Amendments to the Inertia Requirements Methodology

Consultation paper - Standard consultation for the National Electricity Market

Published: 5 July 2024

aemo.com.au

New South Wales | Queensland | South Australia | Victoria | Australian Capital Territory | Tasmania | Western Australia

Australian Energy Market Operator Ltd ABN 94 072 010 327

Explanatory statement and consultation notice

This consultation paper commences the first stage of the standard rules consultation procedure[1] conducted by AEMO to update the Inertia Requirements Methodology (the **Methodology**) published under National Electricity Rules (**NER**) 5.20.4. The standard rules consultation procedure is described in NER 8.9.2.

The Australian Energy Market Commission (**AEMC**) published the *National Electricity Amendment (Improving security frameworks for the energy transition) Rule 2024* (**Amending Rule**) in March 2024[2]. With effect from 1 December 2024, the Amending Rule introduces new inertia planning requirements, removes restrictions on the procurement of synthetic inertia, and increases alignment between the inertia and system strength procurement frameworks.

AEMO proposes to amend the Methodology by 1 December 2024 to reflect these new requirements and changes. AEMO is also proposing additional changes to the Methodology to improve the accuracy and utility of AEMO's annual inertia assessments.

The requirements and proposed changes are summarised below. The detailed sections of this paper include more information on the proposal, options, and AEMO's supporting rationale.

- **Section 3.1 – NER requirement: system-wide inertia level and inertia sub-network allocation**
  - The Amending Rule introduces a new annual obligation on AEMO to calculate a system-wide inertia level[3] to support secure interconnected operation on the mainland. AEMO must allocate portions of this inertia level among mainland inertia sub-networks based on a balanced procurement approach.
  - AEMO proposes that the Methodology detail an approach to calculating system-wide inertia that meets RoCoF and frequency requirements and ensures that the system can find a new stable operating point following credible system disturbances.
- **Section 3.2 – NER requirement: process for determining sub-network islanding risk**
  - The Amending Rule requires that the Methodology describe how the likelihood of a sub-network islanding is determined[4] and sets out the matters that AEMO must take into account in its determination[5].
  - AEMO proposes to provide a set of principles in the Methodology that will guide AEMO's determination of sub-network islanding risk in each annual Inertia Report. These principles include the level and duration of inertia typically available, the inertia sub-network allocation in adjacent sub-networks, and the likelihood of islanding under contingency events.
- **Section 3.3 – NER requirement: inertia network services specification**
  - The Amending Rule requires that the Methodology include a new inertia network service specification that sets out the required capabilities of synchronous and synthetic inertia service

[1] The standard rules consultation procedure is described in NER 8.9.2.

[2] At https://www.aemc.gov.au/sites/default/files/2024-03/ERC0290%20-%20ISF%20final%20determination.pdf.

[3] New clause 5.20B.2(b)(1) to be substituted by the Amending Rule.

[4] New clause 5.20.4(d2) to be inserted by the Amending Rule.

[5] New clause 5.20B.2(d) to be inserted by the Amending Rule.

providers, and the process and requirements for AEMO to approve the equipment by which inertia network services will be made available[6].

- AEMO proposes to include the inertia network service specification as part of the Methodology. The specification is intended to include the requirements outlined in Section 3.3.3, and the testing approach described in Section 3.3.4, as the basis of assessing non-synchronous equipment for the provision of inertia network services. AEMO is seeking feedback on the suitability and completeness of these arrangements.

- **Section 3.4 – Methodology improvement: redispatch assumptions**
  - The current Methodology assumes that a generating unit's output will reduce to its Minimum Operating Level via the central dispatch process under certain conditions to reduce the size of the generation contingency to the lowest practical level[7].
  - AEMO proposes to amend this assumption in the Methodology to account for circumstances where it is not practicable to reduce the size of a contingency event by reducing a generating unit's output in advance of the contingency occurring.
- **Section 3.5 – Methodology improvement: credible events leading to island formation**
  - The current Methodology does not explicitly account for the contingency event that causes a viable island to form, and instead assumes that during credible islanding risks the appropriate interconnector flows could be constrained to manage this risk. However, historical events[8] have shown that this is not always a valid assumption.
  - AEMO proposes to amend the Methodology to allow satisfactory inertia level requirements to consider credible events that may cause the formation of an island.
- **Section 3.6 – Methodology improvement: additional modelling considerations**
  - The Amending Rule requires that AEMO annually publish a forecast of inertia requirements for the next 10 years[9]. To improve the accuracy of these inertia requirement forecasts, AEMO proposes to update the Methodology to explicitly provide for:
    - Modelling expected changes in supply, demand, and network assumptions over the 10-year horizon. This includes, but is not limited to, generator retirement, committed projects, network augmentations, distributed photovoltaics (**DPV**), and load modelling assumptions.
    - Improvements to the modelling approach to account for network parameters that impact contingency sizes, and possible use of more sophisticated modelling approaches (such as multi-mass models (**MMM**s)) where necessary to add confidence to system-wide inertia results.
- **Section 3.7 – Methodology improvement: other amendments and updates**

  This section discusses the impact of other minor amendments and proposed updates to reflect the Amending Rule and to improve the clarity or accuracy of the existing Methodology.

---

[6] New clause 5.20.4(f) to be inserted by the Amending Rule.

[7] See p 18, https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-security-market-frameworks-review/2018/inertia_requirements_methodology_published.pdf?la=en&_sm_au_=iVVNjrDPDvrGWTv7j03pfK3k7WNW4.

[8] See https://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Final-report---SA-separation-event-1-December-2016.pdf.

[9] New clause 5.20B.2(b) to be substituted by the Amending Rule.

- **Revised NSCAS arrangements**

  The Amending Rule changes the definitions of "NSCAS need" and "NSCAS gap" [10]. This change allows shortfalls in inertia network services and system strength services to be identified under the NSCAS framework within a rolling three-year period[11]. AEMO proposes to update the Methodology to remove references to the previous approach.

- **Terminology updates**

  The Amending Rule changes the NER-defined term "minimum threshold level of inertia" to "satisfactory inertia level" and "secure operating level of inertia" to "secure inertia level". However, there is no change to the content of the definitions of these two inertia requirements[12]. AEMO proposes to update these terms accordingly in the Methodology.

AEMO's review of the Procedure and stakeholder feedback may identify some additional minor corrections and clarifications, which would be specified in the draft report.

Consultation notice

AEMO is now consulting on this proposal and invites written submissions from interested persons on the issues identified in this paper to **2024_security_consultations@aemo.com.au** by 5:00 pm (Melbourne time) on **2 August 2024**.

Submissions may make alternative or additional proposals you consider may better meet the objectives of this consultation and the national electricity objective in section 7 of the National Electricity Law. Please include supporting reasons.

Before making a submission, please read and take note of AEMO's consultation submission guidelines, which can be found at https://aemo.com.au/consultations. Subject to those guidelines, submissions will be published on AEMO's website.

Please identify any parts of your submission that you wish to remain confidential and explain why. AEMO may still publish that information if it does not consider it to be confidential but will consult with you before doing so. Material identified as confidential may be given less weight in the decision-making process than material that is published.

Submissions received after the closing date and time will not be valid, and AEMO is not obliged to consider them. Any late submissions should explain the reason for lateness and the detriment to you if AEMO does not consider your submission.

Interested persons can request a meeting with AEMO to discuss any particularly complex, sensitive or confidential matters relating to the proposal. Please refer to NER 8.9.1(k). Meeting requests must be received by the end of the submission period and include reasons for the request. AEMO will try to accommodate reasonable meeting requests but, where appropriate, may hold joint meetings with other stakeholders or convene a meeting with a broader industry group. Subject to confidentiality restrictions, AEMO will publish a summary of matters discussed at stakeholder meetings.

---

[10] New NER Chapter 10 definitions of 'NSCAS gap' and 'NSCAS need' to be substituted by the Amending Rule.

[11] New clause 5.20.3(c1) to be inserted by the Amending Rule.

[12] New clause 5.20B.2(b)(3) and (4) to be inserted by the Amending Rule.

Contents

Explanatory statement and consultation notice **3**

1. Stakeholder consultation process **7**

2. Background **8**
2.1. Context for this consultation 8
2.2. NER requirements 9
2.3. The national electricity objective 10

3. Proposal discussion **11**
3.1. NER requirement: System-wide inertia level and inertia sub-network allocation 12
3.2. NER requirement: process for determining sub-network islanding risk 16
3.3. NER requirement: inertia network services specification 17
3.4. Methodology improvement: redispatch assumptions 20
3.5. Methodology improvement: credible events leading to island formation 21
3.6. Methodology improvement: additional modelling considerations 22
3.7. Methodology improvement: other amendments and updates 24

Appendix A. Glossary **26**

Tables

Table 1 FOS mainland system frequency outcomes (in effect from 9 October 2023) 14

Figures

Figure 1 Key Amending Rule clauses discussed in this consultation paper 9
Figure 2 High level overview of assessment methodology for system-wide inertia levels 12
Figure 3 Conceptual power system simulation steps to determine system-wide inertia and allocations. 13
Figure 4 Relationship between inertia and FFR in Queensland from 2023 inertia requirements study 15

1. Stakeholder consultation process

As required by the National Electricity Rules (**NER**) clause 5.20.4, AEMO is consulting on the proposed amendments to the Inertia Requirements Methodology (**Methodology**) in accordance with the standard Rules consultation procedures in NER 8.9.2.

Note that this document uses terms defined in the NER, which are intended to have the same meanings. There is a glossary of additional terms and abbreviations in Appendix A.

AEMO's indicative process and timeline for this consultation are outlined below. Future dates may be adjusted and additional steps may be included if necessary, as the consultation progresses.

Consultation steps	Dates
Consultation paper published	5 July 2024
Submissions due on consultation paper	2 August 2024
Draft report and draft Methodology published	Expected 9 September 2024
Submissions due on draft report	Expected 7 October 2024
Final report and final Methodology published	Expected 5 November 2024

2. Background

2.1. Context for this consultation

The Australian Energy Market Commission (**AEMC**) published the *National Electricity Amendment (Improving security frameworks for the energy transition) Rule 2024* (**Amending Rule**) in March 2024. The Amending Rule will expand the system security procurement frameworks for the National Electricity Market (**NEM**), providing AEMO with new tools to manage power system security in the NEM through the energy transition.

The Amending Rule requires changes to several AEMO documents, including the Methodology which is the focus of this consultation. In addition to required changes, AEMO is also proposing several amendments that improve the clarity, accuracy, or utility of the Methodology itself.

The Amending Rule has made four key updates to the inertia framework:

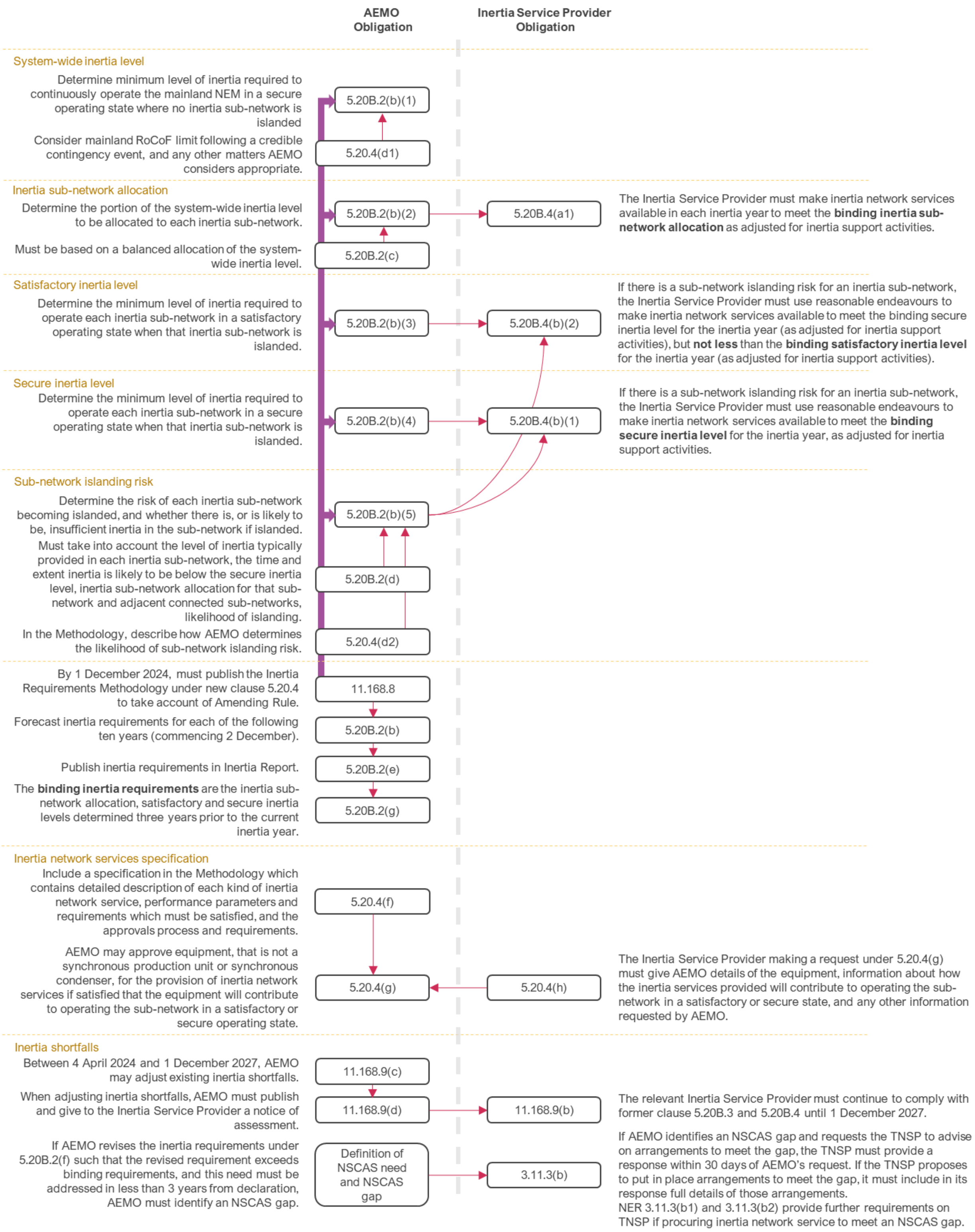
1. AEMO must now set a system-wide inertia level for the mainland NEM regions, based on satisfying relevant frequency excursion bands and rate of change of frequency (**RoCoF**) limits following any credible contingency event. Previously no inertia requirements were specified during the typical interconnected operation of NEM mainland regions.
2. AEMO must allocate portions of this new system-wide inertia level among mainland inertia sub-networks in a way that promotes balanced procurement. The relevant transmission network service provider (**TNSP**) must then procure sufficient services or assets to ensure the full regional allocation is continuously available.
   - If AEMO determines that a sub-network carries a likely risk of islanding, the relevant TNSP must also procure to meet higher local requirements that can be enabled during periods where such a credible contingency event is in effect.
3. The Amending Rule aligns the procurement timeframes of the system strength and inertia frameworks, providing TNSPs with an opportunity for greater investment coordination. In particular:
   - AEMO must annually forecast the inertia requirements for all inertia sub-networks over a 10-year period commencing 1 December 2024.
   - TNSPs will be required to procure inertia to meet the inertia requirements as published three years prior, starting from 1 December 2027.
   - In the interim three years, the Amending Rule allows AEMO to address any identified inertia shortfall through the network support and control ancillary service (**NSCAS**) framework.
4. The Amending Rule broadens the scope of services capable of meeting requirements to qualify as an inertia network service to include synthetic and other non-synchronous service providers. Procurement from these providers is subject to AEMO approval.
   - To facilitate this process, AEMO is required to consult on an inertia network service specification to be included in the Methodology which details the minimum requirements and performance parameters that such services must meet.

AEMO is also conducting a separate consultation process on proposed changes to the NSCAS procedures that implement other aspects of the Amending Rule.

2.2. NER requirements

Figure 1 lists some clauses in the Amending Rule which impose obligations on either AEMO or the TNSPs and are discussed in this consultation paper.

Figure 1 Key Amending Rule clauses discussed in this consultation paper



2.3. The national electricity objective

Within the specific requirements of the NER applicable to this proposal, AEMO will seek to make a determination that is consistent with the national electricity objective (**NEO**) and, where considering options, to select the one best aligned with the NEO.

The NEO is expressed in section 7 of the National Electricity Law as:

> *to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:*
>
> *(a) price, quality, safety, reliability and security of supply of electricity; and*
>
> *(b) the reliability, safety and security of the national electricity system; and*
>
> *(c) the achievement of targets set by a participating jurisdiction—*
>
> *(i) for reducing Australia's greenhouse gas emissions; or*
>
> *(ii) that are likely to contribute to reducing Australia's greenhouse gas emissions.*

3. Proposal discussion

AEMO proposes to amend the Methodology, effective from 1 December 2024, by:

- Including a methodology for determining the new system-wide inertia level, and the allocation of this to individual inertia sub-networks.
- Including a new specification that describes each kind of inertia network service, the relevant performance parameters, requirements to be satisfied by the service, and the process and requirements for AEMO to approve associated equipment.
- Removing sections in the existing Methodology related to inertia shortfall determination and replacing these with references to the NSCAS Description and Quantity Procedure for the new inertia NSCAS gap arrangements.

AEMO also proposes to amend the Methodology to improve the accuracy of inertia assessments by:

- Explicitly allowing consideration of representative operational scenarios when determining inertia requirements, including the dispatch levels at which generators may be tripped, and scenarios that may cause reclassification of contingency events as credible contingency events.
- Explicitly allowing consideration of future network changes and the behaviours of load and distributed photovoltaics (**DPV**) in the power system simulation studies. This allows more accurate representation of the network to be considered in determining the inertia requirements over a 10-year horizon.
- Explicitly allowing for tuning of the models to account for network parameters that impact contingency sizes, and the possible implementation of more sophisticated models. This will allow more accurate frequency deviations and RoCoF to be calculated.

AEMO expects that some other minor drafting improvements or corrections to the Procedure may be identified during this consultation.

The amendments considered in this proposal will mostly affect TNSPs who are responsible for meeting their binding inertia requirements, and AEMO who can procure inertia network services to meet the binding inertia requirements through the NSCAS framework as a last resort. Other Market Participants may be able to provide an inertia network service to resolve a declared NSCAS gap.

The following subsections give more details on AEMO's proposed amendments to the Methodology, including the requirements, issues giving rise to the proposals, and any alternative options considered.

3.1. NER requirement: System-wide inertia level and inertia sub-network allocation

3.1.1. Issue description

The Amending Rule introduces a new obligation on AEMO to set a system-wide inertia level, which will be defined under new clause 5.20B.2(b)(1) as:

> *the minimum level of* inertia *required to continuously operate the* power system *(excluding the Tasmania* region*) in a* secure operating state *where no* inertia sub-network *is* islanded.

New clause 5.20.4(d1) will require that, in determining the system-wide inertia level, AEMO considers:

> *(1)* *the rate of change of* frequency *limit for the mainland following a* credible contingency event*, as specified in the* frequency operating standard*; and*
>
> *(2)* *any matters* AEMO *considers appropriate.*

AEMO must allocate portions of the system-wide inertia level to each inertia sub-network (excluding the Tasmania region). New clause 5.20B.2(b)(2) will define inertia sub-network allocation as:

> *for each* inertia sub-network*, the portion of the* system-wide inertia level *allocated to that* inertia sub-network*, as determined in accordance with paragraph (c).*

Paragraph (c) of new clause 5.20B.2 will require the inertia sub-network allocation to be based on:

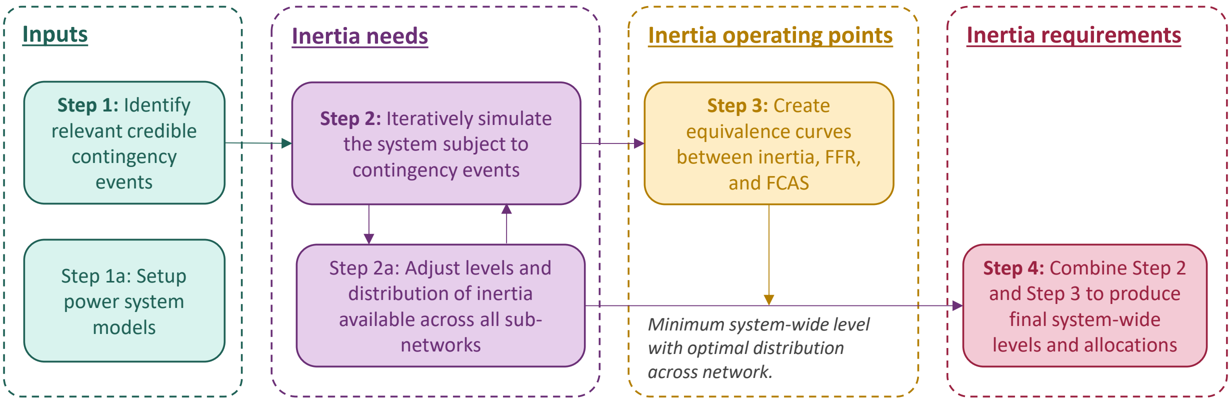
> *(1)* *a balanced allocation of the* system-wide inertia level *across the* national grid *(excluding the Tasmania* region*); and*
>
> *(2)* *any other matters* AEMO *considers appropriate.*
>
> *provided that the sum of all portions allocated to all* inertia sub-networks *must not exceed the* system-wide inertia level*.*

The existing methodology for calculating regional islanded inertia requirements, including the secure inertia level and satisfactory inertia level, remains largely unchanged.

3.1.2. Description of proposal

AEMO proposes to calculate the system-wide inertia level using the following four step methodology:

Figure 2 High level overview of assessment methodology for system-wide inertia levels



Step 1: Identify the most significant credible contingencies.

This step identifies all relevant credible contingency events to be tested in the power system simulation studies, which can include events such as:

- **Generation contingency** – this is the generating unit/generating system whose loss produces the highest RoCoF measured at any location in the power system.
- **Load contingency** – generally, the largest load in the NEM would be an industrial load, such as a smelter or potline, the size of which is largely uncontrollable via the central dispatch process.
- **Separation event** – a credible contingency affecting a transmission element that results in an island.

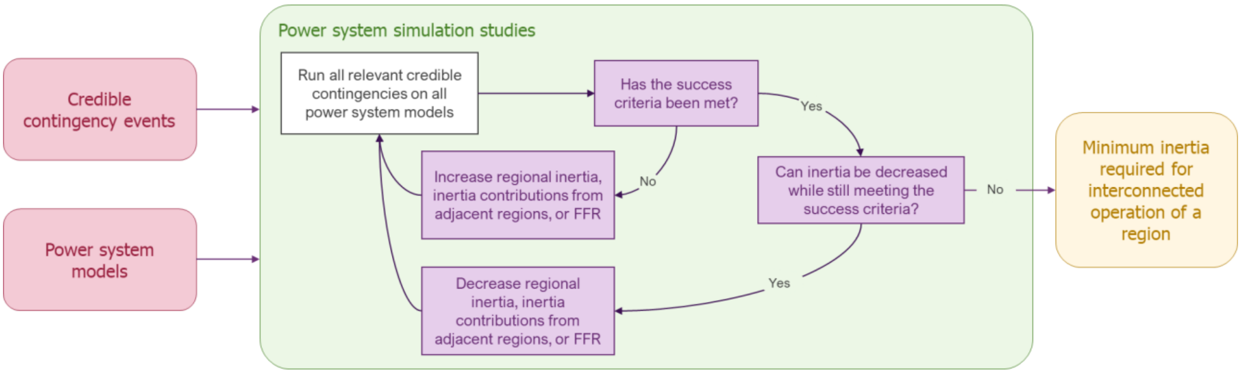
Some of these contingencies may include an associated reduction in DPV output or load due to the voltage dip caused by the contingency. AEMO intends to use the latest DPV and load models available to capture the impact of this response on inertia requirements.

Step 2: Undertake power system studies to identify minimum inertia requirements.

AEMO would undertake power system simulation studies to assess the frequency trajectory in various NEM scenarios following each of the credible contingency events identified in Step 1. For each of these cases, AEMO would simulate the system with different levels of inertia in each mainland region until satisfied that the minimum level required for secure interconnected operation is identified in all regions.

Figure 3 below provides a simplified view of the iterative steps that AEMO proposes to take in its power system simulation studies to determine the minimum inertia required during interconnected operation, taking account of the locational implications of inertia placement across the NEM.

Figure 3 Conceptual power system simulation steps to determine system-wide inertia and allocations.



The following success criteria must be met at a minimum in all regions for the resulting case to be considered as having sufficient inertia:

- RoCoF and frequency requirements specified in the latest version of the Frequency Operating Standard (**FOS**)[13] are met for all interconnected operating conditions. ￼￼ below provides a summary of the FOS requirements in effect from 9 October 2023.
- Following any credible contingency event, all regions must find a new stable operating point:
  - Voltages in the high voltage transmission network returned to nominal voltages.

[13] See https://www.aemc.gov.au/sites/default/files/2023-04/FOS%20-%20CLEAN.pdf.

- No automatic load (under-frequency load shedding (**UFLS**)) or generation shedding (over-frequency generation shedding (**OFGS**)) occurred.
- All in-service generation remain connected and returned to new steady-state conditions, except generators included in any special control or protection scheme.

Table 1 FOS mainland system frequency outcomes (in effect from 9 October 2023)

Condition	Containment band (hertz (Hz))	Stabilisation band (Hz)	Recovery band (Hz)	RoCoF
Generation event or load event	49.5 - 50.5	49.85 - 50.15 (within 5 minutes)		±1 hertz per second (**Hz/s**) (measured over any 500 millisecond (ms) period)
Network event	49.0 - 51.0	49.5 - 50.5 (within 1 minute)	49.85 - 50.15 (within 1 minute)	
Separation event	49.0 - 51.0	49.5 - 50.5 (within 2 minutes)	49.85 - 50.15 (within 10 minutes)	
Protected event	47.0 - 52.0	49.5 - 50.5 (within 2 minutes)	49.85 - 50.15 (within 10 minutes)	As per the protected event declaration

To ensure power system security in the NEM, AEMO's power system studies are designed to accurately represent the future system needs and plausible "worst" case scenarios. Examples of matters that AEMO may consider in these studies include:

- **Supply and demand** – generally, the highest RoCoF is expected to occur following contingency events during low demand periods with low synchronous generation dispatch.
- **Forward-looking models** – under new clause 5.20B.2(g), the binding inertia sub-network allocation, binding satisfactory inertia level, and the binding secure inertia level will be respectively the forecast inertia sub-network allocation, forecast satisfactory inertia level, and forecast secure inertia level, as determined three years prior to the current inertia year[14]. AEMO will model any network changes it considers significant and relevant within the next 10 years[15].
- **Inertia distribution** – AEMO will vary the inertia distribution across the NEM in its power system simulation studies to understand the impacts of the distribution on the level of inertia required overall, and by each inertia sub-network during interconnected operation for a variety of conditions.

Step 3: Model the relationships between fast frequency response (FFR) and inertia in each inertia sub-network.

AEMO will vary the levels of FFR and inertia available in its power system simulation studies to test a selected number of operating points. Then, a tuned[16] model is used to identify a range of FFR and inertia combinations that maintain an acceptable frequency response. Figure 4 below is extracted from the 2023 Inertia Report[17] to provide an example of what the relationship between inertia and FFR typically looks like.

---

[14] New definition to be inserted in NER Chapter 10 by the Amending Rule.

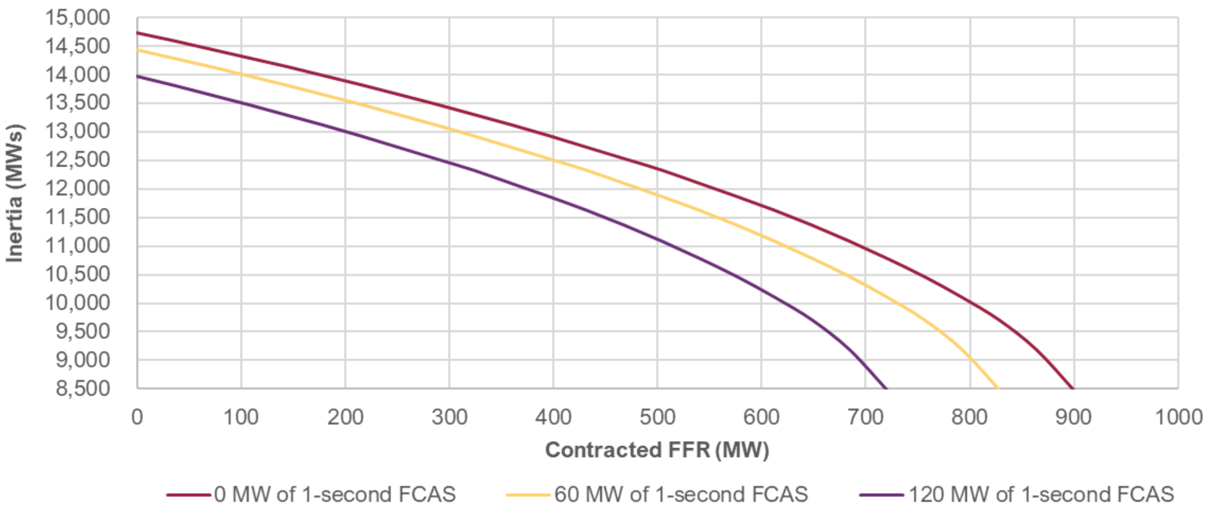
[15] See section 3.6.2 for AEMO's proposal on power system software simulation models.

[16] See section 3.6.3 for AEMO's proposal on tuning.

[17] At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/system-security-planning.

This approach was previously used to develop the relationships between regional inertia levels, contracted FFR and 1-second frequency control ancillary services (**FCAS**), for the purposes of determining secure and satisfactory inertia levels. For consistency, AEMO proposes to apply the same approach for the allocated levels of system-wide inertia.

Figure 4 Relationship between inertia and FFR in Queensland from 2023 inertia requirements study



MWs: megawatt seconds

Step 4: Determine the inertia sub-network allocation and system-wide inertia level.

For each inertia sub-network, the inertia sub-network allocation is calculated as the inertia requirement determined in Step 2 as adjusted for the level of FFR contracted by the relevant TNSP and the assumed levels of Very Fast Frequency Control Ancillary Service (**VFFCAS**) available in that region using the relationships developed in Step 3.

After determining the inertia sub-network allocation for all mainland regions, the system-wide inertia level is calculated as the sum of the inertia sub-network allocation of all regions (excluding Tasmania).

Questions

- Do you consider the proposed high-level methodology for determining the system-wide inertia levels and inertia sub-network allocations is appropriate?
- If not, what specific alternatives or additions might better address the NER requirement, and why?
- Are there any other issues relevant to the system-wide inertia level and inertia sub-network allocation methodology that AEMO ought to take into account?

3.2. NER requirement: process for determining sub-network islanding risk

3.2.1. Issue description

New clause 5.20.4(d2) will require the Methodology to describe how the likelihood of a sub-network islanding risk is determined for each inertia sub-network. AEMO must forecast this risk in the Inertia Report for the next 10 years. In making this determination, AEMO must take into account the considerations listed in new clause 5.20B.2(d) as follows:

> *(1) the level of* inertia *typically provided in each* inertia sub-network *having regard to typical patterns of* dispatched generation *in* central dispatch*;*
>
> *(2) over what time period and to what extent the* inertia *that is typically provided in the* inertia sub-network *is or is likely to be below the* secure inertia level*;*
>
> *(3) the* inertia sub-network allocation *for that* inertia sub-network *and adjacent connected* inertia sub-networks*;*
>
> *(4) the likelihood of the* inertia sub-network *becoming* islanded *on the occurrence of any* contingency event*; and*
>
> *(5) any other matters that* AEMO *reasonably considers to be relevant in making its assessment.*

3.2.2. Description of proposal

AEMO proposes to amend the methodology to include the list of factors from NER 5.20B.2(d) that AEMO will consider when determining and forecasting the likelihood of sub-network islanding. In addition to this mandatory list, AEMO proposes to include additional factors relating to evidence from historical islanding events, and the frequency or likelihood of specific non-credible events being reclassified as credible in operational timeframes.

AEMO will assess all listed factors for each inertia sub-network as part of the annual Inertia Report; setting out an explanation of how it has considered each of the considerations published in the Methodology. On a case by case basis, AEMO may consider additional factors it considers relevant to the assessment, and will justify these in the annual Inertia Report where applied. AEMO proposes to classify the resulting likelihood of a sub-network islanding risk as either 'plausible' or 'not plausible' for the purposes of applying any calculated regional inertia requirements.

AEMO considered undertaking this assessment on a quantitative basis, however this was not preferred due to the complexity and difficulty in quantifying the engineering judgements required for each region.

AEMO notes that there may be regions that are unlikely to island individually due to the number and strength of connections they have with adjacent regions but are at risk of forming a combined island. AEMO considers it important to assess the potential for inertia shortfalls in a multi-region island, and so may assess the likelihood of a multi-region island forming and conduct additional inertia assessments.

Questions
• Do you consider the proposed factors for classifying sub-network islanding risk are appropriate? • If not, what additional or alternative factors should also be included in this assessment, and why?

3.3. NER requirement: inertia network services specification

3.3.1. Issue description

The new NER 5.20.4(f) requires that AEMO consult on and publish a detailed specification of the required capabilities of inertia network services as follows:

> *The* inertia requirements methodology *must include a specification (**inertia network service specification**), which contains:*
>
> *(1) a detailed description of each kind of* inertia network service*;*
>
> *(2) the performance parameters and requirements which must be satisfied in order for a service to qualify as the relevant* inertia network service *and also when an* Inertia Service Provider *provides the relevant kind of* inertia network service*; and*
>
> *(3) the process and requirements for AEMO to approve equipment under paragraph (g).*

Under new clause 5.20.4(g), inertia service providers may request AEMO to approve equipment, that is not a synchronous production unit or synchronous condenser, as the means by which inertia network services are to be made available. AEMO may approve the equipment under this clause if satisfied that they will contribute to operation of the inertia sub-network in a satisfactory or secure operating state.

This section considers how such performance requirements can be specified, and how AEMO may assess and/or approve the ability of this equipment to meet the specifications.

3.3.2. Proposal for synchronous inertial response

The NER defines inertia as:

> *Contribution to the capability of the* power system *to resist changes in* frequency *by means of an inertial response from a* generating unit*,* bidirectional unit*, network element or other equipment that is electro-magnetically coupled with the power system and synchronised to the frequency of the power system.*

Noting that the new approval process in new clause NER 5.20.4(g) and (h) applies to equipment that is not a synchronous production unit or synchronous condenser, AEMO considers that synchronous generators and synchronous condensers do not require approvals under clause 5.20.4 of the NER.

3.3.3. Proposal for synthetic inertia performance parameters and requirements

Inverter-based resources (**IBR**) are typically interfaced with the power system through electronic devices rather than electro-magnetic coupling, and do not generally supply inertia as an inherent characteristic. However, it is possible for some IBR to provide a synthetic inertial response through appropriate designs and controls. This type of response can include a spectrum of services that differ in how quickly they can detect a frequency disturbance, and the profile of their response to it.

New clause 5.20.4(f)(2) requires that the Methodology set out parameters for non-synchronous services to qualify as inertia network services. These parameters must ensure services emulate the inertial response of synchronous generators in a transient timeframe without sacrificing system security.

Synthetic inertia is still an emerging area, and industry has not yet reached consensus on its definition. To aid this process, AEMO has published a voluntary specification for grid-forming (**GFM**) inverters[18].

AEMO proposes to draw from the voluntary specification and test specification[19] to provide criteria in the Methodology for synthetic inertia providers to qualify as inertia network services, including:

- The service must provide a synthetic inertial response in the form of a fast change in active power during system transients such as load or generation trip or a system split which results in a frequency change.
- Initiation of the synthetic inertial response must be inherent; that is, it should not require the calculation of frequency or RoCoF through measurements of the grid voltage waveform[20].
- The service's resistance to change in frequency is bi-directional; that is, it must act to resist frequency change for both rising and falling frequency events.
- The inertia constant of the service must be tuned based on both local and broader network conditions and requirements if configurable.
- The service must have sufficient energy buffer to provide an appropriate active power response during system transients without being limited[21].

3.3.4. Proposal for process and requirements to approve equipment

An Inertia Service Provider may request AEMO to approve equipment by which inertia network services are to be made available. As stated in new clause 5.20.4(g), AEMO may approve equipment to provide inertia network services that is not a synchronous production unit or a synchronous condenser if AEMO is satisfied the inertia network services provided by the equipment will contribute to the operation of the inertia sub-network in a satisfactory or secure operating state.

As part of the approvals process, AEMO is proposing an approach that estimates the equivalent inertia supplied by a provider through power system simulation, provided that the service satisfies the performance parameters and requirements proposed in Section 3.3.3.

This estimate would then inform the approval process by verifying its ability to contribute to the operation of the inertia sub-network in a satisfactory or secure operating state. In accordance with new clause 5.20.4(i), AEMO will then use its discretion to grant or withhold equipment approvals.

Three potential approaches are outlined below as examples of approaches that AEMO may consider when quantifying the amount of inertia provided by IBRs. All three approaches were tested through simulations on synchronous generators and GFM IBR with known inertia constants, and all three achieved accurate inertia estimate results.

[18] See https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2023/gfm-voluntary-spec.pdf.

[19] See https://www.aemo.com.au/-/media/files/initiatives/engineering-framework/2023/grid-forming-inverters-jan-2024.pdf?la=en.

[20] Further shaping of the inertial response post-initiation can utilise such calculation.

[21] The size of the energy buffer needed depends on the inertia constant setting (if relevant to the implementation), as well as the RoCoF of the disturbance. An energy buffer can be provided in a number of ways, including by maintaining headroom between the output and maximum output of the plant, using overload capability of the inverter, or oversizing the plant for the plant's intended maximum output.

(1) (a) Quantifying synthetic inertia using the swing equation – 'direct approach'

The direct approach was introduced and investigated in CIGRE Symposium Paper 1296, "Determining inertia contribution from grid-forming battery energy storage systems"[22].

Under CIGRE's direct approach, a known active power disturbance is simulated at the terminals of the service being tested. The RoCoF based on the response of the service to the disturbance is then measured and input into the following formula to approximate the inertia contribution of the service.

$$I_{tot} = \sum_{i=1}^{N} (MW.s)_i = \frac{\Delta P_{MW} * 25}{RoCoF}$$

where:

I_{tot}	=	the total inertia contribution of the plant(s) in MWs.
ΔP_{MW}	=	the size of the contingency applied in MW.
$RoCoF$	=	the rate of change of frequency in Hz/s.

(1) (b) Quantifying synthetic inertia using the swing equation – 'indirect approach'

The above CIGRE paper also introduced an indirect approach – where the service is tested in a system with only synchronous generating units whose inertia contribution is known, and a known active power disturbance is applied to the system. The power system frequency response is monitored to measure the RoCoF, which is then input into the above formula to determine the total inertial response of the system. The known inertia contribution of the synchronous units is then subtracted from the calculated inertial response of the system to approximate the inertial response of the service.

(2) **Probing** frequency injection method

CIGRE Science & Engineering CSE032, "An online probing frequency injection method for Grid-Forming IBRs inertia measurement", introduced a probing frequency injection method which estimates the inertia constant of IBR through injecting a small probing voltage or current signal, with a frequency distinct from the system frequency, at the point of common coupling (**PCC**) bus and then analysing the measured frequency content on the active power and the virtual synchronous speed[23]. The measured power and speed deviations at the frequency of the probing signal are input into the transfer function below to estimate the inertia constant.

$$\frac{|\Delta P(\omega)|}{2\omega|\Delta\Omega(\omega)|} = |H + \frac{D}{2j\omega}|$$

where:

ω	=	the frequency deviation from the fundamental frequency ω_0.
D	=	the damping coefficient.
H	=	the inertia constant.
$\Delta P(s)$	=	the electrical power deviation.
$\Delta\Omega(s)$	=	the speed variation.

---

[22] See https://www.e-cigre.org/publications/detail/cse020-cse-020.html.

[23] See https://cse.cigre.org/cse-n032/an-online-probing-frequency-injection-method-for-grid-forming-ibrs-inertia-measurement.html.

The above equation may need to be adjusted depending on the control strategy of the equipment. The method was tested only on a synchronous machine and a GFM IBR with virtual synchronous machine (**VSM**) control strategy, however the paper noted that the method has the capability to measure inertia from other GFM IBR control types.

Information accompanying request for approval

To implement the requirements of new clause 5.20.4(h), AEMO proposes that, when requesting equipment approval, Inertia Service Providers must provide sufficient evidence that the proposed equipment meets the criteria as defined in this section. Information provided to AEMO must include details of the proposed equipment by which an inertia network service will be made available, and information on how the inertia network services will contribute to the operation of the relevant inertia sub-network in a satisfactory or secure operating state.

Questions
• Are the proposed parameters and requirements for a service to qualify as an inertia network service appropriate? • If not, what specific additions or alternatives should be included, and why? • Which of the approaches outlined for estimating the inertia level provided by non-synchronous equipment do you consider most appropriate, and why? • Are there any alternative approaches to estimating the inertia level provided by non-synchronous equipment which AEMO should consider? • Are there other issues relevant to the inertia service specification that AEMO should consider?

3.4. Methodology improvement: redispatch assumptions

3.4.1. Issue description

In the current Methodology, AEMO follows a four-step process to determine the secure operating level of inertia for an inertia sub-network. The first step identifies relevant contingency events, while subsequent steps use power system analysis to simulate these events and assess the required levels of inertia needed to maintain system security.

Previously, generation contingencies were only tested with generators operating at their minimum stable operating levels, on the basis that generating units will have their output reduced via central dispatch under low inertia conditions, or when Fast FCAS is scarce. This would have the effect of reducing the size of the largest generation contingency to its lowest practical level. However, this is a very optimistic assumption, and has now been reconsidered based on operational experience and emerging risk conditions.

In addition, the Methodology for calculating the relationships between inertia requirements and FFR services must be updated to consider the new Very Fast (1-second) FCAS market introduced in October 2023.

3.4.2. Description of proposal

AEMO proposes to amend steps 1, 2, and 3 of the Methodology[24] for determining secure operating level of inertia.

In Step 1 (which identifies relevant contingency events to study), AEMO proposes to consider both the typical operating conditions and worst-case operating conditions in an island when making this assessment. This may include the trip of generators operating above their minimum stable operating levels, which is currently not contemplated by the existing Methodology. This change will ensure that the secure inertia level allows the inertia sub-network to be operated in a secure operating state under all plausible operational scenarios when the sub-network is islanded.

AEMO proposes to update Step 2 and Step 3 to consider the impact of Very Fast (1-second) FCAS alongside the existing consideration of FFR and Fast (6-Second) FCAS services.

Questions
• Do you consider the proposed amendments appropriate for the calculation of secure inertia levels in each inertia sub-network? • If not, what additional or alternative changes might better address the NER requirement, and why? • Are there any other issues relevant to the secure inertia level requirements that AEMO ought to consider?

3.5. Methodology improvement: credible events leading to island formation

3.5.1. Issue description

Under new clause 5.20B.4(b)(2) of the Amending Rule, if there is a sub-network islanding risk, the relevant inertia service provider must use reasonable endeavours to make inertia network services available to the binding secure inertia level (as adjusted for inertia support activities), but not less than the binding satisfactory inertia level for the inertia year (as adjusted for inertia support activities).

The current methodology for calculating the minimum threshold level of inertia (akin to the newly defined satisfactory level of inertia, see Section 3.7.2), assumes that interconnector flows can be reduced to zero or otherwise managed to ensure that they do not represent the worst-case contingency event that causes an island to form. However, historical events[25] have shown that this is not always a valid assumption.

As such, AEMO proposes that the Methodology be amended to reflect that the satisfactory inertia level should be sufficient for the inertia sub-network to remain in a satisfactory operating state following any plausible credible contingency event, including potential events that result in the inertia sub-network

---

[24] AEMO. Inertia Requirements Methodology. 2018, pages 18-19, at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-security-market-frameworks-review/2018/inertia_requirements_methodology_published.pdf?la=en.

[25] See https://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Final-report---SA-separation-event-1-December-2016.pdf.

becoming islanded. That is, the satisfactory inertia level should be sufficient that the sub-network lands in a satisfactory operating state following the islanding event itself.

3.5.2. Description of proposal

The previous assumption that interconnector flows would be constrained down to zero when there is a credible risk of separation means that interconnector events that lead to an islanded condition are not considered by the studies, even where these may plausibly become credible in operational timeframes.

For the purpose of calculating the satisfactory inertia level, AEMO proposes to amend the Methodology to consider plausible cases where contingency events could credibly lead to islanding[26].

Questions

- Do you consider the proposed amendments appropriate for the calculation of satisfactory inertia levels in each inertia sub-network?
- If not, what additional or alternative changes might better address the NER requirement, and why?
- Are there any other issues relevant to the satisfactory inertia level requirements that AEMO ought to consider?

3.6. Methodology improvement: additional modelling considerations

3.6.1. Issue description

Several improvements are possible to AEMO's inertia power system simulation model and single mass model (**SMM**) to achieve a more accurate determination of inertia requirements. AEMO has identified the following issues:

- The current Methodology does not account for future power system changes when calculating inertia requirements. However, under new clause 5.20B.2(g), the binding inertia requirements are those determined three years prior to the current inertia year, and AEMO must provide 10-year projections of inertia requirements. To support this, the Methodology should be amended to include items relevant to forecasting the future operation of the power system.
- The current Methodology does not consider the impacts of DPV, and uses an assumed load relief value. AEMO has developed dynamic models to represent the aggregate behaviour of DPV and composite load to power system disturbances in the NEM[27], which may be updated over time. Use of these models would better capture the voltage and frequency responses of DPV and load which can have a strong impact on the size of contingency events.

[26] Such as where there is a prior outage on an interconnector or weather conditions cause reclassification.

[27] See https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/operations/power-system-model-development.

3.6.2. Proposal for power system software simulation model

AEMO proposes to include in its power system model any network changes it considers significant and relevant within the next 10 years when calculating the inertia requirements, which may include:

- Committed and anticipated generation, and generator retirement.
- Future network development.
- Demand forecasts.
- DPV in the NEM and its behaviour during power system disturbances.
- Load composition in the NEM and its behaviour during power system disturbances.
- Increased amounts of IBR and its fault ride-through (**FRT**) impacts.

The inclusion of the items listed above is expected to improve the accuracy of the calculated inertia requirements for the future network. Where needed, this may draw on the Integrated System Plan (**ISP**) and the Electricity Statement of Opportunities (**ESOO**).

3.6.3. Proposal for single-mass model tuning

The SMM is based on the swing equation of the power system and iteratively solves a set of equations for frequency to model the behaviour of the system. In addition to using power system models of inertia sub-networks to assess frequency trajectories following contingency events, AEMO expects to use the SMM primarily to model a large number of operating points of varying FFR and inertia levels required to maintain an Acceptable Frequency.

AEMO proposes to tune its SMM to account for network parameters that impact contingency sizes where AEMO considers necessary. This may involve modelling the impacts of load, DPV and IBR responses to contingencies on active power in short (<1 second (**s**)) and medium timeframes (>1 s).

In addition, AEMO proposes to amend the Methodology to allow for a multi-mass model (**MMM**) to be implemented for calculation of system-wide inertia requirement and sub-network allocations.

Questions

- Are the proposed future system conditions appropriate to consider as part of forward-looking inertia studies?
- If not, what additions or alternatives should AEMO consider in forecasting inertia requirements?

3.7. Methodology improvement: other amendments and updates

3.7.1. Revised NSCAS arrangements – issue description and proposal

The Amending Rule requires AEMO to determine forecasted inertia requirements for all inertia sub-networks over 10 years in annual Inertia Reports. Inertia service providers must meet their binding inertia requirements[28], which are the forecasted requirements determined three years prior to the current inertia year.

New clause 5.20B.2(f) requires AEMO to revise inertia requirements as follows:

> *(f) If* AEMO *becomes aware of a material change to the* power system *likely to affect the* inertia requirements*, where the timing, occurrence or impact of the change was unforeseen,* AEMO *must as soon as reasonably practicable, revise and publish its determination of the relevant forecast under paragraph (b).*

The Amending Rule changes the definitions of "NSCAS need" and "NSCAS gap". If AEMO revises the inertia requirements under new clause 5.20B.2(b) in accordance with new clause 5.20B.2(f) such that the revised requirements exceed one or more of the binding inertia requirements, this meets paragraph (b) of the new definition of 'NSCAS need':

> *(b) A requirement for an* inertia network service *necessary to meet the* inertia requirements *where AEMO has revised the* inertia requirements *in accordance with clause 5.20B.2(f) such that the revised* inertia requirements *exceed one or more of the* binding inertia requirements *(as applicable).*

If the above NSCAS need must be addressed within three years from the date AEMO declares it an 'NSCAS gap', AEMO must identify it as an NSCAS gap in a NSCAS report as this meets paragraph (b) of the new definition of 'NSCAS gap':

> *(b) an* NSCAS need *described in paragraph (b) of that definition where the time by which the* Transmission Network Service Provider *(as the* Inertia Service Provider*) must address the* NSCAS gap *is less than 3 years from the date* AEMO *has declared the* NSCAS gap*;*

AEMO proposes to remove descriptions of inertia shortfall determination from the Methodology and refer to the NSCAS Description and Quantity Procedure[29] in the Methodology for the process of calculating inertia shortfalls.

Furthermore, on and from 4 April 2024, AEMO no longer declares new inertia shortfalls under clause 5.20B.3 in accordance with clause 11.168.9(a). As such, AEMO will remove Section 8 of the 2018 Inertia Requirements Methodology. However, inertia service providers must continue to comply with former clauses 5.20B.3 and 5.20B.4 (as in force on 4 April 2024) and meet any existing inertia shortfalls until 1 December 2027.

3.7.2. Terminology updates – issue description and proposal

The Amending Rule will retain the substance of the inertia requirements that AEMO is required to determine for each inertia sub-network by clause 5.20B.2(b)(1) and (2). The current clause provides:

---

[28] New clause 5.20B.4(a1) and 5.20B.4(b) to be inserted by the Amending Rule.

[29] NSCAS Description and Quantity Procedure, also undergoing consultation here: https://aemo.com.au/consultations/current-and-closed-consultations/amendments-to-the-nscas-description-and-quantity-procedure.

> *(1) the minimum threshold level of inertia, being the minimum level of inertia required to operate the inertia sub-network in a satisfactory operating state when the inertia sub-network is islanded; and*
>
> *(2) the secure operating level of inertia, being the minimum level of inertia required to operate the inertia sub-network in a secure operating state when the inertia sub-network is islanded.*

This will be replaced by new clauses 5.20B.2(b)(3) and (4), which provide the following requirements:

> *(3) for each* inertia sub-network*, the minimum level of* inertia *required to operate that* inertia sub-network *in a* satisfactory operating state *when that* inertia sub-network *is* islanded *(**satisfactory inertia level**);*
>
> *(4) for each* inertia sub-network*, the minimum level of inertia required to operate that* inertia sub-network *in a* secure operating state *when that* inertia sub-network *is* islanded *(**secure inertia level**);*

As there is no change to the substance of the definitions of these two requirements, AEMO proposes to update the Methodology with the new terminology where required.

Questions
• Do stakeholders have any other concerns or additions to the proposed minor amendments introduced to maintain consistency with the broader changes in the Amending rule?

Appendix A. Glossary

This document uses terms defined in the NER, with the same meanings. NER acronyms and some additional terms used in this document are defined here for convenience.

Term or acronym	Meaning
Acceptable Frequency	The frequency at all energised busbars of the power system is within the normal operating frequency band, except for brief excursions outside the normal operating frequency band which remain within the normal operating frequency excursion band.
AEMC	Australian Energy Market Commission
Amending Rule	National Electricity Amendment (Improving security frameworks for the energy transition) Rule 2024 No. 9
Contingency FCAS	Each of the following: • Very fast raise service. • Very fast lower service. • Fast raise service. • Fast lower service. • Slow raise service. • Slow lower service. • Delayed raise service. • Delayed lower service.
DPV	distributed photovoltaics
ESOO	Electricity Statement of Opportunities
Fast FCAS	fast raise service and fast lower service
FCAS	frequency control ancillary service/s
FFR	fast frequency response
FRT	fault ride-through
Generation event	Any of the following events: 1. A synchronisation of a generating unit of more than the generation event threshold of: a) for the Mainland: 50 megawatts (**MW**). b) for Tasmania: 20 MW. 2. An event that results in the sudden, unexpected and significant increase or decrease in the generation of one or more generating systems totalling more than the generation event threshold for the region in aggregate within no more than 30 seconds. 3. The disconnection of generation as the result of a credible contingency event (not arising from a load event, a network event, a separation event or part of a multiple contingency event), in respect of either a single generating system or a single dedicated connection asset providing connection to one or more generating systems.
GFM	Grid-forming
IBR	inverter-based resource/s
Inertia Rule	National Electricity Amendment (Managing the rate of change of power system frequency) Rule 2017 No. 9.
Inertia year	Each period of 12 months commencing 2 December.
Island	A part of the power system that includes generation, networks and load, for which all of its alternating current network connections with other parts of the power system have been disconnected, provided that the part: 1. Does not include more than half of the combined generation of each of two regions (determined by available capacity before disconnection); and 2. Contains at least one whole inertia sub-network.
ISP	Integrated System Plan

Term or acronym	Meaning
Load event	• For the Mainland: connection or disconnection of more than 50 MW of load not resulting from a network event, generation event, separation event or part of a multiple contingency event. • For Tasmania: either a change of more than 20 MW of load, or a rapid change of flow by a high voltage direct current interconnector to or from 0 MW to start, stop or reverse its power flow, not arising from a network event, generation event, separation event or part of a multiple contingency event.
Mainland	The Queensland, New South Wales, Victoria and South Australia regions.
Methodology	AEMO's Inertia Requirements Methodology
Minimum Operating Level	As defined in clause S5.2.5.11 of the NER.
MMM	multi-mass model
ms	millisecond/s
MW	megawatt/s
MWs	megawatt-second/s
NEM	National Electricity Market
NEO	National Electricity Objective as expressed in section 7 of the National Electricity Law
NER	National Electricity Rules
Network event	A credible contingency event other than a generation event, load event, separation event or part of a multiple contingency event.
New clause/rule [number]	A clause or rule from the NER as amended by the Amending Rule.
Non-synchronous equipment	See 'IBR'
NSCAS	network support and control ancillary service/s
OFGS	over-frequency generation shedding
PCC	Point of common coupling
RoCoF	rate of change of frequency
s	second/s
Separation event	A credible contingency event affecting a transmission element that results in an island.
SMM	Single mass model, an equivalent representation of generating units with various inertia to a generating unit with an equivalent inertia. This model represents the swing equation of the power system.
Synthetic inertial response	The emulated inertial response from an inverter-based resource that is inherently initiated in response to a power system disturbance, and sufficiently fast and large enough to help manage RoCoF.
TNSP	transmission network service provider
UFLS	under-frequency load shedding
VFFCAS	Very Fast FCAS
VSM	virtual synchronous machine