RELIABILITY STANDARD IMPLEMENTATION GUIDELINES

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VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
1.0	18 December 2015	Initial version following consultation.
1.3	10 October 2016	Update RSIG in accordance with Schedule 2 of the National Electricity Amendment (Energy Adequacy Assessment Projection timeframes) Rule 2016 No. 3.
1.4	[TBA]	Changes related to MT PASA – Reliability Assessment Methodology following the recommended solution proposed by Ernst & Young (EY) and suggested by consulted persons during the RSIG consultation. Updated *intermittent generation* and *network constraint* approach used in ESOO.
2.0	[TBA]	Update RSIG to be consistent with Rules clause 4.8.4A and new format

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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   Definitions and interpretation

1.2.1   Glossary

The words, phrases and abbreviations in the table below have the meanings set out opposite them when used in these Procedures.

Terms defined in the National Electricity Law and the NER have the same meanings in these Procedures unless otherwise specified in this clause.

Defined terms/Terms defined in the NER are intended to be identified in these Procedures by italicising them, but failure to italicise a defined term does not affect its meaning.

Table 1   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

Term	Definition
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*

1.2.2 Interpretation

The following principles of interpretation apply to these Procedures unless otherwise expressly indicated:

(a) These Procedures are subject to the principles of interpretation set out in Schedule 2 of the National Electricity Law.

(b) References to time are references to Australian Eastern Standard Time.

1.3 Related documents

Table 2 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
LOR Declarations	Reserve Level Declaration Guidelines	https://www.aemo.com.au/Stakeholder-Consultation/Consultations/Consultation-on-initial-version-of-Reserve-Level-Declaration-Guidelines

Reference	Title	Location
MT PASA	MT PASA Process Description	https://www.aemo.com.au/-/media/Files/Electricity/NEM/Data/MMS/2016/MT_PASA_Process_Description.pdf
Network constraints	*Constraint* Implementation Guidelines	http://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/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/*Constraint*_Formulation_Guidelines_v10_1.pdf
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

1.4   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 *unserved energy* associated with *power system* security incidents that result from *multiple contingencies, protected events* or *non-credible contingency 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:

(a)   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.

(b)   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.

(c)   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.

(d) 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.

(e) 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 when AEMO determines in accordance with the *reserve level declaration guidelines* that the probability of *load shedding* (other than the reduction or disconnection of *interruptible load*) is, or is forecast to be, more than remote.

1.5   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 any foreseeable circumstances that may require AEMO to implement an *AEMO intervention event*.

The aim of implementing an *AEMO intervention event* is to maintain the reliability of supply and *power system security* where practicable, when a *low reserve* or *lack of reserve* condition exists. *AEMO intervention events* 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 1.3.

2   RELIABILITY STANDARD IMPLEMENTATION PROCESSES

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

(a) 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*.

(b) *Energy Adequacy Assessment Projection* (*EAAP*) to forecast USE for *energy* constrained scenarios over a two-year projection.

(c) Medium Term Projected Assessment of System Adequacy (MT PASA) to forecast USE over a two-year projection.

(d) Short Term Projected Assessment of System Adequacy (ST PASA) to forecast *capacity reserve* over a six-day projection.

As noted above, AEMO runs two processes to implement the *reliability standard* over a two year period: EAAP and MT PASA. The main difference between EAAP and MT PASA is that the EAAP is assessed under a range of predefined energy scenarios and is published at least once every 12 months, whereas the MT PASA is based on participants' best expectation of *generation* availability and is published on a weekly basis.

Detailed information about each process and methodologies applied can be found on AEMO's website (links as listed in Section 1.3).

This section of the Guidelines describes how each process evaluates key components that contribute to AEMO's forecast of reliability. Different assumptions used under the various processes reflect the study 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 3   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 or direction	Forecast USE>0.002% in any forecast year
MT PASA	2 year/Weekly	USE	Inform	4.8.9 instruction, RERT or direction	Forecast USE>0.002% in any forecast year
ST PASA	6 day/2 hours	Capacity	Inform	4.8.9 instruction, RERT or direction	LOR2 or LOR3

2.1   Electricity Statement of Opportunities

AEMO is required to publish an ESOO annually under clause 3.13.3(q) of the NER. The ESOO provides information that 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 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 further action to ensure a response to any potential breaches of the *reliability standard* identified in the ESOO.[3] The purpose of the ESOO is to provide technical and market data that informs the decision-making processes of *Market Participants*, new investors and jurisdictional bodies as they assess opportunities in the NEM over a 10-year period.

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 1.3.

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

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 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 linked to the 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.

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

Extreme weather events are considered by using demand profiles derived from the 10% probability of exceedance[7] (10% POE) maximum demand forecasts. At a minimum, a combination of 50% POE and 10% POE demand profiles from at least five historical reference years 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.

2.1.5 Network constraints

AEMO continues to update and refine *network constraints* through its modelling projects during the year. ESOO uses the latest version of ST PASA formulation *constraints* as a base set, with additional customised *constraints*, and *network constraints* to model future *network* and *generation* upgrades.

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[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.

[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.

Given the ten-year outlook period, ESOO *constraint* equations need to make assumptions on the future 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

2.2 Energy Adequacy Assessment Projection

The EAAP implements the *reliability standard* over a two-year timeframe. 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 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 1.3.

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.

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

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

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 *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 as ST PASA, see section 1.3. 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*.

- 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.

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 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.

Separate reserve assessments are applied for MT PASA and ST PASA processes. MT PASA identifies LRC while ST PASA identifies LOR[9] conditions based on determined *capacity reserve* levels.

AEMO's response to 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:

(a) Notifications to the market via reports, data, or market notices.

(b) Intervening in the market via *directions*[10] under NER clause 4.8.9.

(c) Intervening in the market by *dispatching*[11] contracted *reserve*.[12]

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[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 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.

[11] 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.

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

AEMO assumes that if a period of LRC or LOR is identified, 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 an estimate of expected annual USE as part of the MT PASA process, which is run at least weekly.

MT PASA 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'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 *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 1.3.

2.3.1.1 MT PASA generation capacity

AEMO 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.[13,14] 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 2.3.1.1).
- Committed *generation* development 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 MT PASA modelling. The probability of forced outages is based on historical performance or expert advice where historical performance is not available.

2.3.1.2 MT PASA intermittent generation

Modelling of *intermittent generation* is consistent with the 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

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

[14] 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.

contributions of wind and solar output to total supply, which is particularly relevant at times of high demand.

Significant *non-scheduled intermittent generation* (>30MW) is modelled explicitly as this *generation* can impact *network constraints*. Non significant *non-scheduled intermittent generation* is accounted for through adjustments to demand traces.

2.3.1.3 MT PASA energy constraints

As part of the MT PASA process, *energy constrained Generators* submit weekly *energy* limits. 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 to minimise USE over the year.

2.3.1.4 MT PASA demand

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. AEMO will continue to report demand "as generated" for easy comparison against *generation* availability, and will calculate the auxiliary load within the MT PASA model as a function of *generation* dispatch. AEMO will use the best quality consultant and stakeholder information that can be accessed to forecast the auxiliary load

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

MT PASA uses the latest version of ST PASA formulation *constraints* (see Section 1.3) 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)[15] 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 1.3.

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. Available *capacity reserves* are assessed

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

taking into account *credible contingency events* and estimated forecasting errors for the *available capacity of scheduled generating units*, the *unconstrained intermittent generation forecast* and Operational Demand, 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. The three levels of LOR are defined in the *reserve level declaration guidelines* which are developed according to the process established under clause 4.8.4A of the NER . 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 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.

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*[16] 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, 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 Australian Wind Energy Forecasting System (AWEFS) and Australian Solar Energy Forecasting System (ASEFS) 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[17] for each NEM *region*. This forecast is produced by AEMO's automated Demand Forecasting System[18] (DFS).

The main inputs to the DFS are:

(a) Half-hourly historical demand for NEM *regions*.

(b) Historical and forecast weather data.

(c) *Non-scheduled* wind *generation* forecasts from AWEFS.

(d) *Non-scheduled* solar *generation* forecasts from ASEFS.

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[16] 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.

[17] 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.

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

(e)   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* constrained 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.

2.3.2.6   Network constraints

Capacity reserve is assessed in accordance with the ST PASA process. Even in the 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 1.3.

2.3.2.7   Extreme temperature events

Extreme ambient temperatures affect *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 forecast temperatures exceed *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 1.3.

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 4   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.	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 and 50% POE half-hourly profiles based on NEFR and historical weather patterns.	50% POE half hour demand based on expected weather trends.
Intermittent generation	Sampling hourly profiles based on historic weather patterns.	Sampling hourly profiles based on historic weather patterns	Sampling half-hourly profiles based on 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. Monthly inflow of water assumed for hydro plants based on historical observations. *GELF* information or additional voluntary information provided by participants 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 of both 10% POE and 50% POE.	50% POE.
Network constraints	System normal ST PASA type *constraints*, supplemented with customised *constraints* where appropriate.	System normal *constraints*.	System normal ST PASA type *constraints*, supplemented with customised *constraints* where appropriate. Planned outage *constraints* derived from the Network Outage Schedule information.	ST PASA type *constraints* and outage information from the Network Outage Schedule.