy constraints are considered.
Extreme weather events	Use of both 10% POE and 50% POE.	Scenarios defined in the *EAAP guidelines*.	~~Use 10% POE demand and 90% POE contribution from intermittent generation. Scheduled generation is also considered available at 10% POE ambient conditions.~~Use of both 10% POE and 50% POE.	50% POE.
Network constraints	System normal ~~pre-dispatch~~ST PASA type constraints, supplemented with customised constraints where appropriate.	System normal constraints.	~~MT~~System normal ST PASA type constraints ~~and~~, supplemented with customised constraints where appropriate. Planned outage ~~information~~constraints derived from the Network Outage Schedule information.	ST PASA type constraints and outage information from the Network Outage Schedule.

GLOSSARY

a) In this document, a word or phrase *in this style* has the same meaning as given to that term in the National Electricity Rules.

b) In this document, capitalised words or phrases or acronyms have the meaning set out opposite those words, phrases, or acronyms in the table below.

c) Unless the context otherwise requires, this document will be interpreted in accordance with Schedule 2 of the *National Electricity Law*.

Table 4 Glossary

Term	Definition
AEMO	Australian Energy Market Operator
ASEFS	Australian Solar Energy Forecasting System
AWEFS	Australian Wind Energy Forecasting System
DER	Distributed Energy Resources
DFS	Demand Forecasting System
EAAP	*Energy adequacy assessment projection*
ESOO	Electricity *statement of opportunities*
EV	Electric Vehicles
GELF	*Generator Energy Limitation Framework*
GWh	Gigawatt hours (energy)
LOR	*Lack of reserve*
LRC	*Low reserve* condition
MT PASA	*Medium term PASA*
MW	Megawatt
NEFR	National Electricity Forecasting Report
NEM	National Electricity Market
NER	National Electricity Rules
NTNDP	National Transmission Network Development Plan
NSCAS	Network Support and Control Ancillary Services
PASA	*Projected assessment of system adequacy process*
POE	Probability of Exceedance
RERT	*Reliability and emergency reserve trader*
RSIG	*Reliability standard implementation guidelines*
ST PASA	*Short term PASA*
USE	*Unserved energy*