FRG CONSULTATION

FORCED OUTAGE RATES

Published: **August 2021**

1. STAKEHOLDER CONSULTATION PROCESS

The Australian Energy Market Operator (AEMO) uses transmission line and generator Forced Outage Rates (FOR) forecasts in its annual reliability assessment and generator FOR in the Integrated System Plan (ISP). AEMO commenced a Forecasting Reference Group (FRG) consultation on its FOR with a FRG presentation informing stakeholders of the draft forecasts on 30 June 2021.
During the 30 June 2021 FRG meeting, AEMO presented draft 2021 FOR forecasts in Presentation 1[1] and facilitated stakeholder discussion via Slido.
Shell Energy Australia provided a written submission prior to submissions closing on the 14 July 2021.

AEMO's timeline for this consultation is outlined below.

Deliverable	Indicative date
Draft IASR[2] published for consultation with FRG Consultation dates and information	11 December 2020
Draft IASR Consultation Submissions due	1 February 2021
Draft IASR Scenario and Submissions webinar	3 March 2021
Notice of FRG Consultation circulated to stakeholders	23 June 2021
FRG presentation and discussion on FOR forecasts	30 June 2021
FRG Consultation submissions due	14 July 2021
IASR published	30 July 2021
FRG Consultation report published	23 August 2021

This report should be read in conjunction with the FRG presentation on FOR, the FRG meeting minutes, and the written submissions, which can be found in the FRG Consultation meeting pack[3].

2. CONSULTATION DETAILS

In recognising the importance of FOR to the reliability forecast, AEMO performed an FRG Consultation as defined in the Reliability Forecasting Guidelines (Guidelines). As described in the Guidelines, to preserve confidentiality of participant data, AEMO is limited in the level of detail it can provide when presenting results and answering detailed questions about the data.

Based on discussion in the FRG, AEMO held further FOR discussions with Tas Networks, Energy Australia and the AER. AEMO's response to an email from the AER, prior to the FRG, is included as Appendix A.

To guide stakeholder consideration, AEMO asked for stakeholder feedback on the following questions:

a) Do the identified transmission lines and the identified factors appropriately reflect inter-regional transfer capability?

b) Has AEMO correctly applied its generation FOR methodology?

AEMO received one written submission, from Shell Energy Australia. While this report addresses the written submission, the final FOR forecast utilised input from all discussions and the written submission.

AEMO thanks all stakeholders for their input.

[1] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/other_meetings/frg/2021/frg-meeting-6-pack.zip
[2] See Table 6 in the Draft IASR, available at: https://www.aemo.com.au/consultations/current-and-closed-consultations/2021-planning-and-forecasting-consultation-on-inputs-assumptions-and-scenarios
[3] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/other_meetings/frg/consultations/2021/frg-consultation---forced-outage-rates.zip

3. DISCUSSION OF MATERIAL ISSUES

3.1. Treatment of planned outages

3.1.1. Issue summary and submission

AEMO's June FRG presentation indicated that HILP forced outages were calculated considering 'all outages greater than 5 months'.

Shell Energy submitted that it

> considers that forced outage rates applied for HILP outages should be calculated only on unplanned or forced outages and should not include planned outages, planned outage extensions or reserve outage periods.

3.1.2. AEMO's Assessment

The word 'forced' was accidentally omitted and the presentation sentence should have read "… "all forced outages greater than 5 months". With this clarification, AEMO confirms that planned outages, planned outage extensions and reserve outage periods are not included in forced outage rates.

AEMO also wishes readers to note that AEMO now intends to use 'long duration unplanned outages' in the IASR and beyond as a replacement for the term High Impact Low Probability (HILP).

3.1.3. AEMO's conclusion

AEMO has clarified in the IASR that planned outages, planned outage extensions and reserve outage periods are not included in forced outage rates.

3.2. Generator outage history

3.2.1. Issue summary and submission

AEMO's June FRG presentation noted that 11 years' worth of data was included in determining HILP FOR.

Shell Energy submitted that:

> In considering the calculation of HILP events, AEMO has calculated data based on only the last 11 years of historical data. Current generating units would have data extending beyond this 11 year period, why has AEMO limited the data to only 11 historical years.

In further correspondence to their submission, Shell Energy seek all Generator HILP data, including beyond 11 years, to be published.

3.2.2. AEMO's Assessment

AEMO confirms that it uses all suitable quality outage history data that is readily available for access in an efficient way. AEMO's costs associated with utilising historical data include requesting, collating, assessing and managing data quality, storage and documentation. Participants would incur costs in providing a longer data history as well. AEMO considers the incremental value of the older data does not justify the costs, so AEMO does not plan to remediate or publish older data.
Further, the outage data provided to AEMO from generators is collected confidentially, so AEMO has an obligation to protect this information. For this reason, it cannot publish the data for individual generators.

3.2.3. AEMO's conclusion

AEMO will continue to build on the available outage history using participant submitted information. To preserve the confidentiality of participant submissions, this information will not be released.

3.3. Use of consultant projections for generator forced outage rates

3.3.1. Issue summary and submission

AEMO's June FRG presentation on FOR noted that "In all cases, projections were provided by, or supplemented with consultant projections in consultation with the station owner/operator."

Shell Energy submitted that

> AEMO has compiled rates from a combination of participant's and AEMO's consultant's forecasts of future forced outage rates. Shell Energy requests that forecast of future forced outage rates be supplied based on separation of participant's and AEMO's consultant's forecasts.

3.3.2. AEMO's Assessment

AEMO confirms that participant provided information was used in all circumstances unless the participant was unable to provide a projection or acknowledged their forecast was unsuitable for use. As such, no comparison exists between participants' suitable values and AEMO's consultant values for the same data points. Furthermore, given the limited number of participants, releasing detailed data comparisons is not permissible.

The use of consultant forecasts was limited to:

1. one sizable coal-fired power station that was unable to provide their own estimates for the entire horizon, due to confidential reasons.
2. a small number of power stations that were unable to provide their own estimate for the last 5 years of the horizon, due to confidential reasons.

AEMO could potentially publish a whole of coal aggregate with and without those stations, but the resulting figures would confound the station's FOR with the consultant's forecast of the FOR. In other words, it is not possible to publish non-confidential data that will satisfy the submission's intended insights.

3.3.3. AEMO's conclusion

As above, AEMO notes that consultant FOR values do not overlap with participant FOR values, but address gaps in them. Further, there were gaps only in a limited number of participant FOR values. Only one sizeable coal-fired power station was unable to provide any of their own estimates, due to confidential reasons This fact, combined with the confidentially limitations in providing detailed data, means that AEMO is unable to provide the requested details. The aggregated data already published in the FRG presentation is the most insightful data available to stakeholders. Interested stakeholders are encouraged to view the figures presented in the consultant's 2020 report[4] as a means of comparing AEMO's projections for the 2021 ESOO against AEMO's consultant's forecasts.

3.4. Included transmission flow paths

3.4.1. Issue summary and submission

AEMO's June FRG Presentation listed various transmission lines and their respective modelling approaches.

Shell Energy submitted that it noted

[4] Available at https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/aep-elical-assessment-of-ageing-coal-fired-generation-reliability.pdf

the inclusion of the additional transmission flow paths in this years' modelling. We support the inclusion of transmission lines between Liddell – Muswellbrook – Tamworth – Armidale – Dumaresq – Bulli Creek, and the Murraylink circuit.

Shell Energy, however, does not support the inclusion of transmission lines between South Morang – Dederang – Murray – Upper and Lower Tumut; and Moorabool – Mortlake or Tarrone – Heywood. Shell Energy considers that during periods of high demand, changed flows across these networks may not contribute to meaningful levels of unserved energy, and may simply reduce output on intra-regional generators.

3.4.2. AEMO's Assessment

AEMO determined the eligibility of the included lines as making a material contribution to inter-regional transfer capability by considering the following criteria:

1. The line/flow path should be an interconnector; or connect an interconnector to stronger meshed elements of each regional grid.
2. The line/flow path should have sufficient outage history to justify the additional modelling complexity.
3. When a single credible contingency occurs on the line, it has an effect on inter-regional transfer limits.

3.4.3. AEMO's conclusion

AEMO considers that all transmission lines selected meet the criteria to be considered as materially contributing to inter-regional transfer capability.

3.5. Transmission outage history

3.5.1. Issue summary and submission

AEMO presented transmission FOR and mean time to repair in its June FRG presentation.

Shell Energy questioned the selection of outages used to derive the historic outage rates, with particular focus on the possible inclusion of planned outages, and events where reclassification of the potential loss of double circuit transmission lines as a credible contingency did not occur prior to the occurrence of an unplanned outage. Shell Energy queries the mean time to repair of 21.3 hours and requests the publication of all considered network outages.

3.5.2. AEMO's Assessment

AEMO confirms that the transmission outage history used excludes planned outages (similar to that described in Section 3.1) and includes all identified single credible contingencies and reclassifications. AEMO however notes that available outage history can be difficult to classify and is subject to manual reporting and collection. As such, AEMO notes the available outage history is likely missing many historic events and therefore underestimates outage rates.

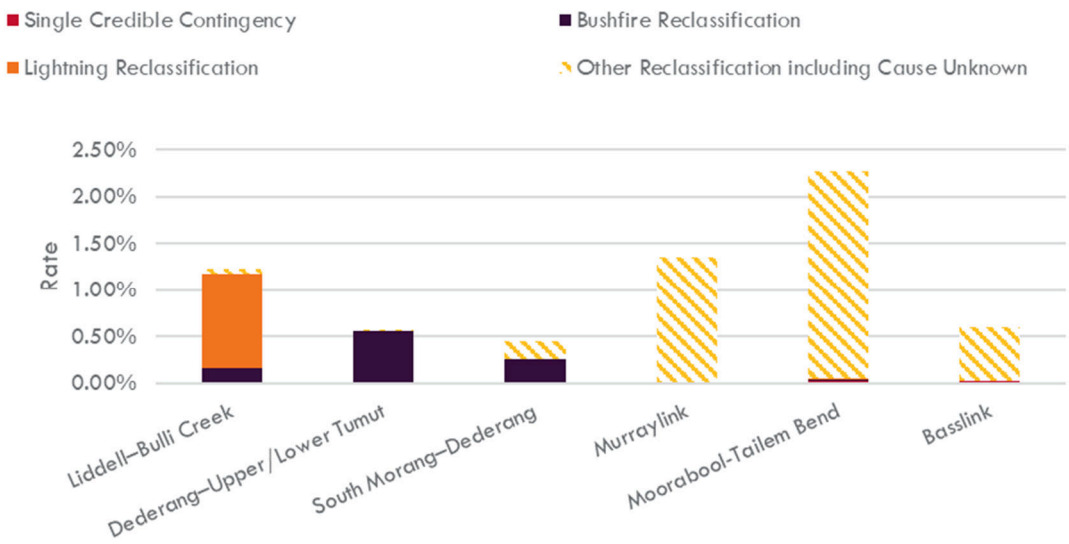
The transmission FORs presented at the June FRG included all available reclassifications, including those that did not occur prior to an unplanned outage, as well as numerous other reclassifications where it is difficult to identify whether they occurred before or after an event. Some of these reclassifications extend for long durations and are responsible for the longer mean time to repair as originally calculated.

Between the 2020 ESOO and the 2021 ESOO, AEMO retained a materially similar methodology for developing transmission FORs, and hence did not consult extensively on the process or values generated in 2021. Historically, the low materiality of transmission FORs as an input further supported a lighter touch approach.

AEMO received stakeholder feedback citing concerns that longer duration reclassification events included in the FOR may have followed a non-credible event. As it is clear that stakeholders were not all aware of the inclusion of these events, and given that inclusion currently has minimal impact on USE expectations, AEMO will implement forced outage rates calculated from events caused only by bushfire reclassification, lightning reclassification and single credible contingencies in this 2021 ESOO. To be clear, the implementation for 2021 ESOO now excludes many reclassification events from the calculated rates, reducing the implemented rates for the Murraylink, Moorabool – Tailem Bend and Basslink lines. The updated Mean Time to Repair is 7.0 hours.

Figure 1 below shows the transmission FOR associated with the categories described above. The *Other Reclassification including Cause Unknown* category is shown for reference, but as per above, is excluded from the final implementation.

Figure 1 Observed outage event rate (2009 – 2021) by category



Given the degree of stakeholder interest, and potentially emerging materiality of transmission FORs as an input, AEMO will consult further on the types of outages to be included in future reliability forecasts.

3.5.3. AEMO's conclusion

In response to stakeholder feedback, in 2021 AEMO will implement transmission forced outage rates calculated from events caused by bushfire reclassification, lightning reclassification and single credible contingencies only. Other reclassifications, which tend to be longer in duration, will be excluded in 2021. AEMO confirms that the decision to include or exclude these outages is not material to the Reliability Forecast for RRO purposes in the 2021 ESOO.

In general terms, AEMO is working to understand procedural and legal requirements regarding enhanced consultation and publication of detailed outage information and categorisations. The Forecasting Approach Register has been updated to track this work.

AEMO commits to increased consultation in advance of the 2022 ESOO, with a particular focus on consultation and data collection from relevant Network Service Providers. AEMO will publish transmission FOR data, subject to confidentiality, at appropriate times in the consultation process.

3.6. Bushfire related Forced Outage Rates

3.6.1. Issue summary and submission

AEMO's June FRG presentation included a model describing transmission FOR due to weather conducive to bushfires. AEMO utilises the Forest Fire Danger Index (FFDI)[5], developed by the CSIRO, to model the impact of meteorological conditions on the danger of forest fires. The transmission FOR model was developed as part of a three year Electricity Sector Climate Information (ESCI) project, and benefitted from input by ElectraNet and the Bushfire and Natural Hazards Cooperative Research Centre. AEMO sought stakeholder input at the October 2020 and May 2021 FRG meetings, prior to the June 2021 FRG.

Shell Energy's submission asked what analysis had been undertaken regarding improved fire risk mitigation practices in Victoria. The submission requested additional evidence regarding the assessment process for calculating the future forecasts for high FFDI conditions.

3.6.2. AEMO's Assessment

The ESCI project outcome was to model bushfire related transmission FOR as a function of historical bushfire related FORs, with a forward looking escalation that reflects climate change. The climate factor used for escalation reflects the shift in FFDI metrics over time according to Representative Climate Pathways (RCPs). Interested stakeholders are encouraged to read the ESCI documentation online[6]. The transmission FOR model is:

$$Forecast\ Outage\ Rate\ \{year\} = Historical\ Outage\ Rate * (1 + climate\ factor\ \{year\}).$$

AEMO has no record of the impact of emerging fire mitigation strategies being raised during stakeholder feedback to this point, however, has received numerous submissions advocating for the further consideration of climate risk. AEMO is confident that the majority of bushfire reclassifications included relate to unplanned major bushfire events, as evidenced by the correlation of the FFDI with major bushfire events of 2009, 2019 and 2020.

Bushfire reclassifications occur when bushfires approach transmission lines, and a bushfire does not need to be in the immediate proximity of the transmission line to force an outage. AEMO acknowledges that fire mitigation strategies change over time, but no quantification of their impact on FOR is currently available. If fire mitigation practices successfully reduce the likelihood of bushfires across vast geographical spreads of vegetation near the Dederang-South Morang and Dederang-Upper/Lower Tumut lines, AEMO considers this will show up in historical analysis over time, and thus reduce the likelihood of a transmission FOR in future years.

As with other AEMO forecasts, the FOR will be assessed in the Forecast Accuracy Report (FAR), published annually. AEMO consults with stakeholders on a Forecast Improvement Plan which prioritises initiatives informed by the FAR and other considerations.

3.6.3. AEMO's conclusion

AEMO considers it premature to incorporate fire mitigation practice changes to modelled FOR because there is currently no data quantifying the impact on FOR. However, AEMO will monitor the availability of suitable data and consider it at the appropriate time. AEMO encourages interested stakeholders to study the published results of the ESCI project for further technical details of the model development, and notes the recently published 2021 IASR describes the modelling in more detail from an energy industry context.

[5] See https://en.wikipedia.org/wiki/McArthur_Forest_Fire_Danger_Index

[6] See https://climatechangeinaustralia.gov.au/en/projects/esci/esci-case-studies/case-study-fire-transmission/

3.7. Constraint details

3.7.1. Issue summary and submission

AEMO's July FRG presentation indicated that "AEMO will apply constraints consistent with those used operationally during single credible contingency events for each line".

Following the presentation and FOR consultation period, Shell Energy sought clarification regarding the use of constraints, suggesting AEMO should use lightning and bushfire reclassification constraints where the outage was driven by such reclassifications. Shell Energy also sought clarification on which specific network elements related to each constraint, noting that the network limits would vary depending on which element was chosen.

3.7.2. AEMO's Assessment

AEMO confirms that the 2021 ESOO implementation of transmission FORs follows an unchanged methodology to that used in previous years. This methodology applies constraints consistent with a single credible contingency on a transmission element within the flow path that would be most relevant to inter-regional transfer capacities.

While it is noted that on some lines, the outage data set is predominantly driven by bushfire or lightning reclassifications, constraints consistent with a single credible contingency are used in 2021. Any change to this approach would need to be consulted upon, and there is no time to implement prior to publishing 2021 ESOO. The following elements were chosen to represent each flow path:

Flow Path	Line in Constraint
Liddell to Bulli Creek	Bulli Creek – Dumaresq 330kV
Dederang to Upper/Lower Tumut	Murray – Upper Tumut 330kV
South Morang to Dederang	South Morang – Dederang 330kV
Murraylink	Murraylink
Moorabool-Tailem Bend	Mortlake-Heywood 500kV
Basslink	Basslink

In future publications, subject to further feedback, AEMO may consider constraints consistent with a bushfire or lightning reclassification. This has been added to the Forecasting Approach Register[7].

3.7.3. AEMO's conclusion

AEMO will consider stakeholder perspectives on the choice of constraints used to represent transmission FORs in advance of the 2022 ESOO.

3.8. Use of Generator Long Duration, and Transmission FORs in the ISP

3.8.1. Issue summary and submission

In AEMO's June FRG, AEMO discussed the proposed application of generator and transmission FORs in ISP capacity outlook modelling. AEMO had proposed to consider generator FORs and generator long duration (HILP) FORs by derating seasonal ratings by the equivalent forced outage rate, but to exclude transmission FORs for modelling simplicity. Given the intent of the ISP to balance investment in transmission and generation, some attendees suggested that this implementation could create a bias.

[7] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-approach

3.8.2. AEMO's Assessment

AEMO internal analysis suggests that any potential bias arising from the consideration of generator long duration (HILP) outages (but not transmission outages) is negligible. However, to eliminate the perception of bias, and address stakeholder concerns, AEMO has adjusted the ISP capacity outlook implementation, as documented in the IASR[8], such that long duration FORs are no longer considered when derating seasonal generator ratings.

3.8.3. AEMO's conclusion

AEMO has adjusted the ISP capacity outlook modelling implementation as documented in the IASR to minimise any potential for bias for the purposes of generator and transmission investment planning.

4. CONCLUSION

AEMO appreciates the submissions provided and have considered their feedback, as addressed in Section 3 above.

[8] 2021-inputs-assumptions-and-scenarios-report.pdf (aemo.com.au)

APPENDIX A. CORRESPONDENCE

The following is AEMO's response to an enquiry from the AER prior to the FRG presentation. The AER agreed to this email being published.

From: AEMO

To: AER

Hi Ashok,

Thanks for your questions. Carla Ziser and Ben Jones (copied in) have responded in green.

Regards,

Daniel

Hi all,

Please find below some of our comments on AEMO's FOR projections scheduled for discussion at tomorrow's FRG.

Our broad assessment is that the FRG presentation on FORs does not provide sufficient evidence to support the assumptions that AEMO plan to make. The amended FRG slides that have just been sent through may have addressed some of the concerns we have raised. If so, we will note this briefly as part of TR item in tomorrow's agenda.

Coal power station FORs and mean time to repair (MTR) assumption

1. Why is an adjustment of FOR to account for HILP events required? Is it to ensure that the ISP accurately accounts for the costs and benefits of meeting the 0.002% USE standard. Or does the assessment of HILP events lie outside the scope of the ISP and more within the scope of other processes such as the RRO which are designed to meet a higher reliability standard (0.0006% USE).

   AEMO differentiates HILP (to be known as long duration unplanned outages) from regular forced outage rates by considering outages observed in history that are greater than five months separately. HILP outages that extend greater than five months are very unlikely, and could result in an overestimation for an individual station if not considered in a longer-term context for a technology class. This process predominantly supports the Reliability Forecast, in which station level forced outage rates and projections are applied. To ensure that the ISP accurately represents reliability of generation, HILP outages are a category of outages not included in

the FOR calculation, and are instead added. Please refer the ESOO & Reliability forecast methodology and Inputs, Assumptions and Scenarios report for more detail.

Insufficient supporting information has been provided to justify the proposed MTR assumptions. These assumptions that are on the order of 6 to 8 months are only supported by a statement that the figure represents the average over the past 11 years.

This assessment seems inconsistent with AEP Elical's (30 June 2020) report, which notes that there have been HILP events between 2015-16 to 2019-20 and these events have led to an averaged forced outage rate of ~2.4 months and a median of ~1.6 months.

Per our ESOO & reliability forecast methodology, AEMO defines HILP forced outages as a full forced outage greater than five months, which may differ from AEP Elical's definition. The MTTR assumptions are a direct reflection of observed HILP events as per AEMO's definition over the last 11 years.

We would also appreciate guidance on:

- Why AEMO has limited its assessment of expected FOR to plant operation over the last 11 years? Are there data quality issues that prevent inclusion of pre-2010 outage data?

For HILP outages at least the last 10 years of data is used, per our ESOO & reliability forecast methodology. AEMO has used the past 11 years based on availability of quality data. Forced outage rates have been derived based on the most recent four years of data only - this approximates well the longer-term outage rates seen by most technologies.

Why the average MTR is the more relevant statistic and not the median given the small sample size?

Average is the statistic agreed to via consultation per our ESOO & RF methodology.

- What are the specific plant failures that have informed the assumptions presented in the draft FRG slides?

Due to confidentiality reasons AEMO is not able to describe specific plant issues; only aggregated figures can be presented in the FRG slides.

- Have the plant failures that contribute to expected FORs represent a complete shut down of the coal or gas power plant or a few units within the facility, or are these considerations accounted for in the averaging process?

This consideration is accounted for in the averaging process.

- Will FOR assumptions be calibrated to plant age in the ISP model (i.e. as plants get older, the ISP would model higher FORs)? If not, why?

The FOR assumptions are held constant past the first 10 years. Whilst it is true in theory that reliability may degrade as plant age, any accuracy of this trend 10+ years into the future cannot be guaranteed. AEMO does not see that applying a trend past the first 10 years of the ISP would introduce a material difference to ISP outcomes. As much as reasonably practicable, AEMO relies on participants forecasts of FORs, which are provided for the first 10 years only.

Transmission line outages – referencing slide 10 and 11 of FRG presentation on 2021 FORs. Please note these are only applied to the Reliability Forecast, and do not feature in ISP modelling.

1. AEMO needs to provide more detail on how it has derived FOR for the transmission lines that have been assessed to have meaningful reliability implications. For instance:
   - Why have the proposed assumptions been drawn from what seems like an 18 month dataset? Can stakeholders be provided the historical evidence that justifies the inclusion of the transmission lines that 'materially contribute to inter-regional transfer capability'.

     12 years of history was used for this purpose. All lines selected are interconnectors or lines that connect the interconnectors to stronger meshed parts of the system in each region. As such, single credible contingencies on these lines are expected to reduce inter-regional transfer capacity. Other lines were considered, however the outage rate was not high enough to justify inclusion. Inclusion of additional lines was supported by specific stakeholder submissions to the IASR.

   - I might have misunderstood but an inconsistent methodology seems to have been applied in determining tx line-FOR data across the lines that have been deemed to be important. Some FORs seem to have been derived from observations, whereas others have been modelled, why is this? What modelling methodology has been used, and is the source verifiable?

     All FORs are derived through observation, however some are constant throughout the year, and others vary throughout the year to reflect likelihood of bushfires. FFDI dependent rates were applied only to lines where the majority of observed incidents were bushfire initiated.

   - How has the mean time to repair assumption been derived? How big is the sample set? If the sample size is 'small', would it not be more appropriate to use the median statistic?
   - The MTTR is a direct reflection of observed repair times across a sample set of >300 outages. Similar to the generator HILP outages, the lines are averaged to avoid overestimating impacts on specific lines.

Weather dependent FORs and FFDIs

1. We provide the following comments on slide 12
   - Do weather dependent FORs apply to a greater subset of tx lines than those identified on slide 10 and 11?

     As indicated on slide 11, only the South Morang-Dederang and Dederang-Upper / Lower Tumut lines apply weather dependent FORs

   - How has the FFDI analysis informed tx FORs, and will the expected FORs vary across the climate scenarios?

     The FFDI analysis is demonstrated in slide 12. The FFDI is escalated consistent with a single climate scenario, as no variation between emissions scenarios are expected within Reliability Forecast timeframes.

   - Can transmission lines be made more resilient to extreme weather events (e.g. through engineering improvements that make them more resilient to wind gusts)? How would this affect tx FOR projections?

     Potentially, however this is beyond the scope of the Reliability Forecast

From: AER

To: AEMO

Subject: Comments on FOR assumptions ahead of FRG (30/6) [SEC=OFFICIAL]

OFFICIAL

Hi all,

Please find below some of our comments on AEMO's FOR projections scheduled for discussion at tomorrow's FRG.

Our broad assessment is that the FRG presentation on FORs does not provide sufficient evidence to support the assumptions that AEMO plan to make. The amended FRG slides that have just been sent through may have addressed some of the concerns we have raised. If so, we will note this briefly as part of TR item in tomorrow's agenda.

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2. Insufficient supporting information has been provided to justify the proposed MTR assumptions. These assumptions that are on the order of 6 to 8 months are only supported by a statement that the figure represents the average over the past 11 years.

   This assessment seems inconsistent with AEP Elical's (30 June 2020) report, which notes that there have been HILP events between 2015-16 to 2019-20 and these events have led to an averaged forced outage rate of ~2.4 months and a median of ~1.6 months.

   We would also appreciate guidance on:

   - Why AEMO has limited its assessment of expected FOR to plant operation over the last 11 years? Are there data quality issues that prevent inclusion of pre-2010 outage data?
   - Why the average MTR is the more relevant statistic and not the median given the small sample size?
   - What are the specific plant failures that have informed the assumptions presented in the draft FRG slides?

- Have the plant failures that contribute to expected FORs represent a complete shut down of the coal or gas power plant or a few units within the facility, or are these considerations accounted for in the averaging process?
- Will FOR assumptions be calibrated to plant age in the ISP model (i.e. as plants get older, the ISP would model higher FORs)? If not, why?

Transmission line outages – referencing slide 10 and 11 of FRG presentation on 2021 FORs.

1. AEMO needs to provide more detail on how it has derived FOR for the transmission lines that have been assessed to have meaningful reliability implications. For instance:
   - Why have the proposed assumptions been drawn from what seems like an 18 month dataset? Can stakeholders be provided the historical evidence that justifies the inclusion of the transmission lines that 'materially contribute to inter-regional transfer capability'.
   - I might have misunderstood but an inconsistent methodology seems to have been applied in determining tx line-FOR data across the lines that have been deemed to be important. Some FORs seem to have been derived from observations, whereas others have been modelled, why is this? What modelling methodology has been used, and is the source verifiable?
   - How has the mean time to repair assumption been derived? How big is the sample set? If the sample size is 'small', would it not be more appropriate to use the median statistic?

Weather dependent FORs and FFDIs

1. We provide the following comments on slide 12
   - Do weather dependent FORs apply to a greater subset of tx lines than those identified on slide 10 and 11?
   - How has the FFDI analysis informed tx FORs, and will the expected FORs vary across the climate scenarios?
   - Can transmission lines be made more resilient to extreme weather events (e.g. through engineering improvements that make them more resilient to wind gusts)? How would this affect tx FOR projections?

Kind regards,

Ashok