

2024 GPSRR Approach Consultation Report

November 2023





Important notice

Purpose

AEMO has prepared this document to report on the consultation completed on its approach paper for the 2024 General Power System Risk Review under clause 5.20A.2(c)(3) of the National Electricity Rules.

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1 Introduction

At the commencement of its annual General Power System Risk Review (GPSRR), AEMO publishes an approach paper under National Electricity Rules (NER) 5.20A.2(c)(3), on which it invites submissions from stakeholders.

AEMO published its approach paper for the 2024 GPSRR on 22 August 2023 and invited submissions from all interested persons. The closing date for submissions was 20 September 2023.

AEMO received written submissions from Energy Queensland, Shell Energy, Synchrony and Simon Bartlett in response to the consultation. Relevant feedback and questions from those submissions have been published on AEMO's website¹. AEMO also invited stakeholders to an industry briefing on the 2024 GPSRR approach paper on 15 September 2023.

AEMO thanks all participating stakeholders for their engagement and contributions to finalising the 2024 GPSRR approach.

AEMO published a final updated version of the approach paper in November 2023². The final approach paper incorporates changes based on AEMO's consideration of feedback received, as well as further review by AEMO on the scope of the work required to complete the GPSRR analysis.

The following sections include summaries of the stakeholder feedback received on the initial approach paper and AEMO's responses (where relevant), together with a description of the changes made to the 2024 GPSRR approach paper in response to submissions or further AEMO review.

¹ Available at <https://aemo.com.au/consultations/current-and-closed-consultations/2024-gpsr-review>.

² See <https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/general-power-system-risk-review>

2 Consultation feedback and responses

This section sets out AEMO's responses to relevant items of feedback raised in each of the four written submissions received on the approach paper, as well as points raised at the industry briefing.

2.1 Is it appropriate to apply the 2022 ISP Step Change scenario to assess future power system risks?

Energy Queensland comment

Energy Queensland agreed that it is appropriate to apply the 2022 *Integrated System Plan (ISP) Step Change* scenario to assess future power system risks for the 2024 GPSRR. Energy Queensland also noted that the December 2023 release of the Draft 2024 ISP will be considered for the 2024 GPSRR and any material changes incorporated. In addition, it noted that major state-based roadmap changes including the Queensland Energy and Jobs Plan and the Victorian offshore wind programs/policies were announced after the 2022 ISP was released.

Shell Energy comment

Shell Energy agreed that it is appropriate to use the 2022 ISP and its underlying input assumptions for preparing the draft 2024 GPSRR. Shell Energy encouraged AEMO to consider updated assumptions where appropriate. Where any 2024 ISP assumptions are used in the modelling, Shell Energy suggested these should be detailed in the draft report.

AEMO response

AEMO acknowledges Energy Queensland and Shell Energy's support in the use of the 2022 ISP *Step Change* scenario, provided that material changes from the Draft 2024 ISP are incorporated. AEMO will also consider any significant impacts of the major state-based roadmap changes for the 2024 GPSRR that are represented in the Draft 2024 ISP.

2.2 What are stakeholder views regarding the risk assessment approach that has been applied for the 2024 GPSRR?

Synchrony comments

Synchrony recommended that the GPSRR Approach should align with the following risk management standards:

- ISO31000 Risk Management.
- ISO55000, 55001 and 55002.
- ISO/IEC/IEEE 16085:2021 Systems and software engineering — Life cycle processes — Risk management.
- AS ISO21504:2016 Project, programme and portfolio management — Guidance on portfolio management.

Synchrony also recommended that context is established before performing risk assessments in alignment with ISO 31000 to ensure consistency among respondents and their risk identification and assessment.

Synchrony noted that the risk approach focuses on specific events and conditions but may not consider the overall system and interactions between different factors.

Synchrony suggested that the existing risk matrix and scoring system is not well-designed to capture the complexities of risks and their impacts comprehensively.

AEMO response

As stated in the 2022 Power System Frequency Risk Review (PSFRR) and 2023 GPSRR³, AEMO applies the principles of the AS/ISO 31000 risk management framework, undertakes root-cause analysis for major power system events, and has adopted the BowTie methodology.

Each year, AEMO reviews and updates the risk assessment process undertaken for the GPSRR. AEMO will continue to consider relevant standards as part of the design of the risk assessment process for future GPSRRs.

AEMO worked with network service providers (NSPs) prior to the drafting of the approach paper to establish the context to ensure consistency between risk assessments and establish a fit-for-purpose framework. This included an initial presentation detailing the risk assessment process, as well as meetings with individual NSPs to talk through the priority risks that were raised. AEMO will consider how to further improve this process and ensure that clear and consistent context is established between all NSPs.

The 2023 GPSRR captured broader risks and indistinct events and/or conditions that could lead to cascading failures and supply disruptions, in addition to a set of priority contingency events. As detailed in Section 3.4 of the 2024 GPSRR approach paper, AEMO plans to continue to capture such events and conditions as part of the 2024 GPSRR.

The 2024 GPSRR approach paper includes a brief summary of the risk assessment process. However, the risk assessment documents completed by NSPs included further descriptions of the risks, as well as justifications for their likelihoods and consequences. AEMO also outlined the GPSRR risk assessment process to participating NSPs in a presentation in May 2023.

If there are any specific recommendations pertaining to the above-mentioned or other relevant standards, AEMO is open to reviewing and considering them.

2.3 What are stakeholder views on how to effectively consider risks where the impact is difficult to define as part of the 2024 GPSRR?

Energy Queensland comments

Energy Queensland supported further analysis of generator SCADA/communications risks (see Section 3.4 of the 2024 GPSRR approach paper) and the consequent implications for generation dispatch and curtailment. Energy Queensland also expressed interest in any strategic measures required to address these, including existing and planned remedial schemes.

³ See <https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/general-power-system-risk-review>.

Energy Queensland supported further analysis of restart methodologies (see Section 3.4 of the 2024 GPSRR approach paper) and would welcome collaboration between AEMO and NSPs.

AEMO response

AEMO is currently undertaking a detailed review of the SCADA failures and market suspensions under NER 4.8.15 and will capture key points of this review in the GPSRR. AEMO is also planning to include discussion of communications risks, the recent SCADA failures and market suspensions, and the impact on generator activity and operational considerations, in the 2024 GPSRR.

In regards to system restart, AEMO has ongoing collaboration with NSPs through the system restart ancillary services (SRAS) working group and SRAS training⁴. AEMO is also planning to summarise key issues in the 2024 GPSRR.

2.4 Are there any priority UFLS contingency events that stakeholders believe should be considered in the 2024 GPSRR?

No specific feedback was provided regarding under frequency load shedding (UFLS) contingencies events to be considered. AEMO intends to study significant multiple contingency events consistent with those considered as part of previous UFLS reviews.

2.5 What are stakeholder views regarding the priority risks proposed to be considered as part of the 2024 GPSRR, including any proposed changes to the events or the methodology for assessment?

Energy Queensland comments

Energy Queensland suggested the following issues may warrant further consideration:

1. **Closure of Eraring** – Energy Queensland noted that the closure of Eraring will be considered in ‘future studies’ but suggests that greater clarity is provided as to what this means. In the view of Energy Queensland, it is important that the Eraring closure and alternative scenarios be incorporated in full as part of the 2024 GPSRR so market participants have sufficient information to plan future investment and operational requirements.
2. **Battery Energy Storage Systems (BESS) operations** – Energy Queensland noted that if BESS models are not available, the GPSRR will utilise ‘generic’ models. However, in this category only thermal and pumped hydro energy storage plant generic models are specifically named/identified. Energy Queensland suggested that in situations where models are unavailable, the operation of BESS may be oversimplified and would appreciate clarity from AEMO.
3. **Distributed energy resources (DER) operations** – Energy Queensland noted that issues related to DER are considered on a limited basis. Further, Energy Queensland referenced the approach paper and suggested that

⁴ See <https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/system-restart-ancillary-services-guideline>.

some of the DER-related voltage/rate of change of frequency (RoCoF) issues are 'out of scope', and while the 2024 GPSRR will comment on these issues on a qualitative basis, a detailed assessment of this growing supply source may not be able to feature in the 2024 GPSRR. Energy Queensland also suggested it is unclear whether the forecasts out to 2028-2029 consider scenarios where distribution system operator (DSO) models start to become active in the distributed NSP ecosystem. In the view of Energy Queensland, this is not evident from the 2023 GPSRR. Energy Queensland noted that these may contribute to material band variations/floor-ceiling RoCoF levels compared to those which adopt a current state 'system normal' National Electricity Market (NEM) model as described in the approach paper.

4. **Scenarios** – Energy Queensland suggested the ability to incorporate additional material contingency events that occur up to December 2023.

Shell Energy comments

In addition to the actionable network projects listed in Table 2 in the 2024 GPSRR Approach Paper, Shell Energy recommended that the double circuit loss of Victoria – New South Wales Interconnector West (VNI West) also be considered as part of the 2024 GPSRR contingency risks. Shell Energy also suggested that the double circuit loss of the Western Renewables Link (WRL) between Bulgana and Sydenham be considered as part of the 2024 GPSRR contingency risks for similar reasons. Shell Energy considered that the double circuit loss of either of VNI West or WRL under some circumstances could potentially lead to an increased probability of an uncontrolled cascading event and/or supply interruptions.

Shell Energy also supported review of the adequacy of current UFLS schemes including current UFLS settings. Noting the relatively large size of new interconnector network assets forecast to commission in the NEM prior to 2030, Shell Energy recommended that AEMO consider more generalised contracted UFLS schemes between 49.5 hertz (Hz) and 49.0 Hz as part of network support and control ancillary services (NSCAS) contracts. Similarly, consideration should be given to NSCAS contracted for over frequency generator tripping or runback schemes.

Contracting for generator runback or tripping schemes may also support the financial contracts market as it would reduce the potential for unit trips due to an uncontrolled NER S5.2.5.7 load rejection event on uncontracted units. Shell Energy considered that implementing contracted frequency support schemes outside the normal frequency control ancillary services (FCAS) operating range, such as wide deadband frequency response, will add resilience to the power system for non-credible or multiple contingency events because of changes due to the energy transition.

Simon Bartlett comments

The submission provided comments regarding the priority risks to be considered in the 2024 GPSRR and Recommendation 10 from the 2022 PSFRR relating to the management of risks associated with non-credible loss of future North Ballarat – Sydenham 500 kilovolts (kV) lines. To respond fully, this submission is covered in Section 2.10 below.

AEMO response

In response to feedback from Energy Queensland's comments on closure of Eraring, BESS operations, DER operations and scenarios, AEMO has the following responses:

1. **Closure of Eraring** – modelling for future dispatches used in the assessment of the 2024 GPSRR priority risks will include the planned retirement of Eraring and all other planned retirements up to FY 2028-29. In addition to this, Recommendation 7 in the 2023 GPSRR discussed Transgrid planning for the retirement of Eraring and the impact on flows in New South Wales. Progress on this recommendation will be tracked in the 2024 GPSRR. Additionally, AEMO is planning to discuss the operational challenges of recent and future planned synchronous generator retirements.
2. **BESS operations** – AEMO intends to use generic BESS models with assumed droop settings based on generic settings of existing systems. This has been clarified in the final approach paper to ensure it is stated explicitly.
3. **DER operations** – AEMO acknowledges Energy Queensland’s concern regarding the consideration of DER in the 2024 GPSRR. The 2024 GPSRR studies will not explicitly model the impact of a DSO role. Study results may identify a benefit in undertaking sensitivities that assess different operational conditions that may arise in a possible DSO future⁵.
 - AEMO does not plan to explicitly model the impact/action of a DSO role in the 2024 GPSRR future studies. However, the 2024 GPSRR will include a section on NEM DER technical performance and compliance, which may include discussion of the impact of the DSO role on power system performance referencing the past and ongoing work by AEMO detailed above.
 - For the 2024 GPSRR, AEMO intends to model DER and projected levels of DER for future studies. This includes RoCoF tripping consistent with the percentage of each inverter type, based on the relevant standards. For studies utilising the simplified/lumped system model (UFLS screening), AEMO cannot directly simulate voltage related shake-off of DER due to the inability of the model to accurately capture system voltage disturbances. AEMO plans to account for this by tripping fixed percentages of distributed photovoltaic (DPV) generation for each disturbance based on operational experience.
4. **Scenarios** – AEMO will exercise discretion based upon the timing of significant reviewable contingency events, the significance, relevance to the GPSRR, and any other information available. Significant reviewable contingency events since the 2023 GPSRR up to the end of the Q1 2024 will be covered, while any events after this period will be covered in subsequent annual GPSRRs. AEMO reviews all power system events and for reviewable operating incidents, will also publish incident reports⁶ under 4.8.15 irrespective of where they occur in the GPSRR cycle.

In response to Shell Energy, AEMO notes that NER S5.1.8 requires NSPs to consider, in planning a network, non-credible contingency events which could adversely impact the stability of the power system. In considering these non-credible contingency events, NSPs should identify and implement suitable controls to minimise disruption or significantly reduce any identified risks. It is anticipated that these controls may involve the implementation of new remedial action schemes, in which case NSPs should consult with AEMO and refer to the Remedial Action Scheme (RAS) Guidelines developed by AEMO and NSPs. For VNI West and WRL, it is the responsibility of AEMO in its role as the Victorian transmission system planner to consider the non-credible loss of

⁵ See <https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/markets-and-framework/open-energy-networks-project#:~:text=Key%20activities%20of%20this%20project,the%20advent%20of%20distribution%20markets> and <https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge/project-edge-reports>.

⁶ See <https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-events-and-reports/power-system-operating-incident-reports>

these circuits under NER S5.1.8. For HumeLink, Transgrid is considering risks relating to non-credible contingencies and is currently consulting with AEMO on suitable controls as part of the 2024 GPSRR.

AEMO notes the support of Shell Energy in regards to the review of the adequacy of current UFLS schemes. The UFLS adequacy review is intended to highlight potential gaps to investigate in more detail and for solution options to be explored, which may include those suggested by Shell Energy.

AEMO has previously made recommendations relating to the review of over frequency generation shedding (OFGS) schemes in South Australia, Western Victoria and Queensland. While an update on the status of these will be included in the 2024 GPSRR, a summary of these is:

- AEMO is presently pursuing recommendations relating to review of OFGS in South Australia, Western Victoria and Queensland identified in the 2020 and 2022 PSFRR. The 2022 PSFRR recommended the development of an OFGS in Queensland. The design of this is currently underway and is expected to be finalised by the end of Q4 2023 such that Powerlink can begin implementation in 2024.
- A review of the OFGS in South Australia/Western Victoria was recommended in the 2020 PSFRR. ElectraNet and AEMO have implemented updated generator settings as part of this review, and further changes may be implemented through ongoing operational improvement. AEMO models key control schemes and runback schemes relevant to the contingencies under evaluation, and new/modified schemes are a possible solution/mitigation to identified risks.

AEMO acknowledges the potential benefit of wide deadband frequency response to assist with extreme frequency events, as well as the need to explore how it interacts with the mandatory primary frequency response (PFR) requirements. AEMO will continue to consider wide-band frequency response as an option, in addition to the existing OFGS and over-frequency protection. The review of UFLS adequacy in the 2024 GPSRR may highlight potential applications and will discuss wide deadband frequency response if a specific need is identified.

2.6 What are stakeholder views regarding the proposed modelling approach for the priority risks for assessment in the 2024 GPSRR?

Energy Queensland comments

Energy Queensland noted the use of short-term half-hourly load forecasts is specified as an input. It is unclear in the approach paper where or how five-minute profiles are utilised and become relevant for the purposes of this risk modelling.

Shell Energy comments

Shell Energy noted the proposed network model set out in Section 4.3. Shell Energy suggested that the currently planned four mainland regions regional model be expanded to a sub-regional model where critical network flow paths, load and generators are more accurately represented. In the view of Shell Energy, this would reduce the impact of all the limitations of the current model as indicated in the approach paper.

Shell Energy noted and agreed with AEMO that mandatory narrow band primary frequency response (MNBPFRR) in accordance with a generating unit's agreed PFR settings are included in the studies but response from an ancillary services load or generating unit for FCAS is not considered in the studies. Shell Energy requested that AEMO provides details in the draft report of how the provision of MNBPFRR was calculated at times of system

stress, given that generating units are not required to provide headroom, foot room or stored energy reserves for the provision of MNBPF. Additionally, Shell Energy recommended that having determined the worst-case stress scenarios from the modelling, further work be undertaken to determine if the current methodology for determining levels of FCAS procurement remains appropriate for the future.

Given the critical support provided to the power system by the existing special protection schemes (SPSs) as listed in Section 4.6, Shell Energy agreed with and supported their inclusion in the modelling.

AEMO response

In response to feedback from Energy Queensland, AEMO notes that market modelling data from PLEXOS is consistent with the ISP, which uses 30-minute intervals. The approach also aligns with AMP snapshots, which are also 30-minute intervals. The 30-minute data is used to identify boundary/worst cases for contingencies that AEMO assesses. While there could be deviations in the data within a 30-minute period (for example, due to interconnector drift), AEMO will consider specific risks relating to drift within a dispatch interval in the 2024 GPSRR.

AEMO notes Shell Energy's comments on the modelling approach. The simplified model approach has evolved and continues to evolve to balance the time required for model setup and time for undertaking analysis. Inclusion of additional flow paths will increase model complexity and time required for model setup, and is not expected to have a material impact on simulation outcomes. Benchmarking was conducted for the 2023 GPSRR simplified model and the accuracy was determined to be acceptable. The simplified model is considered appropriate for UFLS screening studies, while the full NEM Power System Simulation for Engineering (PSS®E) model will be used for the study of HumeLink and a full NEM Power System Computer Aided Design (PSCAD™) model will be used for the study of circuit breaker failure in the Latrobe Valley. The modelling approach will continue to evolve and it is expected that additional detail will be included in models used for future GPSRRs. AEMO will be using the same approach for modelling PFR as was used in the 2023 GPSRR. For the 2023 GPSRR historical studies, AEMO used historical dispatches from the Operations and Planning Data Management System (OPDMS). For future studies, the 2022 ISP forecasting methodology, set out in the 2021 ISP Methodology, was applied to forecast future network dispatch conditions. AEMO agrees with Shell Energy that availability of headroom and foot room is an important consideration, and therefore PSS®E generator models applied in the studies limit power output to reflect each generator's minimum and maximum capacity. The modelling approach is further detailed in Section 4 and Appendix A3 of the 2023 GPSRR.

AEMO notes Shell Energy's support of the modelling of existing SPSs.

2.7 What are stakeholder views regarding the proposed risk cost assessment methodology to be applied in 2024 GPSRR?

Synchrony comments

Synchrony suggested that the approach for calculating Values of Customer Reliability (VCRs) might not fully capture the broader societal and environmental impacts of electricity outages. The focus on economic impacts might lead to an incomplete understanding of the true value of reliability.

Synchrony recommended that the methodology considers higher-level concerns such as national security, critical infrastructure, vulnerable communities, impacts on public health and safety and disruption of essential services.

Synchrony suggested that the VCR approach seems to consider past data and trends for customer behaviour and preferences and may not fully account for changes in customer expectations and behaviours over time.

Synchrony recommended that the approach addresses how VCRs align with higher level national energy objectives.

AEMO response

As detailed in the 2023 GSPRR, the risk cost assessment completed as part of GPSRR is designed to be a preliminary indicator of the feasibility of the recommended mitigation measure. It is expected that the relevant NSP/party responsible for implementing the recommendation undertakes a full detailed risk cost assessment following the completion of the GPSRR. AEMO will consider how best to account for other societal and environmental impacts of electricity outages as part of the GPSRR risk cost assessment process. For the purpose of the current South Australian Protected Event⁷ and justification of the mitigations in place, sensitivity studies were undertaken using a VCR multiplier of 2 to account for the cost of widespread outages. For future detailed analysis, AEMO (or the relevant party) should consider whether such a multiplier or other approach is appropriate.

The Australian Energy Regulator (AER) is continuing to adjust the VCR annually for Consumer Price Index (CPI) and will revisit this approach in the next VCR review due by 31 December 2024⁸. AEMO also notes that the Reliability Panel is currently undertaking a review of the form of the reliability standard to investigate whether the form should be amended to include a tail-risk metric in addition to the current expected unserved energy metric⁹.

2.8 Does the proposed consultation approach meet stakeholder expectations and do stakeholders have any suggestions on how AEMO could best engage with industry on the 2024 GPSRR?

Synchrony comments

Synchrony recommended that engagement be extended to key stakeholder groups such as Engineers Australia, and to provide such groups with more time to provide submissions.

Synchrony submitted that the GPSRR is currently set up to preserve the status quo and is not set up to shift with societal expectations. Synchrony recommended that it may be useful to engage with relevant people on helping shift attitudes aligned with (practical) societal obligations that trickle down from ministers/boards/commissioners, taking influence from outside the system.

AEMO response

Regarding the draft approach paper consultation period, the NER require that AEMO allows at least 20 business days for that consultation. In addition to this, AEMO actively collaborates with NSPs and key external stakeholders as part of risk assessment process, and shares the draft approach paper a week or so prior to publication for industry consultation to provide an opportunity for verbal feedback as well as to help inform written

⁷ For details on the South Australian protected event, see <https://www.aemc.gov.au/market-reviews-advice/request-declaration-protected-event-november-2018> and <https://www.aemc.gov.au/market-reviews-advice/revoking-south-australian-protected-event>.

⁸ See <https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability/update>.

⁹ See <https://www.energycouncil.com.au/media/qluhsmc4/2023-07-11-final-report-form-of-the-reliability-standard-stc.pdf>.

submissions. Feedback and suggestions may be provided at any time, for consideration in current and / or future GPSRRs.

Synchrony specifically identified Engineers Australia as a potentially relevant stakeholder, and AEMO has since directly shared the 2024 GPSRR Approach Paper and encouraged future engagement.

AEMO actively engages with state governments and jurisdictions to ensure the GPSRR approach adapts as appropriate with shifting societal attitudes and expectations. An example of this is Recommendation 4 from the 2023 GPSRR which relates to participating jurisdictions developing emergency contingency plans. For the 2024 GPSRR, AEMO shared an invitation to Jurisdictional System Security Coordinators (JSSCs) to the industry briefing session on 15 September, which included a page turn of the 2024 GPSRR approach paper.

2.9 Other relevant feedback

Energy Queensland comments

Energy Queensland noted that the 2023 GPSRR and the 2024 Approach Paper do not refer to the 25 May 2021 event relating to Callide Power Station. Energy Queensland recommended that AEMO provide confirmation if there were sufficient mitigations available across the system within a reasonable timeframe.

Energy Queensland also noted in relation to Section 3.6 that there have been some smaller-scale market suspensions earlier in 2023 (for example, New South Wales in March due to Supervisory Control and Data Acquisition (SCADA) failure) which are not mentioned in the 2024 GPSRR Approach Paper.

Synchrony comments

Synchrony suggested the following be considered for the GPSRR Approach:

- A clear and consistent context should be established. The document's primary context should be the performance of the overall system or asset portfolio. Each provider's context and priorities should be understood and harmonised to ensure a more accurate and consistent risk assessment.
- A comprehensive risk assessment should be performed including the involvement of risk engineers considering economic, social, security and environmental impacts. Likelihood categories should be revised to a broader scale in more consistent increments. A larger matrix should be considered to assess the relative significance of the full range of risks and opportunities (inherent and residual). Proposed risk treatments should be organised at a variety of levels with consideration of the treatment/control effectiveness, value for money and preferred timing.
- The approach may not capture holistic risks that could impact the overall system. It focuses on specific events and conditions but may not consider the interactions between different factors.
- The proposed processes for risk communication and consultation should be described and based on proactive risk reduction. It should also include communication and consultation with other industries regarding risks and opportunities (such as transport and electric vehicles (EVs)).
- Revisions to the method for calculating VCRs could be considered, to encompass a broader range of impacts including social, environmental, and national security concerns.
- A section for terms and definitions could be included. The use of non-standard risk terms should be kept to a minimum and, where risk terms are introduced, clear definitions should be provided.

AEMO response

In relation to Energy Queensland's submission:

- Callide event recommendations are covered in the 2022 PSFRR and 2023 GPSRR and any open recommendations will continue to be tracked in the 2024 GPSRR and future GPSRRs. Additionally, contingencies considered in the UFLS studies planned for the 2024 GPSRR involve generator contingency events of a similar magnitude to the events of 25 May 2021.
- AEMO plans to summarise the recent SCADA failures and market suspension events as part of the 2024 GPSRR. This has been added to Section 3.6 of the 2024 GPSRR approach paper.

In relation to Synchrony's submission:

- As summarised above, AEMO actively collaborated with NSPs to ensure that risk assessment approaches are consistent. AEMO also provided context for the risk assessment process through a presentation to participating NSPs in May 2023.
- Any preliminary risk cost assessment completed in the GPSRR will include consideration of the effectiveness of the associated mitigation measure, as well as the anticipated timing of implementation. In the 2023 GPSRR, these details were included as part of the risk cost assessment completed for a Queensland – New South Wales Interconnector (QNI) SPS (Recommendation 2).
- The risk assessment documents completed by NSPs in collaboration with AEMO included further consideration of system interactions and overall system risk, as summarised in Section 3.2 of the draft 2024 GPSRR approach paper. Additionally, for any priority risk studied as part of the GPSRR, AEMO works with the relevant NSPs to ensure that system interactions are accurately modelled.
- As described above, the risk cost assessment completed as part of the GPSRR is designed to be a preliminary indicator of the feasibility of the recommended mitigation measure. This risk cost assessment methodology is in line with the AER's Industry practice application note for asset replacement planning¹⁰. This methodology is approved by the AER as it is consistent with the national electricity objective (NEO) and good industry practice.
- Section 3.2 of the draft 2024 GPSRR approach paper includes descriptions of the risk assessment terms and categories, as well as a summary of what additional information was provided by NSPs as part of the completion of the risk assessment document. AEMO considers relevant risk frameworks and will continue to enhance the approach where appropriate and aligned with the objectives of the GPSRR.

2.10 Simon Bartlett submission

AEMO thanks Simon Bartlett for his submission. A summary of the submission's relevant comments and AEMO's response is included below.

¹⁰ See <https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%202025%20January%202019.pdf>.

Simon Bartlett comment

The submission claims that AEMO, in planning the VNI West augmentation, has not considered the risk identified in 2022 PSFRR Recommendation 10.

Background information

Recommendation 10 from the 2022 PSFRR¹¹ states “*Western Renewables Link is anticipated to be delivered and release full capacity by July 2026. This network reinforcement will enable greater transfer of generation from Western Victoria to Melbourne by building a new 220 kV double circuit transmission line from Bulgana to a new terminal station north of Ballarat, and a new 500 kV double circuit line from north of Ballarat to Sydenham. The non-credible loss of the proposed 500 kV lines during periods when the new 500 kV lines flow exceeds the limits of the parallel 220 kV lines, could result in multiple line losses. AEMO (as Victorian transmission planner) will consider this risk in the planning process.*”

In addition, in the 2023 GPSRR, AEMO made a broad recommendation related to implementing suitable controls for significant non-credible contingency events in the NEM. Recommendation 6 from the 2023 GPSRR states “*In line with the requirements of NER S5.1.8, NSPs continue to consider non-credible contingency events which could adversely impact the stability of the power system. In considering these non-credible contingency events, NSPs should identify and implement suitable controls to mitigate any identified risks. It is anticipated that these controls may involve the implementation of new RASs, in which case NSPs should consult with AEMO and refer to the RAS Guidelines developed by AEMO and NSPs*”.

AEMO response

AEMO Victorian Planning¹² (AVP) has considered this risk in its planning process and responded to the 2022 PSFRR recommendations in the 2022 *Victorian Annual Planning Report* (VAPR)¹³, and as such, AVP is currently investigating a control scheme to help mitigate this risk (and a similar risk associated with non-credible contingency events on VNI West). The scheme, like other existing control schemes in the network, will be designed to minimise disruption to the transmission system and reduce the probability of cascading failure, in line with the requirements of NER S5.1.8. As there is an open recommendation being progressed by AVP to mitigate the identified risk, AEMO does not consider the non-credible contingency of the proposed WRL or VNI West circuits a priority risk for assessment in the 2024 GPSRR.

It should be noted that instances of 500 kV double circuit outages are rare. The only known non-credible 500 kV double circuit outage due to failure of primary infrastructure since 2006 was an event in January 2020 where extreme weather (convective downdraft) caused tower failure on lines between Heywood and Moorabool. While this was a significant event, it did not result in loss of residential supply in any NEM region. After this event, design practices were reviewed against current standards and it was found that older design standards did not consider convective downdraft wind gusts in tower design (current standards do consider convective downdraft wind gusts). Although these types of non-credible events are rare, AVP is obligated to evaluate mitigation options for these risks, including consideration of appropriate emergency control schemes, in the planning process. In the case of WRL/VNI West, towers will be designed to the latest standards, meaning the equipment is designed to

¹¹ See 2022 PSFRR at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/psfrr/2022-final-report--power-system-frequency-risk-review.pdf?la=en.

¹² AEMO in its role as the Victorian transmission system planner.

¹³ See Section 4.7, 2022 VAPR, at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/vapr/2022/2022-victorian-annual-planning-report.pdf?la=en.

withstand external events (such as high winds), to maintain a secure and reliable power system. The design and specifications of assets will be informed by locational factors and conditions that are expected to occur over the entire asset life, such as expected maximum wind speeds at the line's precise geographic location, to minimise the risk of asset failure even under extreme conditions.

Other than the tower failure event described above, three other non-credible events caused by maloperation of secondary protection and communications equipment on the 500 kV network have occurred since 2006. Although rare, the likelihood of similar 500 kV line protection and communications equipment maloperation can be greatly reduced with suitable protection design, maintenance and asset management practices.

It should be noted that the design of the 500 kV circuit underwent a significant cost benefit analysis process, and the final option was considered the best outcome for Victorian consumers. Given the cost differential between this option and other options considered, it is unlikely that the design of a RAS to meet the requirements of S5.1.8 would change the preferred option of either project. Further, the cost of a RAS, if proven to cost-effectively reduce this risk, is small relative to the cost of the projects, and total cost would still remain within the range used in the Regulatory Investment Test for Transmission (RIT-T).

Simon Bartlett comment

The submission included an assumption that VNI West will carry up to 4,240 megawatts (MW) of load based on contributions from Murray River Renewable Energy Zone (REZ), Western Victoria REZ, VNI imports and total hosting capacity on VNI West (noting there is diversity in maximum flow contributions to VNI West flows from each of these sources).

AEMO response

Higher flows through major corridors and from REZs can lead to a greater potential for high impact contingency events to occur. This reinforces the need to review existing UFLS capabilities across the NEM as a safety net for large disturbance events as a priority risk in the 2024 GPSRR.

AVP's published REZ transmission limits are limits that are used as inputs to the market modelling, alongside a simplified network model of equivalenced network impedances and other network limitations. Each input REZ transmission limit presented in the VNI West published Project Assessment Conclusions Report (VNI West PACR)¹⁴ was calculated largely in isolation of other REZ limits and, as such and due to various overlapping network limits, it is not expected that multiple REZs can or would reach their REZ transmission limit at the same time.

Additionally, as per the VNI West PACR, the VNI West interconnector is designed and modelled to deliver a maximum transmission capability increase of 1,935 MW from Victoria to New South Wales and 1,669 MW from New South Wales to Victoria. As such, the double-circuit 500 kV lines that form VNI West and WRL will not be expected to carry all of the 4,240 MW of additional REZ limit capacity presented in the VNI West PACR instantaneously. As shown in Figure 1 below, taken from the VNI West PACR, the total maximum flow across all VNI (being the combined capacity of VNI West, the Buronga-Red Cliffs line, and the VNI East lines) will be limited to the range of 3 gigawatts (GW) flow from Victoria to New South Wales and 2 GW from New South Wales to Victoria.

¹⁴ At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/victorian_transmission/vni-west-rit-t/reports-and-updates/vni-west-pacr-volume-1.pdf?a=en.



Figure 1 Flow duration curve on combined VNI interconnectors with VNI West augmentation



Simon Bartlett comment

The submission claimed:

- a non-credible trip of both 500 kV VNI West lines from Bulgana to Sydenham (when these lines are highly loaded) will cause instantaneous or near instantaneous trip of the 220 kV lines in parallel to the 500 kV lines,
- that it follows that this will cause cascading power system collapse and likely blackout of large parts of Victoria, and
- SPS/RAS designed to manage the above risk are unlikely to be effective.

AEMO response

Non-credible contingency events affecting any of the existing critical circuits throughout the NEM are rare. In addition, for a non-credible contingency event to cause cascading failures and potential blackouts to large parts of Victoria, it would:

- need to be a significant event (involving a key double circuit or multiple transmission elements),
- have to be an event which AEMO was unable to foresee and take operational actions to mitigate the risk, and
- Have to occur during worst case or challenging power system conditions (where cascading failure is possible and emergency controls such as UFLS and any RAS schemes designed to manage the non-credible event are less effective).

Given the above, installing significant additional transmission equipment (such as additional circuits) to eliminate the risk of such non-credible contingency events is not economically feasible.

AEMO has responsibilities to identify priority risks with technically and economically feasible solutions through the GPSRR process, and is further obliged to consider the NEO (*to promote efficient investment in, and efficient*

operation and use of, electricity services for the long term interests of consumers of electricity), balancing a number of components to this objective, of which security is only one. RASs have been proven to cost-effectively reduce the risk of key low probability, high impact non-credible events to acceptable levels.

The VNI West project in particular introduces a route-diverse additional interconnector between Victoria and New South Wales, which improves the overall resilience of Victoria's connection to the rest of the NEM against both credible and non-credible contingency events. AVP has considered the implications of operating the WRL 500 kV lines in parallel with the existing 220 kV network and is currently investigating whether the potential risk can be partially or fully mitigated cost-effectively with a RAS.

As per NER S5.1.8, AVP is required to consider non-credible contingency events which could potentially endanger the stability of the power system. In those cases where the consequences to the network are likely to be severe disruption, AVP must install, maintain and upgrade emergency controls within the Victorian Declared Shared Network (DSN), as necessary, to minimise disruption to the transmission network and to significantly reduce the probability of cascading failure.

Measures that AVP has taken in the DSN to date to comply with these rules include implementation of SPS, load shed and generator fast runback schemes. The assertion that control schemes are unlikely to be effective at preventing cascading failure is inconsistent with the basis for these NER requirements and AEMO's operational experience with these schemes. Examples of existing schemes that mitigate the impact of non-credible double circuit outages include:

- The EAPT (Emergency Alcoa-Portland Potline Trip) scheme which detects double circuit failure of 500 kV lines between Heywood and Moorabool and acts to separate the Victorian network from South Australia when frequency and voltage limits are breached. This scheme operates within 170 milliseconds (ms).
- The EMTT (Emergency Moorabool Transformer/Reactor Trip) scheme which detects double circuit failure of 500 kV lines between Moorabool and Sydenham and trips the Moorabool transformers and reactors to ensure voltage stability on the 220 kV network near Geelong. This scheme operates within 300 ms.
- IECS (Interconnector Emergency Control Scheme) which detects N-2 and N-3 circuit failures on the 220 kV and 330 kV network on VNI and initiates controlled automatic load and generator tripping to prevent separation of the Victorian network and further loss of supply following these non-credible contingencies. This scheme operates within 1 second.
- SW500 GFT (South West 500 kV Generator Fast Tripping) scheme which detects double circuit failure of 500 kV lines between Moorabool and Heywood and initiates runback of generators to prevent voltage oscillation following this contingency. This scheme operates within 170 ms.
- UFLS scheme which detects under frequency conditions following a separation between state networks and trips blocks of load to restore the supply demand balance and prevent blackout of the separated network. This scheme operates within 100 ms.

AVP is currently designing a similar WRL scheme to minimise disruption to the network, and significantly reduce the probability of cascading failures following a non-credible double circuit 500 kV outage of the lines between Bulgana and Sydenham, and will similarly design a VNI West scheme to help mitigate the impact of double circuit 500 kV outage of the lines between Bulgana, Kerang and Dinawan. These schemes are likely to include tripping of generators and loads where necessary to prevent system instability and potential overloading of the remaining transmission network. The designs will consider a range of operating conditions and the probability of those conditions in line with the Victorian planning approach. It is anticipated that the schemes will be similar in function

and specification to existing schemes such as IECS on the existing VNI East. In addition, during periods of high Murray generation, power flows on the existing VNI are comparable to expected flows on VNI West.

It should be noted that until design is complete, the full effectiveness of these RAS schemes will be unknown. However, based on experience with other similar schemes in the network, the new schemes, in combination with the WRL and VNI West designs, are likely to significantly reduce the probability of cascading failures (meeting the requirements of NER S5.1.8) in the event of a non-credible trip of both 500 kV WRL lines from Bulgana to Sydenham, or from Kerang to Bulgana. Further, the WRL and VNI West projects deliver significant benefits to consumers and the economic cost of installation of additional route diverse circuits to mitigate non-credible contingency risks would significantly erode the consumer benefit of both projects.

Simon Bartlett comment

The submission asked how AEMO will manage outages of the 11 500 kV circuits between Bannaby and Sydenham, on the assumption each circuit has a 98% availability, and that for 22% of the year one of these 11 500 kV circuits will be on outage and the VNI West project will be constrained to approximately 500 MW.

Background information

AEMO sought clarification on which circuits were included in the 11 500 kV circuits mentioned in the submission, and the source of the 98% availability 500 kV circuit reliability figure. The additional information received is:

- Circuits considered as part of the 11 500 kV circuits in the submission:
 - Three circuits constructed under HumeLink (a double circuit between Bannaby to Wagga, Wagga to Maragle and Maragle to Bannaby).
 - Two circuits constructed under Project EnergyConnect (double circuit between Wagga and Dinawan) (**AEMO note – these circuits will be capable of operation at 500 kV but will be operated at 330 kV**).
 - Four circuits constructed under VNI West (double circuits between Dinawan and New Kerang and between New Kerang and Bulgana).
 - Two circuits constructed under WRL (double circuit between Bulgana and Sydenham).
- The 98% figure quoted in the submission refers to the average availability of 500 kV transmission circuits determined from international surveys undertaken by CIGRE. It covers outages for planned maintenance, forced outages and project outages.

AEMO response

AVP has used historical data from Victoria as an appropriate indicator of future performance. Based on historical data from 500 kV lines in the Victorian network, AVP expects the availability of the average 500 kV line in that network to be approximately 99.8%. There is also potential for new 500 kV circuit reliability to be higher than historical performance, given advancements in design and construction techniques since most of the existing Victorian network was built.

The submission assumed that each 500 kV circuit in Victoria will experience a one-week (planned or unplanned) outage every year and each of these outages would occur at different times of the year. This assumption does not align with current asset management practices or experience operating 500 kV circuits in the NEM, which includes planning outages in a co-ordinated way to minimise the market impact and maintain power system

security. In addition, normal asset management practice is to stagger planned maintenance activities such that all equipment does not require planned outage works in every year.

Planned outages and credible contingency events are part of normal system planning exercises and include the application of constraints as required to maintain power system security and meet the requirements of the NER. Outage management procedures exist to manage all planned and unplanned 500 kV system events. Planned outages occur at times where the system impact is minimised and without compromising security.

The assumption that a 500 MW limit will apply to VNI West at all times when a planned or unplanned outage occurs is overly pessimistic. AEMO also notes that the existing VNI nominal capacity from Victoria to New South Wales is approximately 700 MW-1,600 MW and from New South Wales to Victoria is approximately 400 MW-1,350 MW depending on system conditions.

Simon Bartlett comment

AEMO received some further comments including:

- The simultaneous tripping or outage of a 500 kV double circuit has not been considered in the planning process for VNI West and WRL.
- Statements about the management of the following risks in the NEM:
 - Severe lightning strikes
 - Bushfires
 - Flooding/flood damage
 - Destructive winds
 - Sabotage and vandalism

AEMO response

AVP has considered the risk of a 500 kV double circuit outage in its planning process and, as there is an open recommendation being progressed by AVP to mitigate the identified risk, AEMO does not consider the non-credible contingency of Western Renewables Link circuits a priority risk for assessment in the 2024 GPSRR. In addition, as per NER S5.1.8, TNSPs are required to consider non-credible contingency events which could adversely impact the stability of the power system when planning the network.

To manage non-credible contingencies, AEMO can reclassify non-credible contingencies as credible or take other operational actions to secure the system in response to abnormal conditions (including bushfires, lightning and damaging/destructive winds). Where the likelihood of a significant non-credible contingency event is increased, these actions allow AEMO to maintain power system security. For further information on risk management in the NEM for lightning strikes, bushfires, flooding, destructive winds and vandalism/sabotage please see AEMO's published Power System Security Guidelines¹⁵.

NER 5.20A requires AEMO in identifying priority risks to consider if there are technically and economically feasible solutions to mitigate those risks, the likelihood of the event or condition occurring, and the severity of any likely outcomes. AEMO is further obliged to consider the NEO (*to promote efficient investment in, and efficient*

¹⁵ At https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715%20Power-System-Security-Guidelines.pdf.

operation and use of, electricity services for the long term interests of consumers of electricity), balancing a number of components to this objective of which security is only one.

There may be many external events which have the potential to cause uncontrolled increases or decreases in frequency or cascading outages/major supply disruptions. Factoring in the low likelihood of these types of non-credible contingency events, the availability of other effective means of mitigating the risk and other considerations including those outlined above, installing additional transmission equipment (such as additional circuits) to eliminate or further reduce the risk of such non-credible contingency events across the NEM is not considered economically feasible.

2.11 Industry briefing session

AEMO thanks attendees of the industry briefing session for their engagement and feedback on the 2024 GPSRR approach. Below is a summary of the questions related to the approach paper at the session, and AEMO's responses.

Questions	AEMO responses
Given the advanced stage of 2022 ISP, is one of the scenarios from the 2024 ISP considered in the review?	The forecasting data from the 2022 ISP <i>Step Change</i> scenario will be used in the 2024 GPSRR for future projections. The future dispatch scenarios selected will be reviewed based on the latest ISP information available following the publication of the Draft 2024 ISP in December 2023. If significant differences are identified in the Draft 2024 ISP, additional sensitivities may be conducted. See Section 2.1 for more details on the use of the 2022 ISP <i>Step Change</i> scenario.
Overseas, market operators contract large industrial loads to trip-off during contingencies. Are such frequency management options considered in the 2024 GPSRR?	The UFLS adequacy review for the 2024 GPSRR is intended to highlight potential gaps to investigate in more detail and for solution options to be explored, including those suggested in the industry briefing session. See Section 2.5 for more details on priority risks.
Could AEMO please clarify which single circuit breaker failure (CBF) in the Latrobe Valley leads to loss of multiple generating units?	A fault on the Loy Yang B unit 2 transformer followed by the failure of the single bus circuit breaker (CB) that connects the 500 kV No.3 Bus and Loy Yang B unit 2 results in trip of No.3 bus as well as Loy Yang B units and Valley Power units. AEMO will include a detailed description in the final report on this contingency. See Section 2.5 for more details on priority risks.
Given the low-capacity factor of the Valley Power units how does AEMO factor in the probability of these units being in-service?	AEMO applies historical dispatch conditions as a basis for determining how likely it is the Valley Power units are dispatched. Given their potential impact on this contingency event, AEMO intends to undertake sensitivity studies with them operating if they are not online in the starting case. See Section 2.5 for more details on priority risks.
Is it confirmed that the proposed configuration for HumeLink is a double circuit line?	Transgrid's HumeLink project webpage confirms that HumeLink is a 500 kV double circuit line. See Section 2.5 for more details on priority risks.

3 Summary of changes

Considering the consultation feedback that AEMO has received in both written submissions and the industry Q&A session, AEMO has made a number of updates to the approach paper. These changes have been made as new information has become available, through review of the scope of work required to complete the GPSRR, and for clarification purposes.

In summary, these changes are:

- Throughout the document, updates to change the document from a consultation phase to a final stage and to provide updates on the latest status and timeline.
- In response to Energy Queensland's comment (see Section 2.9), added recent SCADA failures and associated Market Suspension events¹⁶ in mainland NEM regions to Section 3.6.
- Approach paper updated in Section 2.2 to note that ISP projects/major changes to state-based schemes will be considered if they are included in the Draft 2024 ISP.
- Approach paper updated to note in Section 1.3 that the risk assessment approach will be described in the GPSRR report.
- Approach paper updated in Section 3.6 to note that key operational risks will be summarised in the GPSRR paper, such as those that may arise with the planned retirement of thermal power stations.
- Approach paper updated in Section 3.5 to indicate that more detail regarding snapshot selection will be provided in the 2024 GPSRR.
- Approach paper updated in Section 3.6 to note that updates on AEMO's review of the protected event framework will be included in the 2024 GPSRR scope.
- In response to a comment from the industry briefing session (see Section 2.11), added further details to the description of Risk 1 (CBF event in Latrobe Valley leading to trip of multiple large generating units and Basslink instability), including a simplified single line diagram of a CB fail event at Loy Yang power station to Section 3.5.

¹⁶ See <https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-events-and-reports/market-event-reports>.

Abbreviations

Abbreviation	Term	Abbreviation	Term
AC	alternating current	NEO	national electricity objective
AER	Australian Energy Regulator	NER	National Electricity Rules
AEMO	Australian Energy Market Operator	NSCAS	network support and control ancillary services
BESS	battery energy storage system	NSP	Network Service Provider
CB	circuit breaker	NSW	New South Wales
CBF	circuit breaker fail	OFGS	over frequency generator shedding
CMLD	composite load model	OPDMS	Operations and Planning Data Management System
CQ-SQ	Central Queensland – South Queensland	OTR	Operations Technology Roadmap
DER	distributed energy resources	PACR	Project Assessment Conclusions Report
DNSP	distribution network service provider	PFR	primary frequency response
DPV	distributed photovoltaic (generation)	PSCAD™	Power System Computer Aided Design
DSO	distribution system operator	PSFRR	Power System Frequency Risk Review
EAPT	Emergency Alcoa-Portland Potline Tripping	PSS®E	Power System Simulation for Engineering
EDGE	Energy Demand and Generation Exchange	QNI	Queensland – New South Wales Interconnector
EMTT	Emergency Moorabool Transformer/Reactor Trip	RAS	remedial action scheme
ENA	Energy Networks Australia	REZ	renewable energy zone
EUFR	emergency under frequency response	RoCoF	rate of change of frequency
EV	electric vehicle	SCADA	supervisory control and data acquisition
FCAS	frequency control ancillary services	SOCI	Security of Critical Infrastructure Act
HVDC	high voltage direct current	SLACIP	Security Legislation Amendment (Critical Infrastructure Protection)
GPSRR	General Power System Risk Review	SPS	special protection scheme
IECS	Interconnector Emergency Control Scheme	SW500 GFT	South West 500kV Generator Fast Tripping
ISP	<i>Integrated System Plan</i>	TNSP	transmission network service provider
JSSC	Jurisdictional System Security Coordinator	UFLS	under frequency load shedding
kV	kilovolt/s	VAPR	Victorian Annual Planning Report
MNBPFRR	mandatory narrow band primary frequency response	VCR	value of customer reliability
MW	megawatt/s	VIC	Victoria
NEM	National Electricity Market	VNI	Victoria – New South Wales Interconnector
NEMOC	National Electricity Market Operations Committee	WRL	Western Renewables Link