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31 March 2023

John Kim

Inertia Project Lead

Australian Energy Market Commission

Sydney NSW 2000

By online submission

Dear Mr Kim,

Efficient provision of inertia

AEMO welcomes the opportunity to provide a submission to the AEMC's Consultation paper on The Efficient Provision of Inertia.

Through the Integrated System Planning process, AEMO has forecast a decline in synchronous inertia across the NEM in the coming decade. This is an important aspect of the energy transition that needs to be effectively managed - inertia provides multiple contributions to the power system, the most prominent of which is to support frequency management and the rate of change of frequency (RoCoF).

As a result, AEMO has proactively engaged in a number of reforms to better support frequency management for power system security in a grid with high penetration of inverter-based resources. Many of these reforms are currently in-flight and AEMO looks forward to working with the AEMC and stakeholders towards implementation. These reforms interact with both the current inertia framework and possible options to ensure sufficient inertia in the future power system and AEMO appreciates the opportunity to input to this rule change process.

A summary of AEMO's position is that an inertia spot market should not be developed right now due to the breadth of in-flight reforms in frequency management and system service coordination currently underway. We suggest instead that this rule change request consider the significant opportunity to align the provision of inertia with the system strength framework given the possibility for efficiency and economies of scale in the simultaneous provision of these services. There are several inadequacies in the existing framework that could be addressed to allow for more proactive investment in inertia services which would reduce the risk of the transition in the same way the new system strength framework does.

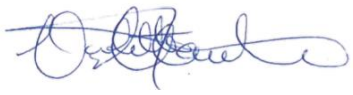
AEMO considers there is a difference between synchronous inertial response and synthetic inertial response, explored in more detail in our recently published Inertia Explained document. We further consider the provision of some elements of inertial response may better align with frequency management arrangements in the future although more investigation is required in this regard.

AEMO notes that a consequence of the current understanding of inertia in the power system is that any coordination of inertia in operational timeframes would not be independent of the means through which it is

delivered, that is, without consideration of secure combinations of online units. This understanding will not be resolved in the timeframe of this rule-change request and accordingly we suggest that any consideration of a market mechanism for inertia would be better placed through a future rule change request. We underscore our perspective that the significant and timely opportunity arising from this rule change request is to coordinate investment in inertia concurrently with system strength.

Should you wish to discuss any of the matters raised in this submission, please contact Kevin Ly, Group Manager – Reform Development & Insights on kevin.ly@aemo.com.au.

Yours sincerely,



Violette Mouchaileh

Executive General Manager, Reform Delivery

Attachment: Considerations and responses to consultation questions

Executive Summary

Through the 2020 and 2022 Integrated System Planning process, AEMO has forecast a decline in synchronous inertia across the NEM in the coming decade. This is an important aspect of the energy transition that needs to be effectively managed - inertia provides multiple contributions to the power system, the most prominent of which is to support frequency management and the rate of change of frequency (RoCoF). As a result, AEMO has proactively engaged in a number of reforms to better support frequency management for power system security in a grid with high penetration of inverter-based resources. Many of these reforms are currently in-flight, including the review of the frequency operating standard, the system strength requirements methodology, the setting of the primary frequency control band and mandatory primary frequency response requirements, and the very fast (1s) frequency response FCAS market that will become operational in October 2023.

Once these in-flight changes have been implemented it is not clear the size of inertial response required in the system in the future That is, there is close interaction between the system strength requirements methodology, primary frequency response, very fast frequency control, and inertia, and it is unclear how much the future system will require inertial response or frequency control beyond that which is provided in aggregate by existing and planned mechanisms. In particular AEMO notes the close interrelationship between system strength, fast frequency response and inertia to achieve similar outcomes for secure power system operation.

AEMO notes that there may be benefits of greater resilience in a future power system that maintains an abundance of inertia across the NEM, which helps to slow down the dynamics of the power system giving control systems more time to act without overly relying on fast-acting control systems that are still being developed and understood. AEMO notes the locational impacts of inertia in maintaining overall power system stability and control, its contribution to rotor angle stability and broader power system stability, and that the use of the 'global aggregate view' model of the NEM does not adequately capture this power system phenomena. AEMO suggests that any enduring framework for inertia recognises the value of having the right quantity and locationality of inertia geographically dispersed at all times.

AEMO sees several inadequacies in the existing framework that, if addressed, could deliver more proactive and coordinated investment in inertia services and offer adaptability to system changes through flexible declaration of inertia sub-networks and a deeper consideration of grid-forming technologies. AEMO suggests such amendments also be considered through this rule change request, and further, that this rule change request consider the opportunity to align the provision of synchronous inertia with the system strength framework given the opportunity for efficiency and economies of scale in the simultaneous provision of these services.

That is, AEMO notes in this submission the close relationship between system strength and inertia and that the obligations on TNSPs to provide both 1) the technical envelope for protection requirements and operational fault levels, and 2) minimum system strength requirements under the new framework, present an opportunity to simultaneously provide inertia. This need not be a replication of the system strength framework for inertia but a recognition that solutions which provide system strength and inertia may go hand-in-hand, particularly relevant when considering a known option for providing high fault levels are synchronous machines which naturally bring at least a small amount of inertia as a by-product.

The impending investment in system strength capability to provide fault level may provide a significant opportunity to concurrently provide inertia with the same technical resource at minimal incremental cost, for

example by adding flywheels to synchronous condensers as recently achieved in South Australia. As a result, AEMO suggests AEMC explore in detail potential options that allow TNSPs to consider inertia when deciding between options that meet their system strength obligations.

AEMO considers there is a difference between synchronous inertial response and synthetic inertial response, explored in more detail in our recently published Inertia Explained document. We further consider the provision of some elements of inertial response may better align with frequency management arrangements in the future although more investigation is required in this regard.

AEMO notes that a consequence of the current understanding of inertia in the power system is that any coordination of inertia in operational timeframes would not be independent of the means through which it is delivered, that is, without consideration of secure combinations of online units. This understanding will not be resolved in the timeframe of this rule-change request, and accordingly we suggest that any consideration of a market mechanism for inertia would be better placed through a future rule change request. We underscore our perspective that the significant and timely opportunity arising from this rule change request is to coordinate investment in inertia concurrently with system strength.

To support the efficient scheduling of inertial response in operational timeframes, AEMO's view on AEMC's alternative options is that operational scheduling (for example through the Operational Security Mechanism [OSM] currently being considered by the AEMC) may allow the market to trial better scheduling of system service and pursue greater economic efficiency whilst avoiding some of the complexities of defining spot markets, presuming appropriate service requirements can be defined. This could be supported by a fit-for-purpose contracting arrangement in the planning timeframe, for example adopting some of the existing features from the NSCAS framework. AEMO emphasises that the primary issues motivating the introduction of the OSM are largely separate from the question of which combination of planning and/or operational frameworks should be used to deliver inertia, and instead developed because of the difficulties of instituting co-optimised spot markets for security services. Whilst procurement via the OSM may be a substitute to a spot market for the specific service of inertia, an inertia spot market is not an alternative to the OSM in general, as the latter is required to accommodate all services necessary for secure system configuration.

AEMO notes that linear programming approaches face significant implementation challenges when co-optimising the procurement of services that involve unit-commitment – for example, in relation to solution optimality, pricing, settlement and re-bidding. There may also be locational requirements that do not easily align with the dispatch model. Accordingly, AEMO expresses reservation whether the spot-market design can be implemented as proposed, or if the procurement of inertia may be suited to a spot market approach at all. This is not to rule it out categorically, but to accept inertia does not have the same characteristics that lends itself to our current approach of co-optimised markets.

AEMO suggests it may be useful to consider how the OSM and other mechanisms for ensuring there is sufficient inertia might complement each other, rather than comparing options against each other. In-flight reforms will continue to inform AEMO's understanding of the rationale for broader enduring arrangements for inertia, but we note that alternative options spanning planning, contracting, and scheduling should not be considered as mutually exclusive.

Noting the breadth of the potential actions identified in AEMO's Engineering Roadmap to 100% Renewables, the consideration of an inertia spot market has not been identified as a priority. Since the roadmap was published, AEMO has provided an overview of perspectives on the role of inertia in the future power system (including synthetic inertial response and its capabilities to replace synchronous inertial response) in the

recent Inertia Explained document. Following from this work, AEMO is currently scoping a small investigative project to expand on several findings of the paper. AEMO is not currently planning to prioritise further effort in FY24 to study the role of inertia in the future NEM but looks forward to engaging with stakeholders through the AEMC's rule change process.

AEMO Responses to Consultation Paper questions

QUESTION 1: TECHNICAL INFORMATION ON INERTIA

Do stakeholders consider there is any additional technical information required to assess the challenges and long-term system requirements related to inertia beyond what AEMO is doing? Do stakeholders have their own technical information or studies that can be shared to help answer these questions?

- AEMO notes there are a number of mechanisms currently being progressed to improve frequency control, including the review of the Frequency Operating Standard, the implementation of the 1s FCAS market, and the establishment of trade-offs between fast frequency response and inertia. These initiatives interact closely with the need for inertia, and AEMO considers it prudent to see the impact of these current in-flight reforms before considering an additional layer of procurement.

- AEMO notes that the nature and detail of additional technical information required will be dependent on the above in-flight initiatives but highlights here that we are currently exploring the quantification of the synthetic inertia provided by grid-forming inverters and its capability to replace the synchronous inertia from synchronous machines. AEMO considers there is a difference between synchronous inertial response and synthetic inertial response. Grid-forming inverters are power-electronics devices which may have limited overload capacity. As a result, the inertial contribution provided by these devices would be variable and dependent on the number of factors such as their operating point, overload capacity (time and duration) etc. In 2020 AEMO declared an inertia gap in SA, which ElectraNet has subsequently addressed by procuring fast frequency response (FFR) services. The relationship between inertia and FFR for the SA region is shown in Figure 3 of this submission, outlining the capability of FFR provision to meaningfully reduce the secure operating level of inertia that must be maintained in each region.

- Studies exploring the interrelationship between synthetic and synchronous inertial response, very fast frequency control, and system strength provision are ongoing, and further detail is included in our recently published Inertia Explained Document.

- AEMO would like to clarify in this submission that the presented sum of regional minimum inertia requirements is not equivalent to the NEM-wide system-intact minimum inertia requirement, as may have been interpreted from Appendix Section A7.4.3 of the 2022 ISP. AEMO would instead state that the NEM-wide system intact inertia requirement is not yet defined but, depending on the number of sub regions identified as at risk of islanding, it is likely to be lower than the sum of regional requirements.

QUESTION 2: INERTIA PROCUREMENT AND ALLOCATION IN REAL-TIME

What are stakeholders' views on the merits (or not) of defining and procuring inertia

requirements dynamically in operational timeframes, as opposed to the current approach (that is, annual assessments that inform longer-term inertia procurement to specified minimum levels)?

- AEMO notes the inertia shortfalls outlined in the 2022 Inertia Report but expects that a variety of solutions are feasible to address them under the current framework and before the shortfalls eventuate. These may include physical inertia provided by synchronous generators, FFR providers such as batteries, or synchronous condensers fitted with flywheels – potentially optimised with investment for system strength services. AEMO is also currently implementing a new very fast FCAS market, and over time this may provide services that reduce regional inertia requirements.

- AEMO notes the AEMC has developed a draft rule to introduce the Operational Security Mechanism to improve certainty and transparency in the delivery of a secure system. AEMO refers to its submission on this draft rule, and notes the practical features incorporated into the mechanism including the allowance for operational timescale procurement of secure configurations or separate services, with the flexibility to progressively transition towards the latter as engineering knowledge evolves.

- AEMO emphasises that the primary issues motivating the introduction of the OSM are largely separate from the question of which combination of planning and/or operational frameworks should be used to deliver inertia. For example, the issue of AEMO's ongoing directions in South Australia and the lack of commercial frameworks to support secure system configurations will persist regardless of any choices around the proposal considered in this rule change. Therefore, though procurement via the OSM may be a substitute to a spot market for the specific service of inertia, an inertia spot market is not an alternative to the OSM in general, as the latter is required to accommodate all services necessary for secure system configuration.

- Beyond efficiency, AEMO notes that there may be benefits of greater resilience in a future power system that maintains an abundance of inertia, which helps to slow down the dynamics of the power system giving control systems more time to act without overly relying on fast-acting control systems that are still being developed and understood.

- As mentioned above, AEMO notes a consequence of the current understanding of inertia in the power system is that any coordination of inertia in operational timeframes would not be independent of the means through which it is delivered, that is, without consideration of secure combinations of online units. This understanding will not be resolved in the timeframe of this rule-change request, and accordingly we suggest that any consideration of a market mechanism for inertia would be better placed through a future rule change request.

- AEMO acknowledges that the consideration of a RoCoF control service similar to that implemented in the WEM has also been listed as an alternative mechanism. AEMO notes this approach maintains technical validity when the initial RoCoF following contingency events is largely the same across the system. However, this is not an appropriate assumption for a system as large and sparse as the NEM

where the locational distribution of inertia and the impedance between clusters of inertia affects how the system responds during transient periods. The NEM's topology consequently results in different RoCoFs across regions.

QUESTION 3: INVESTMENT SIGNALS FOR INERTIA

What are stakeholders' views on the adequacy of the current inertia framework in providing long-term investment signals and the need for reform?

- AEMO sees several inadequacies in the existing framework that, if addressed, could deliver more proactive and coordinated investment in inertia services and offer adaptability to system changes through flexible declaration of inertia sub-networks and a deeper consideration of grid-forming technologies. AEMO suggests such amendments also be considered through this rule change request, and further, that this rule change request consider the opportunity to align the provision of synchronous inertia with the system strength framework given the opportunity for efficiency and economies of scale in the simultaneous provision of these services.

- That is, AEMO notes in this submission the close relationship between system strength and inertia and that the obligations on TNSPs to provide both 1) the technical envelope for protection requirements and operational fault levels, and 2) minimum system strength requirements under the new framework, present an opportunity to simultaneously provide inertia. This need not be a replication of the system strength framework for inertia but a recognition that solutions which provide system strength and inertia may go hand-in-hand, particularly relevant when considering a known option for providing high fault levels are synchronous machines which naturally bring at least a small amount of inertia as a by-product.

- The impending investment in system strength capability to provide fault level may provide a significant opportunity to concurrently provide inertia with the same technical resource at minimal incremental cost, for example by adding flywheels to synchronous condensers as recently achieved in South Australia. As a result, AEMO suggests AEMC explore in detail potential options that allow TNSPs to consider inertia when deciding between options that meet their system strength obligations.

QUESTION 4: WILL THE AEC'S PROPOSED SOLUTION BEST ADDRESS THE PROBLEMS RAISED?

What are stakeholders' views on the AEC's proposed solution?

Is it the best solution to improve the:

- *efficiency of inertia provision in the operational timeframe?*
- *efficiency of inertia provision in the investment timeframe?*
- *transparency of the power system's inertia requirements?*

- AEMO's Inertia Requirements Methodology is publicly available on this website, alongside other Power System Security Planning methodologies: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/system-security-planning

- AEMO notes that the inertia requirements methodology was developed through consultation, and that the surrounding framework provides the methodology with significant flexibility to be adaptive as system needs change. However, there are some limitations in the NER relating to the scope of inertia sub-networks – particularly NER5.20B.1(c) which requires that any declared inertia sub-network be limited to a single region boundary (or smaller). This may make it more difficult to accommodate specific localised requirements than span two regions, or to consider broader multi-regional and NEM-wide requirements. AEMO notes that the 2022 Inertia Report has considered opportunities for inertia sharing from neighbouring regions when both regions are islanded together, however this assessment is still performed on a region-by-region basis.

- AEMO notes that linear programming approaches face significant implementation challenges when co-optimising the procurement of services that involve unit-commitment – for example, in relation to solution optimality, pricing, settlement and re-bidding. There may also be locational requirements that do not easily align with the dispatch model. Accordingly, AEMO expresses reservation whether the spot-market design can be implemented as proposed, or if the procurement of inertia may be suited to a spot market approach at all. This is not to rule it out categorically, but to accept inertia does not have the same characteristics that lends itself to our current approach of co-optimised markets. AEMO suggests it may be useful to consider how the OSM and other mechanisms for ensuring there is sufficient inertia might complement each other, rather than comparing options against each other.

QUESTION 5: ALTERNATIVE OPTIONS

Do stakeholders consider that any of these options address the problems identified (see Chapter 3) more effectively than the proposed solution of an inertia spot market?

Are there any additional options not identified in this consultation paper that should be investigated?

- AEMO does not view the alternatives in the consultation paper as being mutually exclusive. Central TNSP procurement, ahead coordination, and a co-optimised spot market may all exist and be complementary. That is, a TNSP may invest for market benefits, and ahead arrangement may improve scheduling, particularly with other security services that may not have a spot market, and a spot market may provide efficient marginal price signals.

- To support the efficient scheduling of RoCoF control services in operational timeframes, AEMO's view on AEMC's alternative options is that, presuming appropriate service requirements can be defined, operational scheduling (for example through the Operational Security Mechanism [OSM] currently being considered by the AEMC) may allow the market to trial better scheduling of system service and pursue greater economic efficiency whilst avoiding some of the complexities of defining spot markets. This could be supported by a fit-for-purpose contracting arrangement in the planning timeframe, for example, adopting some of the existing features from the NSCAS framework.

- AEMO notes grid forming inverter capability and standards may affect how we view the future provision of inertia. The understanding of this will progress as technology matures.

- AEMO notes current jurisdictional interest to reconfigure existing power stations for synchronous condenser capability and suggests this be considered alongside the listed alternatives.

QUESTION 6: IMPLEMENTATION CONSIDERATIONS

What are stakeholders' views on the implementation considerations identified?

- AEMO notes a spot market for inertia would add significant complexity to NEMDE, and that this should be considered alongside other implementation considerations.
- AEMO also suggests the sequencing of interacting reforms may help their efficient consideration by stakeholders.
- AEMO underscores our perspective that the significant and timely opportunity arising from this rule change request is to coordinate investment in inertia concurrently with system strength.

QUESTION 7: DO YOU AGREE WITH THE PROPOSED ASSESSMENT FRAMEWORK?

Do you agree with the proposed assessment framework? Are there additional principles that the Commission should take into account or principles included here that are not relevant?

- AEMO suggests that principles of efficiency need not be limited to market efficiency, but that overall power system investment (such as through jurisdictions to retrofit existing generators to provide synchronous inertia) be additionally considered.
- AEMO also suggests the timing of reform consideration be included alongside the existing assessment criteria, noting the detailed interaction of in-flight reforms for frequency management.

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1 Inertia overview

1.1 Definition

AEMO's Power System Requirements define the inertial response of the power system as "a rapid and automatic injection of energy to suppress rapid frequency deviations, slowing the rate of change of frequency (RoCoF)"[1].

AEMO's recently published Inertia Explained report expands on the definition of inertia: "An inertial response is the immediate, inherent, electrical power exchange from a device on the power system in response to a frequency disturbance. Power system inertia is the aggregate equivalent inertia of all devices on the power system capable of providing an inertial response." The paper further clarifies synchronous inertia response from synthetic inertial response:

> "A synchronous inertial response is the electromechanical inertial response from stored kinetic energy in the rotating mass of a machine that is electro-magnetically coupled to the power system's voltage waveform at 50 hertz (Hz)."
>
> "A synthetic inertial response is 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."[2]

To expand here, synchronous inertia is dependent on the amount of kinetic energy stored in rotating masses of the machines (generators and motors) directly connected to the power system (without the use of power electronic inverters). Immediately after a contingency event, the RoCoF of the system mainly depends on the system conditions like the amount of available synchronous inertia and, the amount of generation and/or load loss. After the disturbance, inertia limits the RoCoF which in turn defines the duration before the frequency reaches outside of frequency operating standards. As an example, Figure 1 shows the time required for the frequency to reach the under-frequency load shedding threshold of 49 Hz (for a 50 Hz system) at three different inertia levels. For simplicity, this example excludes the response from frequency containment reserves and any load damping available to the system.

[1] AEMO Power System Requirements 2021. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf

[2] AEMO Inertia Explained, 2023

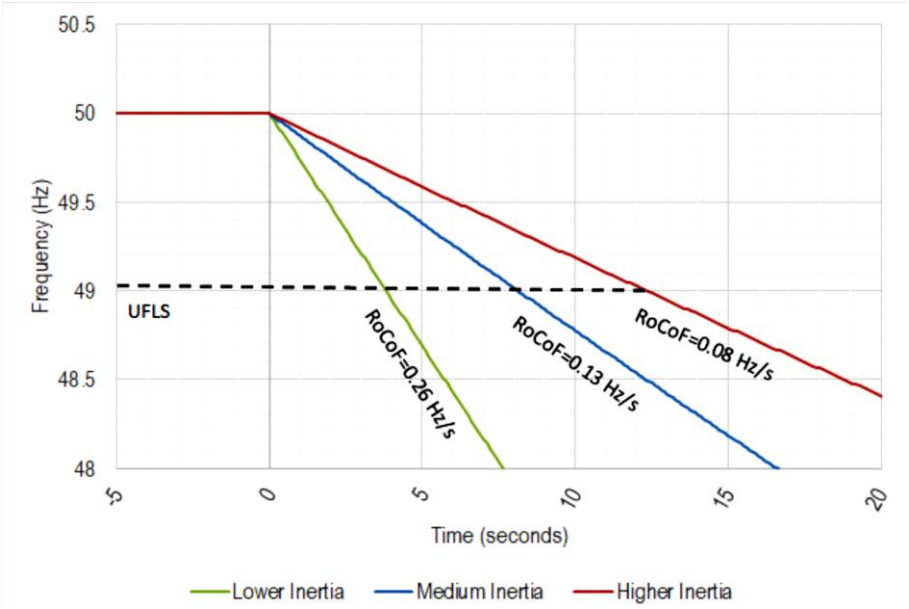


Figure 1 The impact of inertia on the rate of change of frequency. (CIGRE TB 851 "Impact of High Penetration of inverter-based generation on system inertia of networks.")

1.2 Role in current power system operation

The level of inertia in the power system is a core input to the design of NEM frequency control mechanisms, including contingency Frequency Control Ancillary Services (FCAS) and various emergency frequency control schemes. A power system with high inertia exhibits a lower ROCOF, allowing more time for frequency management mechanisms to act effectively.

AEMO notes here that whilst efficiency of procurement is important, there may be benefits of greater resilience in a future power system that maintains an abundance of inertia, which helps to slow down the dynamics of the power system, giving control systems more time to act without overly relying on fast-acting control systems that are still being developed and understood.

2 Projection of available inertia in the NEM

AEMO's Inertia Report of 2022[3] applied the inertia rules framework to the generation and transmission network outcomes in the Step Change scenario of AEMO's 2022 Integrated System Plan (ISP). Key findings include:

- New inertia shortfalls were identified in Queensland and Victoria, with existing shortfalls confirmed in South Australia and Tasmania (Figure 2). These shortfalls will need to be addressed by the responsible Inertia Service Providers in each region.

[3] AEMO 2022 Inertia Report. https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2022/2022-inertia-report.pdf?la=en

- In general, available levels of inertia are declining across the NEM as synchronous generator behaviour changes, penetration of IBR increases, and minimum demand projections decline.

- AEMO expects that a variety of solutions will be feasible to meet these emerging needs, including through physical inertia from existing or converted synchronous generators, greater levels of FFR, new technologies, and network assets such as synchronous condensers fitted with flywheels – potentially optimised with investment for system strength services.

- AEMO is also implementing a new very fast FCAS market, which over time may provide services that reduce the current inertia requirements across the NEM.

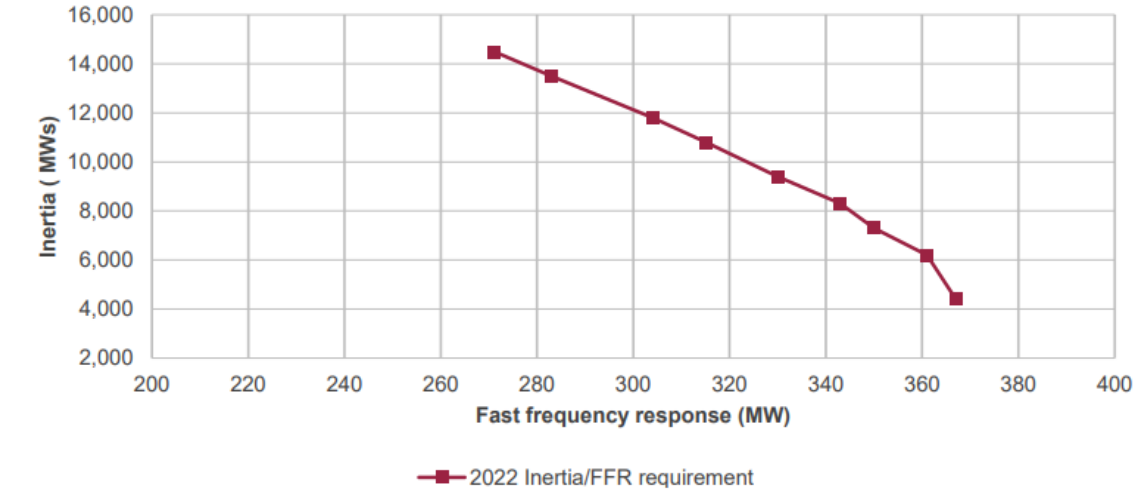
AEMO considers that the identification of these shortfalls is part of the planning process, and expects that delivery of investment or services, via existing mechanisms and in-flight reforms, would typically be capable of addressing them.

New South Wales	Queensland	South Australia	Tasmania	Victoria
				
No shortfall declared, although inertia declines observed in forecast.	New shortfall ranging from 8,200 megawatt seconds (MWs) to 10,352 MWs against the secure operating level, from 1 July 2026.	Existing shortfall is confirmed consistent with the 2021 assessment.	Existing shortfall is confirmed consistent with the 2021 assessment.	New shortfall ranging from 2,421 MWs to 2,482 MWs against the secure operating level, from 1 July 2026 onwards.

Figure 2 2022 inertia review outcomes for the NEM, for the five-year period to December 2027. Source: AEMO 2022 Inertia Report

AEMO would like to clarify in this submission that the sum of regional minimum inertia requirements is not the NEM-wide system-intact minimum inertia requirement as may have been interpreted from Appendix Section A7.4.3 of the 2022 ISP. AEMO would instead state that the NEM-wide system intact inertia requirement is not yet defined but is likely to be lower than the sum of regional requirements.

Whilst a power system with high inertia exhibits a lower RoCoF, allowing more time for frequency arrest mechanisms to act effectively, a low inertia power system could still sufficiently arrest a change in frequency with a faster and/or greater magnitude of primary frequency response. In this regard, inertia is one option in a suite of mechanisms to meet frequency stability needs, and AEMO notes the capability of very fast frequency control to reduce the minimum level of inertia required for secure power system operation (Figure 3).



A. The figure represents the relationship between the level of inertia required against the amount of FFR required for each level of inertia.
B. Square data points show actual operating points which have been modelled and provide a secure system. A line is drawn between the operating points to broadly indicate where the system may be considered to be secure.

Figure 3 2022 Secure operating level of inertia requirement, South Australia (Source: AEMO 2022 Inertia Report)

3 Role of inertia in future power system operation

AEMO expects inertial responses (either delivered by synchronous machines or inverter based resources) to remain a critical service for the secure operation of the NEM. However, the future abundance of synchronous inertia will drive how it needs to be considered in power system operation. Notionally, a better understanding of the impact of synchronous inertia at smaller timescales (beyond frequency control) would be required if we were to reach critically low levels of inertia in the NEM.

The two critical characteristics for the impact of inertial responses are the absolute quantity available and its locational distribution. From a frequency control perspective, AEMO expects absolute quantities of required synchronous inertia to meet RoCoF limits and frequency control requirements to be lower than the current requirements, as a greater range of frequency control mechanisms become available (specifically the very fast FCAS). However, there is a concurrent risk if this were to occur, the NEM could reach critically low levels of available synchronous inertia. In such scenarios, it would no longer be appropriate to consider inertia a global aggregate parameter. Instead, local and faster dynamics of the power system would need to be considered through the study of smaller timescale power system phenomena beyond frequency control. These phenomena sensitively depend on network typology and plant characteristics that understanding them would require both detailed technical studies and operational experience to validate findings of the technical studies, which are currently not prioritised given the projections of available inertia, the nature and breadth of inflight interacting reforms, and the broader requirements for power system studies to support the energy transition.

AEMO notes the benefits of greater resilience in a future power system that maintains an abundance of inertia across the NEM, which helps to slow down the dynamics of the power system, giving control systems more time to act without overly relying on fast-acting control systems that are still being developed and understood. AEMO notes the locational impacts of inertia in maintaining overall power system stability and control, and that the use of the ‘global aggregate view’ model of the NEM does not adequately capture this power system

phenomena. AEMO suggests that any enduring framework for inertia recognises the value of having right quantity of inertia geographically dispersed at all times.

AEMO further notes that work is underway to develop a standard for grid-forming inverters and their capability to provide synthetic inertial responses that may directly replace synchronous inertia. For further detail on functional requirements for inertial response in the future power system, AEMO refers to the Engineering Framework 2022 Roadmap to 100% Renewables.[4]

4 Perspectives of current arrangements

AEMO sees several inadequacies in the existing framework that, if addressed, could deliver more proactive and coordinated investment in inertia services and offer adaptability to system changes through flexible declaration of inertia sub-networks and a deeper consideration of grid-forming technologies. AEMO suggests such amendments also be considered through this rule change request.

There are some limitations in the NER relating to the allowable scope of inertia sub-networks – particularly NER5.20B.1(c) which requires that any declared inertia sub-network be limited to a single region boundary (or smaller). This may make it more difficult to accommodate specific localised requirements that span a regional boundary, or to consider broader multi-regional and NEM-wide requirements. AEMO notes that the 2022 Inertia Report has considered opportunities for inertia sharing from neighbouring regions when both regions are islanded together; however, this assessment is still performed on a region-by-region basis.

Future amendments to the methodology are likely as the system evolves, including to apply new RoCoF standards and to quantify inertia impacts from grid-forming technology.

AEMO notes in this submission the close relationship between system strength and inertia, and that the obligations on TNSPs to provide both 1) the technical envelope for protection requirements and operational fault levels, and 2) minimum system strength requirements under the new framework, present an opportunity to simultaneously provide inertia needs efficiently at minimal incremental cost. This need not be a replication of the system strength framework for inertia but a recognition that solutions which provide system strength and inertia may go hand-in-hand.

The impending investment in system strength capability thus provides a significant opportunity to concurrently provide inertia with the same technical resource at minimal incremental cost, for example by adding flywheels to synchronous condensers as recently achieved in South Australia.[5] As a result, AEMO suggests AEMC explore in more detail a potential enduring option that allows TNSPs to consider inertia when deciding between options that meet their system strength obligations. AEMO suggests TNSPs may support this

[4] AEMO Roadmap to 100% Renewables, December 2022. https://aemo.com.au/-/media/files/initiatives/engineering-framework/2022/engineering-roadmap-to-100-per-cent-renewables.pdf?la=en&hash=42E784478D88B1DFAF5D92F7C63D219D

[5] ElectraNet estimated the incremental cost of adding flywheels to the four synchronous condensers installed to meet SA system strength requirements in 2019 at $1m per unit, each providing 1,1000MWs of inertia. AEMO notes the current inertia gap is 360MWs. https://www.aer.gov.au/system/files/ElectraNet%20-%20System%20Strength%20Economic%20Evaluation%20Report%20-%2018%20February%202018.PDF

consideration through estimates of the incremental costs required to provide inertia alongside system strength investments.

4.1 Interaction with inflight reforms and interdependencies

AEMO notes there are a number of mechanisms currently being progressed to improve frequency control, including the review of the frequency operating standard, the setting of the primary frequency control band and mandatory primary frequency response requirements, the development of a grid-forming inverter standard, and very fast (1s) frequency response FCAS market that will become operational in October 2023. These initiatives interact closely with the need for inertia, and AEMO considers it prudent to see the impact of these current in-flight reforms before considering additional layers of reform.

4.2 Interaction with an OSM

AEMO notes the AEMC has developed a draft rule to introduce the Operational Security Mechanism to improve certainty and transparency in the delivery of a secure system. AEMO refers to its submission on this draft rule, and notes the practical features incorporated into the mechanism including the allowance for operational timescale procurement of secure configurations or separate services, with the flexibility to progressively transition towards the latter as engineering knowledge evolves. [6]

AEMO emphasises that the primary issues motivating the introduction of the OSM are largely separate from the question of which combination of planning and/or operational frameworks should be used to deliver inertia. Whilst procurement via the OSM may be an alternative pathway to a spot market for the specific service of inertia, an inertia spot market is not an alternative to the OSM in general, as the latter is required to accommodate all services necessary for secure system configuration.

In-flight reforms will continue to inform AEMO's understanding of the rationale for broader enduring arrangements for inertia, but we note that alternative options spanning planning, contracting, and scheduling should not be considered as mutually exclusive.

5 AEMO perspectives of future procurement

To support the future efficient scheduling of inertial response services in operational timeframes, AEMO's view on AEMC's alternative options are that operational scheduling (for example through the Operational Security Mechanism [OSM] currently being considered by the AEMC) may allow the market to trial how to better schedule system service provision in operational timeframes and pursue greater economic efficiency of procurement.

AEMO notes that linear programming approaches face significant implementation challenges when co-optimising the procurement of services that involve unit-commitment – for example, in relation to solution

[6] AEMO Submission to the AEMC Draft Rule Change Determination on the Operational Security Mechanism 2022. https://www.aemc.gov.au/sites/default/files/2022-11/AEMO.pdf

optimality, pricing, settlement and re-bidding. There may also be locational requirements that do not easily align with the dispatch model. Accordingly, AEMO expresses reservation whether the spot-market design can be implemented as proposed, or if the procurement of inertia may be suited to a spot market approach at all. This is not to rule it out categorically, but to accept inertia does not have the same characteristics that lends itself to our current approach of co-optimised markets.

AEMO suggests it may be useful to consider how the OSM and other mechanisms for ensuring there is sufficient inertia might complement each other, rather than comparing options against each other. In-flight reforms will continue to inform AEMO's understanding of the rationale for broader enduring arrangements for inertia, but we note that alternative options spanning planning, contracting, and scheduling should not be considered as mutually exclusive.

AEMO further suggests that principles of efficiency need not be limited to market efficiency, but that overall power system investment (such as through jurisdictions to retrofit existing generators to provide synchronous inertia) be additionally considered.

AEMO again underscores the potential benefits of greater resilience in a future power system that maintains an abundance of inertia across the NEM. We reiterate our perspective that the significant and timely opportunity arising from this rule change request is to coordinate investment in inertia concurrently with system strength, and suggest that any consideration of a market mechanism for inertia would be better placed through a future rule change request.

6 Future work

Noting the breadth of the potential actions identified in AEMO's Engineering Framework Roadmap to 100% Renewables Report, the consideration of an inertia spot market has not been identified as a priority for AEMO. Since the roadmap was published, AEMO has provided an overview of perspectives on the role of inertia in the future power system (including synthetic inertia and its capabilities to replace synchronous inertia) in the recent Inertia Explained document. Following from this work, AEMO is currently scoping a small investigative project to expand on several findings of the paper. AEMO is not currently planning to prioritise further effort in FY24 to study the role of inertia in the future NEM but looks forward to engaging with stakeholders through the AEMC's rule change process.