GUIDEBOOK FOR FORCED OUTAGE DATA RECORDING:
DEFINITIONS AND ASSUMPTIONS

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PART 1: DATA COLLECTION REQUIREMENTS FOR GENERATORS

1. Introduction

This guidebook has been developed by the Forced Outage Data Working Group (FODWG) to assist generators in the provision of forced outage data to AEMO. It provides an outline of:

- AEMO’s requirements regarding the collection of generator forced outage data;
- AEMO’s data collection process; and
- the definitions assumed by AEMO.

Appendix 4 provides a number of detailed examples to clarify the intent of the definitions. Examples are also provided to distinguish between recommended practices for different plant types, based on fuel source or market activity. The concepts canvassed in this document are not exhaustive for all occurrences of generator forced outages. The FODWG and AEMO are interested to learn about actual outage incidents, which can be incorporated into Appendix 4 of this document. Any information provided to AEMO will be considered by the working group when updating this guidebook. Those who wish to contribute examples of actual outage incidents can contact Andrew Robertson of AEMO at (03) 9648 8796.

This document is broadly consistent with the IEEE standards for the reporting of generator performance, “IEEE Standard Definitions for use in reporting Electric Generating Unit Reliability, Availability and Productivity”. Any departure from the IEEE standards is identified in this document.

2. Application of Generator Forced Outage Data to NEM Processes

Forced Outage Rates (FOR) are a significant input into market simulations conducted for reliability assessment and other longer term planning studies. In previous NEMMCO (now part of AEMO) reliability assessments, FORs have been highlighted as the most significant factor in the determination of regional minimum reserve levels. In general terms, high generator forced outage rates can cause higher levels of unserved energy within regions. This leads to a higher minimum reserve level requirement to ensure that the unserved energy does not exceed the Reliability Standard.

Generator forced outage data is currently collected by AEMO for use in market simulations related to periodic reliability assessments and the National Transmission Network Development Plan (NTNDP). Market simulations conducted for the purpose of assessing NEM reliability encompass minimum reserve level assessments and reserve assessments for the reliability safety net process. The results from NTNDP market simulations provide a forecast of network adequacy to identify potential opportunities for augmentations to National Transmission Flow Paths.
Jurisdictional Planning Bodies may also conduct market simulations, often as part of their Annual Planning Reviews and when justifying augmentations of the market benefits limb of the regulatory test. It is AEMO’s aim to:

- make generators aware of the importance of forced outage data and its role in determining minimum reserve levels;
- streamline the collection of forced outage data and ensure generators are reporting such information on a consistent basis;
- ensure that all parties are using consistent data, for example government and industry bodies; and
- ensure this data accurately models the reliability of generators in the NEM.

3. **AEMO’s Data Collection Process**

3.1 **Determining the Appropriate Contact**

Each year AEMO conducts a review of the list of contacts for the FOR data collection process to ensure the most appropriate person(s) receives the request for forced outage rate data.

3.2 **Formal Request**

A formal letter of request for FOR data is emailed by AEMO to each of the generator contacts. AEMO requests the data to be returned within 4 weeks.

3.3 **Specification of Data to be Collected**

This Guidebook and a Microsoft Excel spreadsheet template form, which specifies the data to be provided, accompany the data request. Definitions for the data types that AEMO requests may be found in Appendix 1 of this Guidebook. Data is collected on an annual basis. In most cases, AEMO only requires that generators provide forced outage data for the most recent year. AEMO then appends this data to the previous years’ data collected for the relevant generating unit.

AEMO requests that information be provided on a per unit basis as historical information indicates that seemingly identical units can have significant differences in their performance.

3.4 **Timeline for Data Collection Process**

<table>
<thead>
<tr>
<th>Activities</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update contacts list</td>
<td>Late August</td>
</tr>
<tr>
<td>Send out formal request electronically</td>
<td>Early September</td>
</tr>
</tbody>
</table>
4. Descriptions of Forced, Maintenance and Planned Outages

The following descriptions should be read in conjunction with the definition list in Appendix 1. They are intended to assist in the interpretation of the definitions by understanding their context and intent. To the extent that a description contradicts a definition, the definition should be followed.

The descriptions and definitions relate only to the confidential collection of outage statistics by AEMO for the purposes of reliability and NTNDP modelling. AEMO requires historical data from generators on a consistent basis across the NEM. Note the definitions in Appendix 1 are similar, but not identical to other outage statistical standards, e.g. IEEE, former ESAA, former ETSA, former Pacific Power etc.

4.1 Forced Outages

Forced outages are not planned or maintenance outages. In principle, “forced outages” represent the risk that a unit’s capacity will be affected by limitations beyond a generator’s control. An outage (including full outage, partial outage or a failed start) is considered “forced” if the outage cannot reasonably be delayed beyond 48 hours. Note: Some generators use the threshold “beyond the next weekend”. However, AEMO requires a 48-hour threshold for its forced outage data collection as this is considered a reasonable period for which a heat wave may be present, usually requiring additional capacity online. For low utilisation units (for example, peaking gas turbines) or units in the Available But Not Committed State, forced outages may be deliberately extended for market/commercial reasons and the “time to repair” adjusted so that units “mean time to repair” for “peak demand” is not overestimated.

4.1.1 Timing/Duration

- An outage is “forced” if it could not have been delayed by 48 hours from identification of the problem had there been a strong commercial desire to do so.

- For low utilisation units or units in the Available, but not committed state an outage should be recorded as “forced” only for the minimum reasonable period of repair, i.e. if the outage duration could have been reduced in the presence of a strong commercial driver, only the estimated shorter duration should be recorded.
• The balance of the outage would be of a maintenance type.

• Generators may choose to not record very short-term or transient outages of less than 30 minutes.

• Start-up failure is a separate category of failure and is most relevant when modelling fast start/lower utilisation plant performance. For high utilisation plant (ie base load) this classification is not as relevant and may be captured in full forced outage data.

4.1.2 5% of Winter Capacity Threshold for Partial Forced Outages

Some of the definitions in Appendix 1 state a 5% of Winter Capacity threshold for the reporting of partial forced outages. This should be interpreted as the maximum tolerance permitted for reporting of partial outage data. While it is desirable that all data on partial forced outages be collected, generators may choose not to report partial outages of less than 5% of the units Winter Capacity.

4.1.3 Cause

AEMO only requires generating companies to provide data on forced outages caused by factors within the power station or through its inputs, e.g. fuel supply. Forced outages caused by factors outside of a power station that units would normally not be expected to ride through based on their performance standards, e.g. fault deep in the transmission system, will be collected separately.

Forced outages caused by a station specific problem include:

• Any failure of mechanical, fuel handling, controls or electrical equipment within the generator’s ownership or direct responsibility;
  – i.e. From the point the generator is responsible for the fuel through to the electrical connection point;

• A failure of a mine or fuel transport system dedicated to that power station with a resulting fuel shortage that results in a reduction in output;
  – This may not apply where generation is reduced to prolong the existing fuel storage at the power station;
  – Limits caused by hydrological storage levels will be handled separately by AEMO. Reductions in plant capacity due to lower head heights should not be reported as partial outages;

• Inadvertent or operator error;
  – These may fall below the minimum recording time threshold of 30 minutes;

• Limitations caused by fuel quality that cannot be avoided even if there was a strong commercial desire to do so;
– This may not apply to limits intended to reduce rate of boiler fouling that could be tolerated for a brief period;
– This may not apply if an extra coal mill could be brought into service during periods of high demand;

• Outages caused initially by a network disturbance where the generator could be reasonably expected to remain in service as specified by National Electricity Rules (NER) or its connection agreement;
• Limitations caused by environmental or safety restrictions that cannot be legally exceeded even for a short period;

For the purposes of AEMO modelling forced outages should exclude:

• Outages caused by a failure of network equipment not owned or controlled by the power station, even if dedicated to that power station (e.g. network connection equipment beyond the connection point). AEMO will receive this information from the Network Service Provider (NSP);
• Outages caused directly or indirectly by industrial action\(^1\);
• Outages caused initially by a network disturbance beyond the thresholds that the generator is expected to ride through;
• Outages caused by general (non-connection) network congestion, fault levels etc;
• Outages caused by a general fuel supply shortfall, e.g. gas curtailment\(^2\);
• Capacity limitations caused by adverse ambient conditions (these are collected elsewhere by AEMO modelling).

4.2 Planned Outages

A planned outage (full or partial) is an outage that has been anticipated well in advance, even if the timing plan has changed. E.g., outages that have been planned well in advance and listed in AEMO’s Medium term Projected Assessment of System Adequacy\(^3\) (MT PASA)

\(^1\) The definition presumes a degree of political/emergency powers discretion over industrial action.

\(^2\) The exclusion of gas curtailment presumes a degree of political/emergency discretion over the allocation of fuel during a supply shortfall-which is generally true.

\(^3\) A comprehensive programme of information collection, analysis and disclosure of medium-term, power system reliability prospects. This assessment, which covers a period of 24 months, must be issued weekly by AEMO and enables market participants to make decisions concerning supply, demand and outages.
or incorporate planning documentation. Planned Outages are not forced or maintenance outages.

AEMO does not require data on maintenance or planned outages to be provided, but a description of a planned outage is included to assist understanding of outages that are not defined as forced.

4.3 Maintenance Outages

Maintenance Outages are not forced or planned outages. A maintenance outage refers to an outage that has not been anticipated well in advance, but could have been deferred or the unit being maintained recalled had there been a commercial driver to do so.

Maintenance outages may include:

- A tube leak repair that has been undertaken immediately despite being assessed as deferrable for 48 hours;
- Extra time taken to repair a forced outage as there was no commercial driver to repair immediately.

5. Prioritisation of Data

A prioritisation of data items for each type of generating plant has been provided below. The table indicates the importance of collecting data for each type of plant from the various operational states listed.

<table>
<thead>
<tr>
<th>TYPE OF PLANT</th>
<th>COMMITTED(^4) DATA</th>
<th>AVAILABLE, BUT NOT COMMITTED DATA</th>
<th>FAILED STARTS(^5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Load Plant</td>
<td>H</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Intermediate – Non Hydro</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Intermediate Hydro</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Peaking Plant</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

Level of importance: H = High; M = Medium; L = Low

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\(^4\) Please refer to Appendix 1 for a definition of Committed.

\(^5\) Failed Start is not considered an operational state. However, information on failed starts is particularly important for some type of plant such as Peaking Plant.
Note: It is expected that some of this data, such as failed start data, may not be available for small hydro or range units. Whilst the impact of this data may be significant for the larger units it may not be considered to be critical for smaller units (ie < 20MW). However, generators should endeavour to provide as much forced outage information about the plant as possible to ensure accurate modelling of plant reliability.
PART 2: EQUATIONS USED BY AEMO

6. Equations

6.1 Equations Used to Model Forced Outages in Market Simulations

AEMO currently uses a market simulation tool called Prophet (Intelligent Energy Systems) for NTNDP and other market simulation related work. The inputs to Prophet to describe the availability of plant are based on a state transition model and are not entered as a forced outage rate. Instead the user specifies the mean time to transition from one state to another where the various states are defined as “Available”, “UnAvailable” and “PartiallyAvailable”. AEMO performs a number of simple calculations to determine the mean time between transitions for each unit to be entered into the Prophet state transition model. These calculations are performed on the forced outage history provided by the generators to AEMO on an annual basis.

The following equations have been provided to illustrate how AEMO determines the mean time between transitions entered into Prophet from the raw data provided by the generators.

Six types of transitions from one state to another are feasible;

1. Available to UnAvailable
2. Available to PartiallyAvailable
3. UnAvailable to PartiallyAvailable
4. UnAvailable to Available
5. PartiallyAvailable to Available
6. PartiallyAvailable to UnAvailable

AEMO calculates the mean time to transition from one state to another as follows;

1. Available to UnAvailable
   \[ \frac{\text{Running Hours for Fully Available}}{\text{No. Transitions from Available to UnAvailable}} \]

2. Available to PartiallyAvailable
   \[ \frac{\text{Running Hours for Fully Available}}{\text{No. Transitions from Available to PartiallyAvailable}} \]

3. UnAvailable to PartiallyAvailable
   \[ \frac{\text{Total Time in UnAvailable state}}{\text{No. Transitions from UnAvailable to PartiallyAvailable}} \]

4. UnAvailable to Available
   \[ \frac{\text{Total Time in UnAvailable state}}{\text{No. Transitions from UnAvailable to Available}} \]

5. PartiallyAvailable to Available

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6. Partially Available to UnAvailable

\[
\text{Mean Derating} = \frac{\text{Total energy lost due to partial outages from Committed state}}{\text{No. Hours in partial outage state} \times \text{Gross Maximum Capacity}}
\]

The value calculated for the Mean Derating for each unit is applied each time the unit suffers a partial outage in simulations from the Committed state. This approach is intended to model the long term average energy lost for each unit due to partial outages while Committed. AEMO has considered modelling a number of different levels of derating for each unit although this significantly increases the level of modelling complexity. It is thought that a single derating provides a reasonable indication of energy lost.

6.2 IEEE Definition

For reporting purposes AEMO publishes the mean time to transitions and IEEE based calculations when describing plant availability. The IEEE equations are listed below. AEMO recognises the commercially sensitive nature of plant availability data and does not publish individual unit statistics. Instead AEMO aggregates plant outage statistics by region and plant to preserve confidentiality. Forced Outage Rate:

\[
\text{FOR} = \frac{\text{FOH}}{\text{FOH} + \text{SH}} \times 100
\]

Where,

\[
\text{FOH} = \text{Forced Outage Hours} \\
\text{SH} = \text{Service Hours}
\]

Equivalent Forced Outage Rate:

\[
\text{EFOR} = \frac{\text{FOH} + \text{EFDH}}{\text{FOH} + \text{SH} + \text{ERSFDH}} \times 100
\]
Where,

\[ EFDH = \text{Equivalent Forced Derated Hours} \]
\[ = \sum (\text{derated hours in service} \times \text{MW loss}) \]
\[ \frac{\text{GMC}^6}{\text{GMC}} \]

\[ ERSFDH = \sum (\text{derated hours in reserve shutdown} \times \text{MW loss}) \]
\[ \frac{\text{GMC}}{\text{GMC}} \]

Note 1: Appendix 2 provides a comparison between AEMO and IEEE definitions.

Note 2: Whilst AEMO calculates and publishes aggregate statistics based on the IEEE definitions above; there are subtle differences between the IEEE and AEMO definitions used when collecting the forced outage rate data. As a result there is potential for small deviations from the actual IEEE values.

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\(^6\) When calculating IEEE based values AEMO uses the Winter Capacity of the unit (WC) in place of the Gross Maximum Capacity (GMC)
APPENDIX 1 – DEFINITIONS OF TERMS

This section provides the definitions applicable to the data required by AEMO. AEMO recognises that some organisations may wish to collect data that provides Forced Outage Rate statistics that are internationally comparable. To assist this process, Appendix 2 shows a comparison between the terms used by AEMO and those contained in the IEEE Standard. The appendix also identifies where the definitions used by AEMO differ from those used by the IEEE.

Examples of how these definitions should be interpreted for different plant types are provided in Appendix 4.

1. States

**Committed State (CS)**

When the unit is electrically connected and generating or pumping. Note: A unit is not considered to be in the Committed State if it is in synchronous condenser mode.

**Available, But Not Committed State**

The unit is available for dispatch as a generator or pump, but is not electrically connected and is not in the Committed State (that is, it is not running).

**Committed Hours (CH)**

Number of hours the unit was in the Committed State.

Note: Do not include hours in service as a synchronous condenser. It is assumed that a machine’s failure rate in synchronous condenser mode is lower due to less mechanical stress. Therefore including data specific to this mode in the calculations may give optimistic outcomes.

2. Capacities

**Winter Capacity (WC)**

The maximum capacity of a unit assuming winter ambient temperature conditions. This should be reported on a “generator terminal” basis.

**Unit Derating**

The magnitude (MW) of a temporary reduction in the capacity of a unit with respect to its Winter Capacity (WC).

Note1: For the purpose of Forced Outage Reporting a Unit Derating should not include a temporary reduction in the capacity of a unit due to ambient temperature limitations.

**Material Derating**

Unit Derating of 5% or more of the unit’s Winter Capacity (WC).
3. Full Forced Outages

**Full Forced Outage Committed State [FFO (Committed State)]**

An outage of a unit which cannot reasonably be delayed beyond 48 hours following identification of the problem, which results in the unit being removed from the Committed State.

**Full Forced Outage Available, But Not Committed State [FFO (Available, But Not Committed State)]**

An outage of a unit which cannot reasonably be delayed beyond 48 hours following identification of the problem, which results in the unit being removed from the Available, But Not Committed State.

**Full Forced Outage Hours Committed State [FFOH (Committed State)]**

The number of hours of Full Forced Outage from the Committed State (CS).

*Note1: Do not include Full Forced Outage hours due to failed starts as a Full Forced Outage from the Committed State.*

*Note2: For low utilisation units (for example, peaking gas turbines) or units in the Available, But Not Committed State, forced outages may be deliberately extended for market/commercial reasons. This can give rise to significant forced outage hours when in fact no effort was made to repair the unit. In such instances the forced outage hours may be time adjusted so that units’ time to repair” for peak demand periods is not overestimated.*

**Full Forced Outage Hours Available, But Not Committed State [FFOH (Available, But Not Committed State)]**

The number of hours of Full Forced Outage from the Available, But Not Committed State.

4. Partial Forced Outages

**Partial Forced Outage Committed State [PFO (Committed State)]**

Unit Derating caused by failure of a component of a unit when in the Committed State, which cannot reasonably be delayed beyond 48 hours following identification of the problem.

*Note1: Generators may choose not to report Partial Forced Outages for Unit Deratings less than the Material Derating of the unit.*

*Note2: Please refer to Appendix 5 when reporting the number of Partial Forced Outages from the Committed State.*

*Note3: Seasonal deratings due to ambient temperature limitations and hydrological conditions such as low head heights should not be reported as partial forced outages.*
Partial Forced Outage Available, But Not Committed State [PFO (Available, But Not Committed State)]

Unit Derating caused by failure of a component of a unit when in the Available, But Not Committed State, which cannot reasonably be delayed beyond 48 hours following identification of the problem.

See Note1 and Note3 for 1.11 above.

Partial Forced Outage Hours Committed State [PFOH (Committed State)]

The number of hours of Partial Forced Outage from the Committed State.

Partial Forced Outage Hours Available, But Not Committed State [PFOH (Available, But Not Committed State)]

The number of hours of Partial Forced Outage from the Available, But Not Committed State.

Forced Derated Generation Committed State

The generation (MWh) that was not available as a result of a Forced Unit Derating from the Committed State.

Note1: Generators may choose not to report Forced Derated Generation for Unit Deratings less than the Material Derating of the unit.

Note2: Energy lost due to seasonal deratings should not be included as Forced Derated Generation.

Note3: Energy lost due to reductions in plant capacity as a result of hydrological limitations (low head heights etc) should not be included as Forced Derated Generation.

Forced Derated Generation Available, But Not Committed State

The generation (MWh) that was not available as a result of a Forced Unit Derating from the Available, But Not Committed State.

See Note1 to Note3 for 1.15 above.

5. Failed Starts

Failed Start

An attempt to start a unit, which required termination of the unit run-up sequence prior to being electrically connected due to abnormal condition.

Note1: Repeated starting failures without accomplishing corrective repairs are counted as a single Failed Start.

Note2: A generator may choose to ignore reporting a Failed Start if the unit is successfully electrically connected within 30 minutes of the initial attempt to start.
Note3: Failed Start data for Baseload plant that does not typically commit in response to price signals (as it is already committed) is low priority. Generators of this type may include any Failed Starts as Full Forced Outages.

**Failed Start Hours**

The number of hours of Full Forced Outage due to a Failed Start.

**Starting Attempt**

An attempt to bring a unit into the Committed State.

Note1: Repeated initiations of the starting sequence without accomplishing corrective repairs are counted as a single Starting Attempt.
## APPENDIX 2 – COMPARISON OF AEMO AND IEEE TERMS

<table>
<thead>
<tr>
<th>AEMO TERM</th>
<th>IEEE TERM</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Committed State (CS)</td>
<td>In Service</td>
<td>In the IEEE standard, generation in the in-service state is taken to be the actual capacity (or energy) generated. This is equivalent to what AEMO refers to as committed generation capacity (or energy).</td>
</tr>
<tr>
<td>Available, But Not Committed State</td>
<td>Reserve Shutdown</td>
<td></td>
</tr>
<tr>
<td>Committed Hours (CH)</td>
<td>Service Hours (SH)</td>
<td>Service hours should be treated strictly as the number of hours the unit was electrically connected and generating or pumping.</td>
</tr>
<tr>
<td>Winter Capacity (WC)</td>
<td>Dependable Capacity</td>
<td>In the IEEE standard, the Dependable Capacity changes according to seasonal variations. To avoid confusion only the winter capacity should be used.</td>
</tr>
<tr>
<td>Winter Capacity (WC)</td>
<td>referred to as Gross Maximum Capacity (GMC)</td>
<td></td>
</tr>
<tr>
<td>Unit Derating</td>
<td>Unit Derating</td>
<td>In the IEEE standard a Unit Derating is the difference between the Dependable Capacity and the Available Capacity, where the Dependable Capacity is modified for ambient limitations. AEMO refers to a Unit Derating as the magnitude (MW) of a temporary reduction in the unit's capacity due to component failure only. The magnitude of the Unit Derating is always reported relative to the Unit’s Winter Capacity (WC)</td>
</tr>
<tr>
<td>Material Derating</td>
<td></td>
<td>The IEEE standard does not provide for the application of any derating thresholds.</td>
</tr>
<tr>
<td>Full Forced Outage Committed State [FFO (Committed State)]</td>
<td>Unplanned Outage</td>
<td>In the IEEE standard, Full Forced Outages are separated into various classes of “Unplanned Outage”, depending on what time frame they need to occur within.</td>
</tr>
<tr>
<td></td>
<td>Class 1 – 3 (From In Service State)</td>
<td></td>
</tr>
<tr>
<td>AEMO TERM</td>
<td>IEEE TERM</td>
<td>NOTES</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>-------</td>
</tr>
<tr>
<td>AEMO only considers class 1-3 in reporting Full Forced Outages. Class 1 – Requires immediate removal from service Class 2 – Does not require immediate removal from service, but requires removal within 6 hours Class 3 – Can be postponed beyond 6 hours, but requires that a unit be removed from the In Service state before the end of the next weekend. Class 2 and 3 outages can only be applied from the In Service, or Committed State (CS). In the NEM a Full Forced Outage Committed State [FFO (Committed State)] is any outage of a unit which cannot reasonably be delayed beyond 48 hours following identification of the problem, which results in the unit being removed from the Committed State. Forced Outages from the Reserve Shutdown state should be reported as Full Forced Outages Available, But Not Committed State [FFO (Available But Not Committed State)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Forced Outage Available, But Not Committed State [FFO (Available But Not Committed State)]</td>
<td>Unplanned Outage Class 1 (From Reserve Shutdown State)</td>
<td>See notes above for Full Forced Outage Committed State [FFO (Committed State)]</td>
</tr>
<tr>
<td>Full Forced Outage Hours Committed State [FFOH (Committed State)]</td>
<td>Forced Outage Hours (FOH) Class 1 – 3 (From In Service State)</td>
<td>In the IEEE standard the Forced Outage Hours (FOH) is the number of hours a unit was in a Class 0-3 unplanned outage state from either the In Service or Reserve Shutdown State. Class 0 refers to the Forced Outage Hours that result from an unsuccessful attempt to bring a unit into the In Service State (Failed Start).</td>
</tr>
<tr>
<td>AEMO TERM</td>
<td>IEEE TERM</td>
<td>NOTES</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the NEM Full Forced Outage Hours Committed State [FFOH (Committed State)] should include only those forced outage hours that occurred when the unit was in the Committed State and should not include Forced Outage Hours due to Failed Starts. Forced Outage Hours due to failed starts are reported separately as Failed Start Hours. Forced Outage Hours that occur from the Reserve Shutdown State should be reported as Full Forced Outage Hours Available, But Not Committed State [FFO (Available But Not Committed State)].</td>
</tr>
<tr>
<td>Full Forced Outage Hours Available, But Not Committed State [FFOH (Available But Not Committed State)]</td>
<td>Forced Outage Hours (FOH) Class 1 (From Reserve Shutdown State)</td>
<td>See notes above for Full Forced Outage Hours Committed State [FFOH (Committed State)]</td>
</tr>
<tr>
<td>Partial Forced Outage Committed State [PFO (Committed State)]</td>
<td>Unplanned Derating Class 1 – 3 (From In Service State)</td>
<td>In the IEEE standard, Partial Forced Outages are separated into various classes of “Unplanned Derating”, depending on what time frame they need to occur within. AEMO only considers class 1-3 in reporting Partial Forced Outages. Class 1 – Requires immediate reduction of capacity Class 2 – Does not require immediate reduction of capacity, but requires a reduction of capacity within 6 hours Class 3 – Can be postponed beyond 6 hours, but requires a reduction of capacity before the end of the next weekend. In the NEM a Partial Forced Outage Committed State [PFO (Committed State)] is any Unit Derating caused by failure of a component of a unit when in the Committed State, which cannot reasonably be...</td>
</tr>
<tr>
<td>AEMO TERM</td>
<td>IEEE TERM</td>
<td>NOTES</td>
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<tr>
<td>Partial Forced Outage Available, But Not Committed State [PFO (Available But Not Committed State)]</td>
<td>Unplanned Derating Class 1 – 3 (From Reserve Shutdown State)</td>
<td>See notes above for Partial Forced Outage Committed State [PFO (Committed State)]</td>
</tr>
<tr>
<td>Partial Forced Outage Hours Committed State [PFOH Committed State]</td>
<td>In Service Forced Derated Hours (IFDH)</td>
<td>In the IEEE standard energy lost due to forced deratings from the In Service State are modelled as an equivalent number of full forced outage hours. This results in the IEEE term of Equivalent Forced Derated Hours (EFDH).</td>
</tr>
<tr>
<td>Partial Forced Outage Hours Available, But Not Committed State [PFOH (Available But Not Committed State)]</td>
<td>Reserve Shutdown Forced Derated Hours (RSFDH)</td>
<td>In the IEEE standard, energy lost due to forced deratings from the Reserve Shutdown State are modelled as an equivalent number of full forced outage hours. This results in the IEEE term of Equivalent Forced Derated Hours Reserve Shutdown (EFDHRS).</td>
</tr>
<tr>
<td>Forced Derated Generation Committed State</td>
<td>Derated Generation (DG)</td>
<td>In the IEEE standard, Derated Generation is reported relative to the Maximum Capacity of the unit and includes energy lost due to Unplanned Unit Deratings from either the In Service or Reserve Shutdown State. In the NEM Forced Derated Generation should be reported relative to the Winter Capacity of the unit and is reported for the Committed State and Available, But Not Committed State separately. Generators should report the Forced Derated Generation for each Partial Forced Outage (PFO)</td>
</tr>
<tr>
<td>AEMO TERM</td>
<td>IEEE TERM</td>
<td>NOTES</td>
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<tr>
<td>Failed Start</td>
<td>Unplanned Outage</td>
<td></td>
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<td></td>
<td>Class 0 - Starting Failure</td>
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<tr>
<td>Failed Start Hours</td>
<td>Forced Outage Hours (FOH)</td>
<td></td>
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<td></td>
<td>Class 0</td>
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<tr>
<td>Starting Attempt</td>
<td>Starting Attempt</td>
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</tbody>
</table>
APPENDIX 3 – RELATIONSHIP BETWEEN TIME AND ENERGY

This appendix has been provided to illustrate the various relationships between time and energy (both delivered and potential energy) in the operating states of the generator. The vertical axis represents the capacity (MW) of the unit and the horizontal axis the period hours. The total area of the diagram is therefore the megawatt hour (MWh) of energy that could have been generated if the unit were operating continuously at its Winter Capacity (WC) for the Period Hours. The illustration is divided into a number of vertical segments through time representing various operating states that the unit may experience. Some of these vertical segments are further divided to show the energy associated with different types of loss within that operating state.

For example, consider the “Committed State Hours”. This section of the graph reflects that a portion of the Period Hours the generator will be in the Committed State. Whilst in the Committed State the unit is generally producing energy, as shown by “Energy Generated”. Depending on demand and market conditions at the time the unit may not be fully dispatched and may experience a “Discretionary Reduction” in its capacity. The “Committed Unit Derating” represents the loss in energy due to partial outage while in the Committed State.

The various steps associated with the “Committed Unit Derating” illustrate that the derating may be of different magnitudes.
Note 1: Available, But Not Committed Generation – This encompasses the period where none of the generating units capacity has been dispatched, even though the unit is available.
APPENDIX 4 – PRACTICAL EXAMPLES

Full Forced Outages

1.1 Duration of Full Forced Outages

Forced outage > 30 minutes duration

A unit trips from high load due to high hydrogen temperature because of a faulty temperature switch. The fault is identified and the unit is returned to service after two hours.

Assessment

The outage is recorded as a full forced outage of two hours duration.

Forced outage < 30 minutes duration

A unit trips whilst a technician is blowing out an airflow transmitter leg. The technician had inadvertently gone to an in service transmitter and the unit is returned to service immediately the mistake has been identified. The unit is synchronised 25 minutes after the trip.

Assessment

AEMO does not require this outage to be recorded as a full forced outage because it is less than 30 minutes duration. Note: this outage may still be recorded as a forced outage of 25 minutes duration in data supplied to AEMO, at the discretion of the generator.

Forced outage running into a planned outage

A unit trips on loss of the 11kV unit auxiliaries board due to an earth fault in the B electric feed pump (50% capacity). The remaining two 50% electric feed pumps are available but it will take 12 hours to test and disconnect the B pump to clear the 11kV board of the fault. Since a planned maintenance outage is due to commence in two days time, it is decided to commence the planned maintenance outage two days early and carry out the repairs to the B pump using resources available for the maintenance outage. Repairs to the B pump are completed ten days after the failure and the unit is returned to service after a 12 day planned maintenance period.

Assessment

The outage is recorded initially as a full forced outage of 12 hours duration and then as planned maintenance for the remaining 11½ days. Even though disconnection work on the B pump may not have been carried out in the first 12 hours of the outage, a reasonable time to test and disconnect the pump is estimated to be 12 hours, after which the remaining two pumps would have become available. Hence a full forced outage duration of 12 hours is booked against the 11kV unit auxiliaries board due to the B electric feed pump fault.
1.2 Outages Due to Component Failures

Forced outage due to equipment within the boundary of the power station

A unit trips on a generator transformer protection due to an operation of a buchholz relay. It was found that gas had accumulated over several weeks and analysis revealed early signs of insulation breakdown in the tap changer. Following testing, it was decided to return the unit to service and to regularly monitor the tap changer until the next maintenance outage. The transformer is owned and maintained by the Network Service Provider. The unit is synchronised 24 hours after the trip.

Assessment

The outage is recorded as a full forced outage of 24 hours duration since it was caused by plant on the generator side of the connection point. Because the transformer is located within the power station boundary and is dedicated to a generator, a forced outage is recorded irrespective of the owner of the equipment. Note: if the condition of the transformer was such that unit load was then limited to a maximum of 80% CMR until the next maintenance outage, then a partial forced outage would also be recorded against the generator for the amount that the unit was derated until the maintenance outage.

Forced outage due to equipment not owned by generator

A unit trips due to an interzone fault in the switchyard which opened both the generator and bay coupler circuit breakers. The fault was isolated, enabling the unit to be returned to service on the generator circuit breaker after 36 hours.

Assessment

AEMO does not require this outage to be recorded as a full forced outage because it was caused by a failure of network equipment not owned by the power station on the network side of the connection point. Note: the generator may still record this outage as full forced outage in its own data collection, but to avoid double counting this outage must not be included in data supplied to AEMO since it will be the Network Service Provider who will supply this information to AEMO.

Forced outage due to failure to meet technical standards

A unit trips on undervoltage during a severe system disturbance. Analysis showed that the voltage swing was within the Technical Performance Standards limits agreed to by AEMO for that power station. The unit is returned to service after six hours.

Assessment

The outage is recorded as a full forced outage of 6 hours even though the outage was caused by a failure of network equipment not owned by the power station. This is because the generator could be reasonably expected to remain in service throughout the disturbance according to its Technical Performance Standards agreed with AEMO.
1.3 Scheduling of Forced Outages

Outage that can be deferred for 48 hours

A small water wall tube leak is detected external to the boiler. The leak is gradually deteriorating but the make-up rate is manageable and it does not appear to be impinging on any other tubes. The area is roped off and monitored. The unit is taken out of service three days later on Friday night to carry out the repairs over the weekend.

Assessment

For AEMO data, the outage is recorded as a maintenance outage because the unit was able to remain in service beyond 48 hours from identification of the tube leak.

Note:

The IEEE standard requires that a unit be capable of remaining in service until after the next weekend to avoid being classed as an "Unplanned Outage Class 3" outage. AEMO requires only a 48 hour postponement period and so generators following the IEEE standard may wish to define a Class 3a outage as one that can be postponed beyond 6 hours and up to 48 hours and a Class 3b outage as one that can be postponed beyond 48 hours and up to the end of the next weekend.

Outage that can be deferred for 48 hours but is taken out of service early

A unit experiences sudden step change in vibration on the LP turbine but the vibration is not severe enough to trip the unit. The indications are that a blade tip has dislodged because condensate conductivity has also increased and so the unit must be taken out of service to check the problem and make repairs. After some discussion, management determines that, if required, the unit could remain in service until Friday night (in three days time) without further deterioration. However, there is an opportunity to commit another unit and remove this unit from service after the approaching evening peak (Wednesday).

Assessment

The outage is recorded as a maintenance outage because, even though it was taken out of service within 48 hours, it could have remained in service beyond 48 hours if it had been required to do so.

Outage that cannot be deferred for 48 hours despite strong commercial desire to run

A generator suffers a high hydrogen leakage rate and it is calculated that hydrogen usage rate will exhaust available supplies at the station within 24 hours. As external hydrogen supplies will not be available for 36 hours, the unit is taken out of service after the evening peak to realign a faulty hydrogen seal. The unit is returned to service after 3 days.

Assessment

The outage is recorded as a full forced outage of 3 days duration because the unit outage could not have been reasonably deferred beyond 48 hours after the hydrogen seal fault was
detected. If, however, it was assessed that emergency hydrogen supplies could have been obtained within 12 hours to keep pace with the leakage rate and the outage could have been deferred beyond 48 hours, then, even if the unit is taken out of service immediately, the outage would be recorded as a maintenance outage.

**Outage that cannot be deferred for 48 hours but runs into reserve shutdown**

On Friday afternoon, an intermediate load generator develops a bearing oil leak that is driving oil into the slipring enclosure. Gradually over the next few hours oil misting and brush gear sparking is increasing in the enclosure indicating that the unit must come out of service. The unit continues to operate over the evening peak and is taken out of service for its normal weekend shutdown. The unit is not needed until the following Monday morning and the required repairs are carried out on Saturday day shift, taking 8 hours to complete.

*Assessment*

Even though the unit was not required over the weekend, the unit could not have operated during this period. Therefore the outage is recorded as a full forced outage of 8 hours duration. The remainder of the weekend is recorded as reserve shutdown.

**1.4 Outages due to Industrial Dispute**

**Outage due to industrial dispute**

A unit trips due to a faulty component in the burner management system (BMS). The fault is quickly identified and the component could be replaced within an hour and the unit returned to service but the maintenance crew refuses to carry out the work in sympathy of a fitter dismissed that afternoon. Following discussions with management the unit is returned to service after 12 hours with a delay of 10 hours attributed to the local industrial dispute.

*Assessment*

A forced outage of 2 hours would be recorded against the BMS component failure only.

**Partial Outages**

**1.5 Duration of Full Forced Outages**

**Partial forced outage > 30 minutes duration, delayed repair but no actual load loss**

A mill trips out of service on Friday evening due to a burnt out lube oil pump motor and maximum unit capacity is reduced by 50 MW from 400 MW to 350 MW because the standby mill is under planned maintenance at the time. Because only 300 MW output was required for the remainder of the weekend, it was decided to change the motor during day shift the next day. The motor was replaced in 3 hours.

*Assessment*

A partial forced derating of 50 MW and 3 hours duration is recorded against the mill. Even though no output was actually lost, the mill was forced out of service and the maximum capability of the unit was reduced by 50 MW. Only 3 hours duration is recorded because the
replacement could have been completed in 3 hours on the Friday evening, had there been a commercial driver to do so.

**Partial forced outage going into a reserve shutdown period**

A boiler circulation pump suffers a motor failure while in service and the 400 MW unit is derated by 50 MW to 350 MW due to boiler manufacturer recommendations. It takes 3 weeks to remove and replace the motor and at the end of the second week, the unit is taken out of service and placed on reserve shutdown.

**Assessment**

A partial forced outage of 2 weeks duration and 50 MW derating is recorded from the committed state. In addition a 1 week duration partial forced outage of derating 50MW from the Available But Not Committed State is recorded.

**Note:**

AEMO requires that partial forced outage hours are recorded, not only while a unit is in the "Committed State", but also during periods when the unit is in the "Available But Not Committed State" (i.e. reserve shutdown)

1.6 **Outages Due to Component Failures**

**Partial derating due to commercial considerations**

Over a period of time, a 400 MW unit is only able to achieve 390 MW due to boiler fouling. Over a further period of ten days the capability reduces to 370 MW and the unit is taken out of service for a planned boiler washdown.

**Assessment**

The partial derating is recorded as a partial maintenance outage since the generator has made a commercial decision to defer the boiler washdown until a suitable time. Had there been a commercial driver to restore the capability to Winter Capacity, then the generator could take steps to achieve this objective.

1.7 **Magnitude of Partial Derating**

**Partial derating < 5% of Winter Capacity**

A 400 MW unit loses an HP heater due to a number of leaking tubes and capacity is reduced by 10 MW to 390 MW due to boiler heat release limits. The leaking tubes are plugged and the heater is returned to service after 6 days.

**Assessment**

AEMO encourages generators to record all partial forced outages. A partial forced derating of 10 MW and 6 day duration would be recorded against the HP heater.

**Note:**
Some generators allow a defined derating threshold, below which partial outages are not recorded. AEMO permits a maximum 5% of Winter Capacity derating threshold. In this example, the 10 MW derating would fall within the 5% of Winter Capacity allowance (up to 20 MW allowed) and the generator would not be required to record the partial outage if its policy permits a reporting threshold.

1.8 Partial Outages occurring in parallel

Two partial forced outages occurring in parallel

A mill trips out of service on Friday evening due to a burnt out lube oil pump motor and maximum unit capacity is reduced by 50 MW from 400 MW to 350 MW because the standby mill is under planned maintenance at the time. The motor was replaced in 3 hours. However, two hours into the mill outage, an ID fan experiences heavy vibration and it is quickly assessed that the fan must be taken out of service immediately, reducing maximum unit capacity by 180 MW to 220 MW. An internal inspection revealed a loose vane control arm which is repaired in 6 hours and the fan returned to service.

Assessment

Even though the partial outages overlapped both outages should be reported as independent events. Therefore a partial forced outage of 180 MW derating and 6 hours duration is recorded against the ID fan. In addition a 3 hour partial forced outage of 50MW derating is reported against the mill repair. See appendix 5 for more information.

Failed Starts

Start up failure during return to service from a trip

A unit trips on low drum level during a feed pump control excursion. Under normal circumstances the unit could have been returned to service within 2 hours but problems with the lighting up torches meant that the turbine cooled beyond its differential expansion limits, delaying the unit return to service by a further 6 hours.

Assessment

A full forced outage of 2 hours would be recorded against the drum level trip and a start up failure of 6 hours against the lighting up torch problem. Note: AEMO does not require high utilisation plant (e.g. this base load generator) to record start up failures. In this case, a full forced outage of 8 hours duration could have been recorded.

Start up failure during return to service from stand-by

A gas turbine is committed at 14:00 hours on a summer afternoon but fails to synchronise due to a faulty contact in the check synchronising circuit. A technician is called out to the remote site, replaces a relay and the unit is synchronised at 16:00 hours.

Assessment

A start up failure of 2 hours is recorded against the gas turbine unit.
Plant fault resulting in possible Start up failure during Available But Not Dispatched State

A hydro unit becomes committed and minutes after a mechanical fitter observes a hydraulic oil leak in the governor oil system. The hydraulic oil system is taken out of service and the leak repaired in 4 hours. During this period the hydro unit is unable to run.

Assessment

A full forced outage of 4 hours would be recorded against the hydro governor system.

Start up failure during a routine test of peaking plant

A gas turbine is bid in for a routine one-hour synchronised test in April. During the run up, there is a small fire in the fuel pump which also damages the fuel regulating valve. It is determined that a replacement valve could be flown in from the US and fitted within 3 days but because it is mid-season, it is decided to repair and re-machine the damaged valve using a local contractor. The gas turbine is bid in as unavailable and work is completed by early May after delays in obtaining parts.

Assessment

A start up failure of 3 days is recorded against the gas turbine even though the failure occurred during a routine test when the plant was not required for commercial generation. The failure time is limited to 3 days because, had there been a strong commercial driver to replace the damaged equipment quickly, the minimum time that this could have been reasonably achieved was 3 days. The remainder of the outage is recorded as a maintenance outage.

Start up failure during return to service from planned maintenance

During the run up following a maintenance outage on a base load plant, damage is sustained to one of the turbine bearings. It is discovered that a piece of rag was left in one of the oil lines during maintenance and the resulting bearing replacement requires a 3 day outage.

Assessment

A start up failure is recorded and not a maintenance outage extension because the failure occurred while the unit was being returned to service, or during the recommissioning period.

Note:

AEMO does not require a start up failure to be recorded if the plant is high utilisation, base load plant. In this case, a full forced outage or a maintenance outage in forced mode could have been recorded against this maintenance error. However, if the plant is fast start, low utilisation plant, then a start up failure must be recorded.
APPENDIX 5 – REPORTING THE NUMBER OF OUTAGES

AEMO recognises that it is possible for forced outages of the same, or different type to overlap. As a result reporting of the number of forced outages can be ambiguous. This appendix has been provided as an aid when determining the number of outages the plant has suffered. Consider the following illustration of plant availability versus time. The graph depicts a hypothetical series of forced outages for 400MW generator across a period of 250 days. Reductions in capacity are represented by the various shaded areas.

When reporting the number of forced outages generators should report each forced outage explicitly. Where overlapping outages occur all outages should be reported rather than reporting only the effective forced outage that the unit has suffered.
For example, in the above illustration there has been;

**Five partial forced outages from the Committed State**
- Electric feed pump coupling (200MW Unit Derating from Day 10 to Day 30)
- Mill thrust bearing failure (50MW Unit Derating from Day 20 to Day 120)
- FD fan vane linkage failure (150MW Unit Derating from Day 50 to Day 70)
- Airheater soot blower stuck (100MW Unit Derating from Day 90 to Day 100)
- Boiler circulation pump failure (100MW Unit Derating from Day 170 to Day 190)

**One partial forced outage from the Available, But Not Committed State**
- Boiler circulation pump failure (100MW Unit Derating from Day 190 to Day 200)

**Two full forced outages from the Committed State**
- Tube leak (full outage from Day 140 to Day 160)
- 11kV board fault (full outage from Day 230 to Day 240)