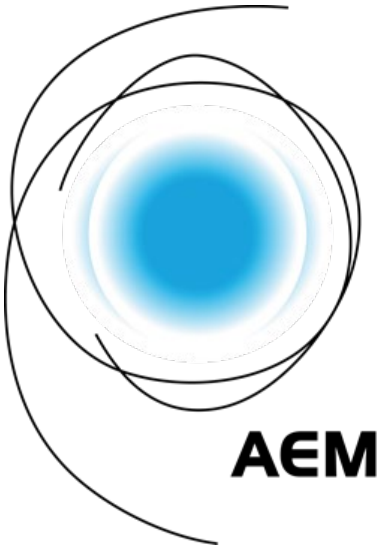
Essential system services and inertia in the NEM

June 2022



Contents

Summary

Essential system services (ESS) help keep the electricity grid in a safe, stable, and secure operating state. Getting the right ESS at the right time and in the right locations is vital for efficiently promoting consumers' interests as the sector undergoes unprecedented change as we transition to net zero.

The ESB's post 2025 recommendations set out a recommended way forward for ESS. This recognised that there is significant value where resources can provide flexibility and essential capabilities, allowing system needs to be met through a different mix of resources to what is used today. Stakeholder feedback suggested that addressing missing system services cannot wait until 2025.

Taking steps to identify, specify, value and procure these services will incentivise service providers to offer their diverse technical capabilities to market and ensure least cost outcomes for consumers. So the AEMC & AEMO have been working together to progress a number of power system security related projects.

This purpose of this paper is to:

1. set out the progress on ESS reform initiatives to date and
2. to set out more detail on the potential next priority in ESS – inertia

The ESB recommended using AEMO's Engineering Framework to consider technical requirements for inertia, including to coordinate and draw from other related initiatives, ahead of moving towards its long-term priority vision of a spot market approach for valuing and procuring inertia. This work and the current reforms on foot are expected to inform the ESS reform pathway for development of an inertia spot market and allow for the market to evolve as it matures.

We are seeking stakeholder feedback on the question posed in relation to the factors informing how the AEC's rule change request is progressed by 21 July 2022 via the AEMC's website, www.aemc.gov.au.

Please contact Clare Stark (clare.stark@aemc.gov.au) or Nicole Dodd (Nicole.Dodd@aemo.com.au) with questions or feedback at any stage.

1 Essential system services (ESS)

Essential system services (ESS) help keep the electricity grid in a safe, stable, and secure operating state. Getting the right ESS at the right time and in the right locations is vital for efficiently promoting consumers' interests as the sector undergoes unprecedented change as we transition to net zero.

Australia's National Electricity Market (NEM) is at the forefront of the energy transition globally. We have one of the highest penetrations of inverter-based resources worldwide, which is rapidly displacing the dispatch of synchronous generation. A variety of influencing factors is driving us towards new and previously unobserved operational conditions. Reform is required to ensure the power system remains secure through the transition.

In July 2021, the Energy Security Board (ESB) proposed a reform pathway to manage this unprecedented change in the NEM, including ESS reforms. This was endorsed by Energy Ministers through the National Cabinet Energy Reform Commission (NCERC) in October 2021. The pathway reaffirmed work already being progressed by the Australian Energy Market Commission (AEMC), Australian Energy Market Operator (AEMO), the Australian Energy Regulator (AER), and industry.

AEMO and the AEMC are working together on initiatives identified in the ESB's ESS reform pathway. The proposed initiatives are complex and interrelated, so it is important to prioritise and sequence them appropriately to manage their cost and complexity and ensure value in delivery. The ESB prioritised the initiatives as either *immediate*, *initial*, or *longer-term* reforms based on the urgency of the power system needs they addressed, as well as the work underway or required to deliver them. As a package, these initiatives address the immediate needs of the transitioning power system and will evolve as the power system evolves.

This joint paper describes the status of the initiatives underway and the linkages between them. We also explore next steps for the longer-term ESS initiative to consider an inertia spot market and the Australian Energy Council's (AEC) related rule change request. We are now seeking feedback on the factors informing how this is progressed, including interactions with the work underway to deliver the immediate and initial ESS initiatives.

What are essential system services and why is reform required?

Essential system services (ESS) help keep the parameters of the electricity system within acceptable limits so that it can reliably and securely deliver electricity.

Each ESS targets a different power system requirement beyond ensuring enough supply to meet consumer needs and includes a range of interdependent, technical, and operational requirements. For example, maintaining frequency and voltage around the levels required to maintain a secure and reliable power system.

Some ESS are currently explicitly valued, such as frequency control. Other ESS, such as fault current provision, have not traditionally been explicitly valued as they are provided as a by-product of synchronous generation by coal, gas, and hydro and have historically been available in sufficient quantities.

The increase of inverter-based resources means we must rethink how ESS are defined and delivered. The ESS required depends on the mix of equipment being used on the power system. How each service is delivered by different equipment, as well as the mix of services each provides, can also affect the mix of ESS required each day.

Different technologies also have different capabilities to provide ESS. We need to harness the diverse technical capabilities across the generation mix while maintaining our ability to meet the power system's requirements.

The AEMC and AEMO are considering mechanisms to efficiently and appropriately identify, specify, value and procure these interdependent services (i.e. unbundle) to maintain grid stability and security through the transition.

2 Progressing ESS initiatives for power system security

AEMO and the AEMC have made significant progress on the ESS transitional pathways recommended by the ESB, both through rule changes and broader work programs.

The ESB's post-2025 transitional pathway included immediate frequency control reforms, as well as initial reforms for inertia, operating reserves, and structured procurement and scheduling mechanisms including system strength. The introduction of an inertia spot market was a longer-term reform in the ESS pathway.

The introduction of an inertia spot market would complement the recommendation to move towards unbundled system services over time, drawing on experience and learning from the initial reforms. To inform this recommendation, the ESB engaged FTI Consulting to consider how best to procure the required services. They concluded that ideally spot market arrangements, combined with co-optimisation should be used where possible and that the NEM should progressively move towards spot market provision for services. But they noted that for some services spot market arrangement may not be appropriate (either now or ever).

The ESB considers ESS markets should move progressively in that direction. Although there is a preference for real-time signalling, there is also recognition that not all system services are suited for spot market-based procurement given current technology and understanding. Structured procurement would be used in cases where spot markets are not currently appropriate and may provide important insights on the pathway towards the incremental development of spot markets.

The ESS pathway builds on existing mechanisms such as AEMO's existing suite of Frequency Control Ancillary Services (FCAS) and the standards that must be met to connect to the power system. Network Support and Control Ancillary Services (NSCAS) and other mechanisms support investment in inertia and other system services before gaps arise and provide a foundation for these reforms. While operating reserves do not currently have an explicit mechanism, as noted by the ESB, the signal to supply reserves is implicitly provided through the energy spot market.

Ongoing technical research and analysis is required to ensure that the needs of the power system are provided to support a secure system. This work is underway, with the global power system industry collectively undertaking detailed analysis and research.

The market bodies continue to monitor and advise on the operation of these mechanisms as part of their efforts to progress rule changes and the ESB's ESS reforms. Work also continues on:

- AEMO's **Engineering Framework** to coordinate work to inform the technical aspects of these initiatives and improve our understanding of the power system as it transitions. The Engineering Framework will identify and facilitate implementation of priority actions in the energy transition, a subsection of which are the ESS reforms.
- AEMO's collaboration with the Reform Delivery Committee to navigate the delivery of interdependent ESS reforms, as well as the broader suite of ESB recommended reforms, through developing a **Regulatory and IT NEM2025 Implementation Roadmap**. Consultation on the initial roadmap has recently closed, and AEMO will

continue to work with the Reform Delivery Committee to progress consideration of the implementation pathway.

The following sub-sections provide updates on the ESB's ESS reforms for frequency, inertia, operating reserves, and system strength. It also updated on the operational security mechanism which would support provision of ESS in operational timeframes generally. AEMO and the AEMC encourage all interested stakeholders to engage directly with the consultation processes underway to shape these reforms. Look for the references in each topic to find ways to share your feedback.

2.1 Frequency

Frequency control services are necessary to keep frequency in the NEM around 50 Hz under normal conditions and to manage frequency according to the frequency operating standard (FOS) when there are disturbances in the NEM.

FFR help to manage frequency after disturbances in the power system, e.g. quickly injecting replacement energy to prevent power system frequency from dropping too low.

PFR helps manage frequency control during normal operation and is currently provided through arrangements requiring dispatched generators to respond automatically to changes in power system frequency.

ESB recommendation

Introduce two new fast frequency response (FFR) frequency control services and develop enduring primary frequency arrangements (PFR).

Status of initiatives

The AEMC has been working through two rule changes, supported closely by AEMO and with input from other market bodies, industry, and stakeholders.

- **Fast frequency response**. Two FFR markets will commence in October 2023 after the AEMC made a rule in July 2021 requiring AEMO to define and value these 'very fast FCAS'. The introduction of these services will help keep the future power system secure and foster innovation in faster responding technologies that will help lower costs for consumers. AEMO's recent issues paper opened consultation on incorporating the very fast frequency services into the market ancillary service specifications (MASS) AEMO is also progressing the system and process changes to enable FFR through dispatch and settlement.
- **Primary frequency response**. While the AEMC put in place arrangements that mandated that generators provide primary frequency response, the AEMC also set out that this on its own was not a complete solution. Therefore, the AEMC has been undertaking further work on how to incentivise and reward the provision of primary frequency response. The AEMC published a draft determination in September 2021 that confirmed that mandatory PFR arrangements would endure beyond the sunset date (June 2023) but would be complemented by new incentive arrangements. These would be provided through significant changes to the causer pays process currently used for regulation FCAS cost recovery. The proposed changes include frequency performance payments to market participants whose plant operates to help control system

frequency. The AEMC recently published a directions paper in May 2022 that provided further detail to stakeholders on the proposed frequency performance payments process set out in the draft rule. A final determination is currently due by July 2022

Related initiatives

In April 2022, the Reliability Panel initiated a review of the NEM frequency operating standard (FOS). The FOS defines the range of allowable frequency for the power system under different conditions, including normal operation and after system disturbances that affect frequency. The Panel also recognised an opportunity to improve the way the FOS specifies frequency performance during normal operation. The issues paper for this review has recently been published for consultation and the review will be completed by April 2023.

The FOS review and implementation of FFR will inform the appropriate enduring arrangements for inertia, as is described later in this paper. In particular, the FFR final rule requires AEMO to explicitly communicate how the level of inertia in the power system informed the quantity and type of ancillary services procured.

2.2 Inertia

Inertia is resistance to a change in momentum and supports maintaining a stable system when there are disturbances. Inertia reduces the rate at which frequency in the NEM changes when there are disturbances and can help to support a stable voltage waveform.

Inertia is discussed in more detail in the next section which is dedicated to inertia related reforms.

ESB recommendation

Further work by the market bodies to consider steps to move to a lower inertia system and consider an inertia spot market in the longer-term. Continue to analyse frequency services, synchronous inertia, and equivalent synthetic inertia, as well as interactions with other ESS.

Status of initiatives

Consideration of steps to move to a lower inertia system, including work to define and value inertia as a service, are being progressed through a number of initiatives (see next section). The AEMC has received a rule change request to progress the longer-term reform initiative for an inertia spot market.

Related initiatives

Related initiatives that inform the progress of the initial and longer-term inertia reform initiatives are described later in this paper.

2.3 Operating reserves

Every power system needs operating reserves, or available but unutilised power reserves, to ensure the system can cope with unexpected variations in supply and demand. Unlike other ESS, operating reserves are not about the control of frequency or voltage for security, but rather about plant being ready to provide capacity for reliability. Currently operating reserves are implicitly provided 'in market' as a by-product of generators managing their risks in the energy market.

ESB recommendation

Consider a mechanism to unbundle reserves from energy to explicitly value operating reserves to manage uncertainty in dispatch with changing generation and demand profiles.

Status of initiatives

The AEMC is considering two rule changes relating to reserve markets in the NEM. The first of these rule changes is the Operating reserve market rule change submitted by Infigen Energy. The second is the Introduction of ramping services rule change submitted by Delta Electricity.

The AEMC intends to publish a draft determination by June 2023 following additional time to obtain further information, including:

- Technical advice from AEMO relating to how key elements of the design would be implemented which is due by June 2022
- Data on the operation of the market under five-minute financial settlement and wholesale demand response, and
- progression of delivery of the various post 2025 reforms by the Energy Security Board, including those relating to resource adequacy, such as a potential capacity mechanism.

Related initiatives

The ESB made broader recommendations around mechanisms to develop resource adequacy mechanisms (RAMs) and manage ageing thermal retirement. The RAMs work includes consideration of a capacity mechanism, with the ESB developing a more detailed design. If a capacity mechanism is progressed it will have implications for the design of an operating reserve mechanism as both are intended to value capacity, albeit in different timescales.

AEMO is also redeveloping the methodology and system for short-term and pre-dispatch projected assessment of system adequacy (ST PASA and PD PASA). This would incorporate new requirements for publication of short-term data as set out in the AEMC's recent rule amending the short-term projected assessment of system adequacy (ST PASA) framework. In terms of provision of operating reserves, this should help:

- The market better understand the value of providing reserves at any given point in time by increasing transparency around availability and uncertainty in the market.

- Provide a signal for market participants to manage their reserves to target the periods of need for reserve, including potentially holding capacity for later periods when it will be more valuable for the system.

The Reliability Panel is currently reviewing the Reliability Standards and Settings, including the market price cap (MPC). The MPC dictates the degree of real-time risk in the energy market, creating incentives for market participants to hold capacity in reserve to manage these risks. This would impact the need for an operating reserve service to value and procure reserves in close-to real-time. A draft report from the Panel on this review is due in June 2022, ahead of a final report in September 2022.

The AEMC is also progressing a rule change that relates to collecting and publishing better information about the reliability of generators in the future, by requiring generators to provide more information on this into MT PASA. This also progresses one of the ESB's recommendations to improve resource adequacy outcomes in the NEM. A draft determination was published in May 2022, ahead of a final determination due by August 2022.

2.4 System strength

System strength is the measure of a power system's ability to maintain a stable voltage waveform and is critical to a secure power system. With the changing generation mix from synchronous to inverter-based resources, there is a reduction in the traditional supply of system strength with a corresponding increase in demand in new locations.

ESB recommendation

Structured procurement of system strength in the investment timeframe to provide system strength in an efficient manner. Central procurement of system strength services, led by TNSPs, to leverage considerable economies of scope and scale.

Status of initiatives

In October 2021, the AEMC made a final determination to put in place an evolved framework for the efficient provision of system strength in the NEM. The framework has a three-pronged approach:

- **Supply side:** A new transmission standard for system strength to provide system strength when and where it is needed. A subset of TNSPs, known as system strength service provider (SSS Provider), must meet the two components of the standard as set by AEMO forecasts. These components consist of the minimum level of system strength required for power system security, and the additional level of the service required for a stable voltage waveform to host projected levels of inverter-based resources (IBR).
- **Demand side:** New access standards for relevant generators, loads and market network service providers. These ensure that connecting parties efficiently demand system strength by using high quality plant.
- **Coordination:** A charging mechanism so parties who use system strength services pay for them. This charge varies by location in the network and the amount of system strength the connecting plant will consume, sending a price signal to connecting parties. The price signal will ensure that connections are coordinated with

SSS Provider's investments. Connecting parties have the choice of paying the charge or opting out providing their own system strength to remediate their own impact.

To implement this framework, AEMO is required to update the System Strength Requirements Methodology, the System Strength Impact Assessment Guidelines, and the Power System Stability Guidelines in line with the Rule change. AEMO is consulting on these documents and will produce an updated System Strength Report for December 2022, enabling SSS Providers to meet the system strength standard by December 2025. The AER has also recently consulted on proposed amendments to the electricity transmission pricing methodology to incorporate guidance on system strength charges.

Related initiatives

The Operational Security Mechanism, currently under consideration by the AEMC, would provide a means for more efficient scheduling of system strength providers in the operational timeframe. This is discussed below.

AEMO's Integrated System Plan (ISP) also informs the requirements for system strength and supporting efficient levels of IBR.

2.5 Operational security mechanism (structured procurement and scheduling mechanisms)

Changing power system dynamics create a need to consider the appropriate means for scheduling and provision of ESS to deliver secure outcomes efficiently. Structured procurement and scheduling mechanisms provide a market-based means for the valuing, procurement and scheduling of ESS that maintain the security of the power system.

These mechanisms should ensure the full range of requirements in the NEM are met operationally and assist in learning to operate under new conditions and with new technologies.

ESB recommendation

Implementation of a Unit Commitment for Security (UCS) mechanism to schedule resources providing services under structured procurement arrangements. Consider a System Security Mechanism (SSM), as a short-term procurement option to complement planning-based solutions and provide the system configuration needed to maintain security.

Status of initiatives

The AEMC is considering options to efficiently value, procure, and schedule ESS through the Operational Security Mechanism (OSM) rule change. This consolidates two rule change proposals – one to introduce an ex-ante, day ahead capacity commitment mechanism (from Delta Electricity) and one to introduce a market for 'synchronous services' (from Hydro Tasmania). This consolidated rule change process is also the avenue by which further consideration of issues raised through the development of the UCS and SSM, as contemplated by the ESB, is being progressed.

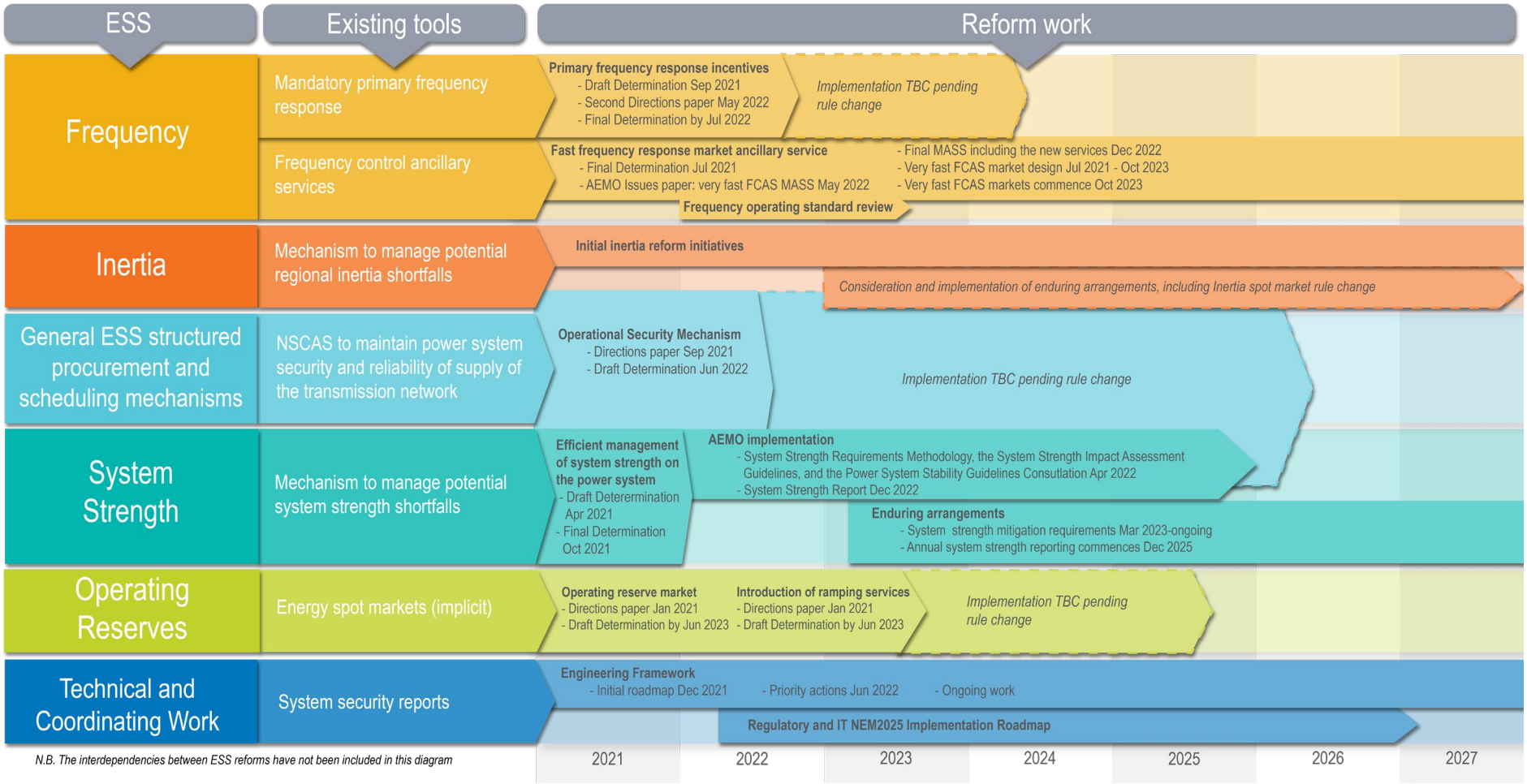
An OSM would provide a complementary means for valuing, scheduling, and procuring system services through a market mechanism, and provide a tool to help the market evolve through the transition. The AEMC plans to publish a consolidated draft determination in June 2022.

Related initiatives

Under the evolved system strength framework, SSS Providers can meet their obligations by options such as signing agreements with in-market participants that provide system strength or delivering network options to meet the standard. The OSM could be an avenue to schedule in-market resources that provide system strength efficiently in the operational timeframe alongside the rest of the ESS needs of the system, and how this could be achieved is being considered through these rule changes.

Through the Engineering Framework, AEMO has identified a priority set of actions to progress to start addressing the most pressing gaps and decisions that were identified in the Initial Engineering Framework Roadmap published in December 2021. In the Priority Actions Report, AEMO has describes a pathway toward technology-agnostic service specification and provision, and it is recognised that it will be important for market reform to support this pathway for efficient and effective delivery of ESS.

Essential system services reform initiatives



3 Progressing the initial and longer-term inertia reform initiatives

The ESB recommended market bodies consider the appropriate steps to move to a lower inertia system, including work to define and value inertia. The initial inertia reform initiative is focused on continuing to analyse frequency services, synchronous inertia, and equivalent synthetic inertia, as well as interactions with other ESS. The ESB recommended using AEMO's Engineering Framework to consider technical requirements, including to coordinate and draw from other related initiatives.

In the longer term, this work is expected to inform the ESS reform pathway for development of an inertia spot market and allow for the market to evolve as it matures. Solving the technical and policy issues will take time and needs to happen before implementation. A staged approach is therefore prudent to allow for the market and procurement solution to adapt over time, as well as to make sure we are ready to respond when inertia issues become more material.

The AEMC and AEMO have worked on the initial reform initiative with the ESB, AER, industry, and other stakeholders, building better understanding of the need for, and provision of, inertia in the NEM. This so far includes:

- Drawing from related reform initiatives
- Engaging with numerous studies and trials
- Examining experience in other jurisdictions
- Reviewing existing mechanisms, such as AEMO's annual report on inertia requirements for each sub-network.

While work has not yet formally commenced on the longer-term reform initiative for consideration of an inertia spot market, the AEMC received a rule change request from the AEC proposing the creation of a spot market for inertia. Given the progress on the initial reform initiative, as well as work underway on related reforms, we are seeking feedback on factors detailed in this section to inform the AEMC's decision on the appropriate timing for the rule change.

What is inertia?

Inertia can be defined as an object's resistance to any change in its momentum. For example, picture a quokka on a wheel – if the quokka stops running, the wheel and quokka will keep turning until the force of friction makes them stop. Inertia is the reason the wheel initially keeps turning. The more mass the wheel has, the greater its inertia, and the harder it is to stop.

Inertia is important as this resistance to change helps to maintain frequency and voltage within the technical limits of a secure and stable power system. The greater the inertia on the power system, as the less vulnerable it is to disturbances, all else kept equal. For example, when there is more inertia on the power system, frequency changes more slowly which allows more time for frequency control services, such as primary frequency response and FCAS, to address the energy imbalance and arrest the change in frequency. In a similar manner, inertia also supports a stable voltage waveform and so can contribute to system strength.

Inertia has historically been provided by synchronous generators, such as coal, gas, and hydro, as a by-product of their massive and fast spinning parts during generation. The massive, spinning parts of synchronous generators also provide other ESS at the same time, such as fault current. The large mass in the spinning parts innately provides inertia (and other ESS) so there has been no need to value and procure this service separately. However, as coal-fired and, to a lesser extent, gas generators retire the level of inertia in the power system will fall without further action.

It will be important to keep evolving our understanding of power system requirements and continue to define services to meet them. This will help tap into new capabilities in the changing resource mix to provide ESS, while helping to manage interactions in the system that affect ESS provision.

3.1 Defining and valuing inertia requirements

The ESB recommended further work by the market bodies to consider the steps to take in moving to a lower inertia system. To identify the next steps, it is important to establish the current arrangements and changing requirements of the power system. Interactions with other reform initiatives can also inform power system requirements as well as the efficient and effective steps to address them.

Current inertia provision

There are currently no mechanisms in place to value and procure inertia during normal operation in the NEM. This is because, historically, inertia requirements have been more than met through the prevalence of synchronous generation in the generator mix. Inertia is provided as a by-product of energy when synchronous generators are dispatched (see box).

The AEMC introduced a framework in 2017 to ensure security critical inertia when regions are at risk of 'islanding' from the rest of the NEM. Under this framework, AEMO is required to assess the minimum and secure operating levels of inertia for each region, the projected level of inertia in that region over the following five years, and the likelihood of the region becoming islanded. If AEMO identifies a projected shortfall in a region at risk of islanding, the relevant TNSP is required to procure the inertia or alternative frequency control service (including FFR) to meet this shortfall. Proposed investments by the TNSPs to provide inertia network services are subject to a regulatory investment test for transmission, as are any proposed inertia service payments.

AEMO also has tools to address inertia levels if the safety and security of the power system is threatened in the operational timeframe, including:

- Constraining interconnectors to reduce the largest contingency size, which may result in more synchronous generators operating in the region to meet demand
- Using directions as a last resort, for example, to direct a synchronous machine online if insufficient inertia is available in operational timeframes.

Informing an enduring inertia mechanism

The way we meet the power system's requirement for inertia is expected to evolve as the sector transitions and the generation mix changes. Renewable generation and batteries are rapidly entering the system, while the thermal generation fleet has started to retire or operate less frequently. There are various potential operational challenges associated with a reduction in inertia, such as many existing synchronous generators being unable to withstand high rates of change of frequency (RoCoF), existing protection equipment potentially being unable to operate with high RoCoF and maintaining a stable system more generally.

Work is needed to understand the capability and needs of resources as the system evolves, as well as interactions between these needs. This includes understanding when the supply and demand conditions may facilitate the creation of a spot market for the unbundled procurement of inertia, as well as the appropriate design for this market. For example, in the near term, existing synchronous machines may continue to play a role in meeting the current security needs of the NEM. However, growth in renewables and batteries and emerging new sources of inertia and other ESS may reduce the challenge of lower inertia and higher RoCoF.

Various pieces of technical work are building on our understanding of various power system needs, capabilities and resources. AEMO's Engineering Framework is coordinating this work to define the full range of operational, technical, and engineering requirements needed to deliver the futures envisaged in the Integrated System Plan. This includes co-ordinating the technical studies and activities required to understand the requirements and supply options for the range of ESS going forward – including inertia. In the first instance, this includes increasing publicly available information of power system phenomena by reporting on NEM inertia.

This coordinated technical work will inform the understanding gained through AEMO's current processes. For example, the annual review processes that AEMO runs, as described above, considers the future needs for various system security services across regions and sub-regions. AEMO is required to review and declare inertia shortfalls where it identifies these may occur, with TNSPs responsible for taking action to meet any shortfall. In its 2021 System Security Reports, AEMO noted there are challenges not addressed by the current framework including the impact of falling operational demand on inertia and FCAS availability, as well inertia shortfalls which occur less than 1% of the time. Interactions with other ESS can also mask issues as units currently providing inertia when they are providing system strength or energy to the market may mask the need for specific requirements to ensure there is always sufficient inertia in the system.

AEMO's Draft 2022 ISP provides inertia projections out to 2036-37. Appendix 7 of the ISP details this analysis on inertia, noting the assumption that synchronous connection across the NEM would provide a strong inertia base is being challenged and requires review. As the current framework does not support NEM-wide assessment of inertia requirements and shortfalls, AEMO uses the sum of each region's (excluding Tasmania) minimum operating level of inertia and projects a NEM-wide inertia shortfall by 2036-37. This is based on the *Progressive Change* scenario, but stakeholder consensus was the *Step Change* scenario was more likely. This may mean an increasing, accelerating need for new sources of system security services. AEMO has recently published an update to the 2021 System Security Report to take the *Step Change* scenario into account and will publish an update in the final ISP in June 2022 which will consider inertia over the ISP horizon.

In its December 2021 System Security Reports, AEMO declared inertia shortfalls in Queensland and South Australia for the period 2022-2026 and noted that a previously declared inertia shortfall in Tasmania had been resolved until 2024 when a shortfall is projected in that region. While AEMO has projected a strong decline in inertia in New South Wales and Victoria, shortfalls have not been declared at present as islanding of those regions is not considered likely. In the May 2022 update to the System Security Report AEMO rescinded the projected shortfall in Queensland when it assessed the region for the *Step Change* scenario and undertook more comprehensive modelling for this region. AEMO also flagged an intention to undertake additional assessments to consider the treatment of regions not likely to island to consider the available inertia in adjacent regions that may form a separate island within the NEM.

Another piece of work that will deepen our understanding of inertia related issues is the Frequency Operating Standard (FOS) review, which the AEMC has recently initiated through an Issues Paper released by the Reliability Panel. Considerations flagged in the Issues Paper include the impact of inertia on managing frequency in the NEM, including RoCoF limits, a maximum contingency size, and the potential for a system-wide inertia floor. AEMO will provide technical advice to the FOS review.

AEMO has also published an Engineering Framework 'white paper' to help fast track the deployment of advanced inverter capabilities. AEMO is also intending to collaborate with industry further to develop a voluntary advanced

inverter specification. Reforms in other jurisdictions may also be informative, such as future market arrangements for managing RoCoF in Western Australia, noting attention will need to be paid to differences in the specific characteristics and needs of that region or market.

Finally, industry and other stakeholders are also undertaking several trials that will inform understanding of power system requirements and inertia capabilities of different technologies, such as grid-forming battery energy storage systems (BESS). This includes synthetic inertia trials at the Hornsdale Power Reserve and ESCRI Dalrymple BESS, work by Monash University to investigate the integration of renewables into weak grids, and TransGrid's synthetic inertia trial with its Wallgrove Grid Battery.

Understanding and addressing inertia needs

Several recently completed or in-progress reforms relate either directly to understanding and managing the provision of inertia or more broadly to control of power system frequency. Along with the existing inertia shortfall mechanism, these reforms can help to manage the inertia needs in the near term until an appropriate and efficient enduring approach can be brought in.

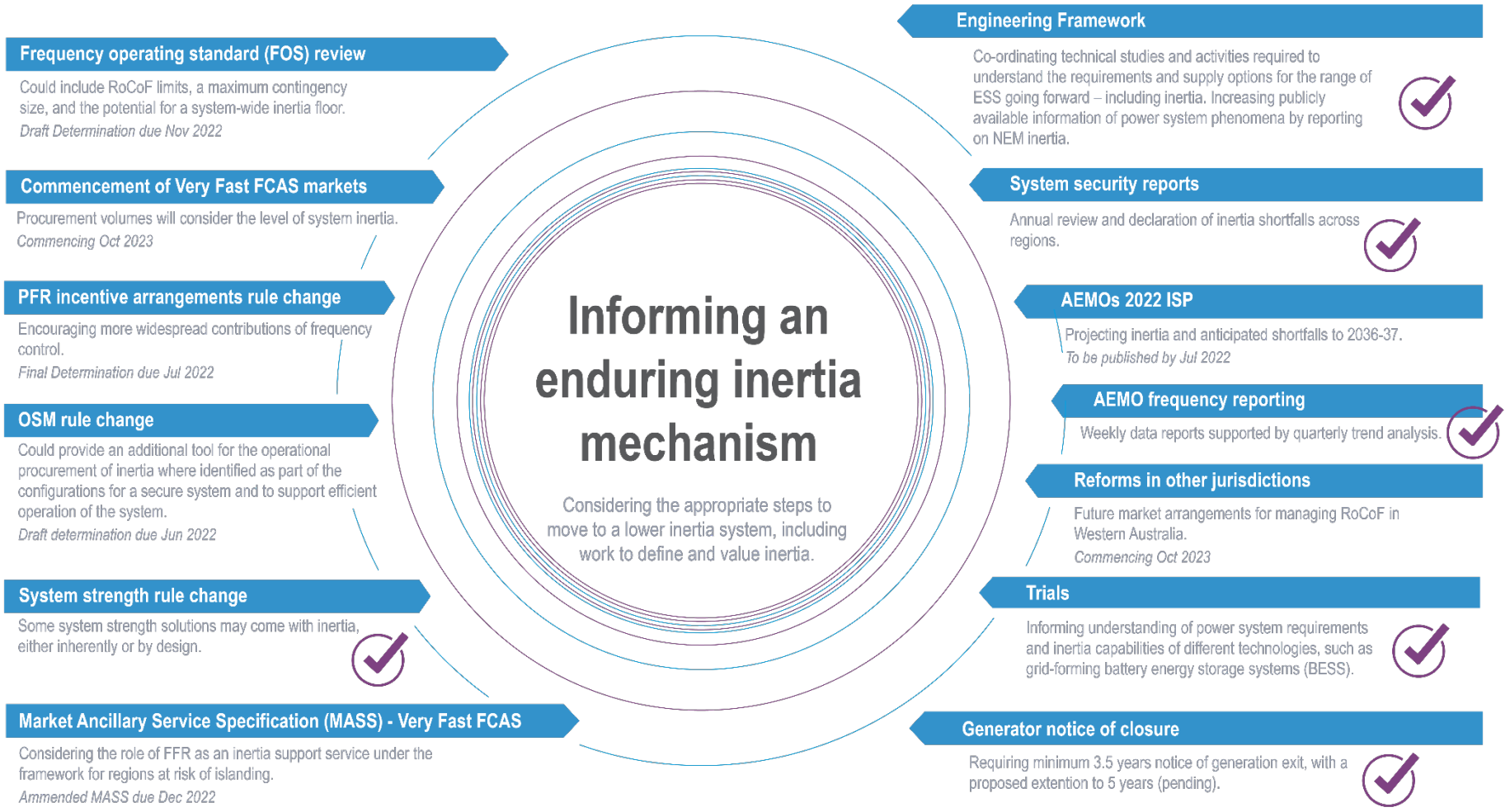
AEMO and the AEMC are progressing these initiatives concurrently and sequencing this work to ensure priorities are met to manage interactions between reforms, as well as making sure we are meeting the needs and the urgency of the power system requirements they address.

The AEMC is progressing the **OSM rule change** for options for the scheduling and provision of ESS (see section on ESS reforms). The OSM is looking at ways to evolve the existing market design to deliver secure outcomes efficiently by looking at solutions to better procure, coordinate, and optimise provision of ESS. This could provide an additional tool for the operational procurement of inertia to support efficient operation of the system. In this way, the OSM could act as a vehicle to help progress the definition of inertia as a service, among other ESS, via operational procurement and encourage market participants to develop capacity to deliver this service. This could potentially allow for evolution and better understanding of inertia needs as the market matures, building on FTI Consulting's recommendation to consider what is an appropriate pathway for development of ESS. The AEMC plans to publish a draft determination for consultation on 30 June 2022.

Other work currently underway to understand and address inertia needs in the near-term includes:

- AEMO is consulting on amendments to the **market ancillary service specification** (MASS) to incorporate very fast FCAS following the FFR rule made in July 2021. The MASS focuses on the service specification, not the market design. However, the services specification for FFR must consider interactions between FFR and inertia, such as:
  - The role of FFR as an inertia support service under the framework for regions at risk of islanding
  - The fact that FCAS and inertia are not directly interchangeable so inertia will need to be procured through other mechanisms.
- AEMO is preparing for the commencement of **very fast FCAS markets** in October 2023. As noted in AEMO's MASS Issues Paper which is out for consultation, the procurement volumes for very fast FCAS will consider the level of system inertia. AEMO will need to develop an estimate of inertia in the NEM to inform very fast FCAS procurement volumes.

- AEMO **quarterly reports** on power system frequency and time error in the NEM. Some of this content is defined by requirements under NER clause 4.8.16(b). AEMO includes additional information in this report to identify trends that are driving changes in frequency and time error, including for example, the rate of change of frequency (RoCoF) observed in the NEM over the quarter. Increasing RoCoF can indicate a reduction in power system inertia or increases in contingency sizes.
- AEMO **weekly reports** provide data to market participants on the performance of power system frequency against the FOS, regulation services enabled in each region, and use of the enabled regulation services. These reports are required under the NER.
- The AEMC is progressing the **PFR incentive arrangements** rule change to establish enduring arrangement for PFR and the incentive arrangements to encourage market participants to support effective and efficient operation of these arrangements (see section 2.1). Encouraging more widespread contributions of frequency control should improve overall power system frequency and may reduce the requirements for inertia.
- The AER, AEMO and TNSPs are working to implement the framework created through the AEMC's **system strength** rule. AEMO has recently initiated consultation on the System Strength Requirements Methodology, the System Strength Impact Assessment Guidelines, and the Power System Stability Guidelines. To address system strength requirements identified by AEMO, TNSPs invest in solutions to provide efficient levels of system strength. Some system strength solutions may come with inertia, either inherently or by design.
- The AEMC's 2018 **generator notice of closure** rule should provide greater transparency for AEMO on when significant sources of inertia intend to leave the market. The closure notice period is a minimum of 3.5 years, noting a pending rule change request submitted to the AEMC by the Minister for Energy proposes to extend this period to 5 years.


Informing an enduring inertia mechanism
Considering the appropriate steps to move to a lower inertia system, including work to define and value inertia.
Frequency operating standard (FOS) review
Could include RoCoF limits, a maximum contingency size, and the potential for a system-wide inertia floor.
Draft Determination due Nov 2022
Commencement of Very Fast FCAS markets
Procurement volumes will consider the level of system inertia.
Commencing Oct 2023
PFR incentive arrangements rule change
Encouraging more widespread contributions of frequency control.
Final Determination due Jul 2022
OSM rule change
Could provide an additional tool for the operational procurement of inertia where identified as part of the configurations for a secure system and to support efficient operation of the system.
Draft determination due Jun 2022
System strength rule change
Some system strength solutions may come with inertia, either inherently or by design.
Market Ancillary Service Specification (MASS) - Very Fast FCAS
Considering the role of FFR as an inertia support service under the framework for regions at risk of islanding.
Ammended MASS due Dec 2022
Engineering Framework
Co-ordinating technical studies and activities required to understand the requirements and supply options for the range of ESS going forward – including inertia. Increasing publicly available information of power system phenomena by reporting on NEM inertia.
System security reports
Annual review and declaration of inertia shortfalls across regions.
AEMOs 2022 ISP
Projecting inertia and anticipated shortfalls to 2036-37.
To be published by Jul 2022
AEMO frequency reporting
Weekly data reports supported by quarterly trend analysis.
Reforms in other jurisdictions
Future market arrangements for managing RoCoF in Western Australia.
Commencing Oct 2023
Trials
Informing understanding of power system requirements and inertia capabilities of different technologies, such as grid-forming battery energy storage systems (BESS).
Generator notice of closure
Requiring minimum 3.5 years notice of generation exit, with a proposed extention to 5 years (pending).

3.2 Future consideration of an inertia spot market

To date, the market bodies have focused on ensuring the robustness of the existing mechanisms and in-flight reforms to support a secure system and on the preparatory work to inform consideration of the power system requirements and market design work. This has also evolved on focussing on addressing critical issues in the regulatory framework such as addressing the degradation in primary frequency response and the unintended consequences from the 'do no harm' arrangements for system strength.

The preparatory power system requirements and market design work will be required to consider the creation of an inertia spot market in the long-term, or other appropriate enduring arrangements. With several mechanisms in place and more in progress to provide for inertia requirements in the NEM in the near-term and to mature the market, work on a spot market has not yet commenced. This is because detailed investigation on inertia in order to understand the technical aspects of it is still required. Work to better understand relevant policy and regulatory issues and the best mechanisms to use through the transition and in an enduring sense is also required. In the near term these mechanisms, as well as reforms described earlier, are expected to help ensure that the system does not face significant inertia shortages. It is important to have a long-term approach for inertia in place before any threat to power system security from a lack of inertia materialises.

The AEC submitted a rule change request to the AEMC in December 2021 proposing an inertia spot market. The AEC noted that while an inertia spot market is not imminently required for power system security, the work required by the AEMC and AEMO is likely to take considerable time – at least four years. The complexity and scale of the task required suggests work begin now to ensure arrangements are in place before the requirement becomes urgent. The AEC argued there are efficiency benefits from replacing mechanisms indirectly managing inertia in the NEM and from signalling the direction of reform to influence investment.

AEC's proposed design

The AEC proposes a design for the forecasting, dispatch, and settlement of an inertia market. Market participants would be able to place energy only, energy and inertia, or inertia only bids which would then be co-optimised through the NEM Dispatch Engine (NEMDE). The market would allow for the procurement of inertia from both synchronous and non-synchronous resources to the extent they are capable of meeting AEMO's technical definition of inertia. Participation in the Inertia Ancillary Service market would be voluntary.

Under the proposed arrangements AEMO would procure inertia to meet the secure operation requirements at a minimum. Total procurement volumes would be co-optimised with the procurement of energy and other market ancillary services. Market participants would face a common clearing price which would likely apply to the mainland, with a separate clearing price set for Tasmania. The market would have a price floor of zero and a price cap could be set by the Reliability Panel.

The AEC recognises that further work is needed to understand the technical requirements of the system for inertia and the best approach to manage inertia in future. It notes that further regulatory work is required to consider interactions with the NER. This includes consideration of the current framework for TNSPs to procure inertia for regions where AEMO has declared a projected inertia shortfall. These technical and regulatory considerations need to be addressed before the approach to implementation can be considered in detail.

Feedback about factors relating to the rule change request

The AEMC's decision on the timing of the initiation of the AEC's rule change request will need to account for a number of factors. This includes balancing the need to prioritise the various initiatives that are being progressed under the significant ESS work program with potentially increasing scarcity of inertia over time as synchronous generation exits the market, and opportunities to leverage efficiencies from introducing a targeted mechanism. It also involves making sure there is a better understanding of technical aspects before regulatory design work commences.

The ESS work program is significant and requires coordinating and prioritising over time. There is a need to coordinate this rule change with many interrelated projects and reforms. The market also needs time to evolve to be in a position where the creation of a spot market for inertia is needed and can be expected to provide value for the market and to overall benefit consumers.

Like any reform to evolve the market, answering the technical and regulatory questions identified by the AEC for the design of an inertia spot market will take time. There are also several other areas that need to be explored further, such as the complexity and practicality of the changes required for NEMDE and systems implementation. In addition, interactions with other reform initiatives will inform understanding of the need for inertia in the power system through the transition, as well as the appropriate design for an inertia spot market or other enduring arrangements.

Recent reforms that do not have the same level of complexity, such as the fast frequency response markets, have taken around two years to develop and will take a further two years to fully implement. The implementation of an inertia spot market could take at least this long. Consideration would also need to be given to whether transitional arrangements are required.

However, we need to ensure there is adequate time to robustly consider, design and implement new initiatives so they are in place when they are needed and provide benefit to the system. To do this, we need to ensure that we better understand the system need for inertia and the adequacy of current and evolving inertia frameworks.

The AEC proposes the timing of this work should also reflect the benefits to consumers from an explicit mechanism to procure inertia replacing the range of mechanisms that would otherwise indirectly manage power system requirements. For example, increased procurement of FCAS, constraining efficient dispatch to limit the largest contingency size, and regional procurement by TNSPs which does not leverage national competitive markets. A spot market would provide a transparent price signal to market participants to make investment and/or unit commitment decisions which can, in turn, incentivise additional cost efficiencies and innovation.

We are seeking your views on:

- **The problem that the AEC's proposal seeks to address:**
  - **This paper outlines work underway to understand technical system needs. Are there additional factors that should be considered in establishing the materiality of the impact of reducing inertia on the system?**
  - **What are the net benefits to market participants and consumers for providing an incentive for unbundled procurement of inertia, and when do they arise? Is there an opportunity for material efficiencies or net benefits from establishing an inertia spot market before significant inertia shortfalls are experienced in the system?**
- **Are there important implementation considerations?**
  - **How should initiation of this rule change interact or work in parallel with milestones of other reforms that are at various stages of development? Are there inertia specific considerations that should feed back into these other reforms?**
  - **When might stakeholders best have capacity to engage with this proposal and implementation of a solution?**

Initiation of the rule change request will be informed by submissions

The AEMC will make a decision on when to initiate the rule change request. In deciding the timing of initiation of the request, stakeholder views on balancing the implementation considerations above will be taken into account.

Once the AEMC initiates a rule change request, the next step in the process is that the AEMC publishes a Consultation Paper to facilitate stakeholder consultation on the rule change request. The AEMC will take certain feedback received to this paper as relevant context when the rule change request is initiated. This will help us have a more timely and efficient process for completing the rule change itself.

AEMO will continue to communicate to stakeholders how inertia work will be progressed through the Engineering Framework, the NEM Implementation Roadmap, and other pieces of technical work.

How to get involved

Written submissions to the questions on factors informing how AEC's rule change request is progressed must be lodged by 21 July 2022 via the AEMC's website, www.aemc.gov.au.

The AEMC and AEMO will also be holding a virtual public forum to present this paper and consult on the questions listed above on Thursday 30 June 2022

Please contact the project leader with questions or feedback at any stage.

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Acronyms

Term	Definition
AEC	Australian Energy Council
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
BESS	Battery Energy Storage System
DER	Distributed Energy Resources
DUID	Dispatchable Unit Identifier
ESB	Energy Security Board
ESS	Essential System Services
FCAS	Frequency Control Ancillary Services
FFR	Fast Frequency Response
FOS	Frequency Operating Standard
IBR	Inverter Based Resources
ISP	Integrated System Plan
MASS	Market Ancillary Service Specification
MPC	Market Price Cap
MWs	Megawatt seconds
NCERC	National Cabinet Energy Reform Commission
NEM	National Energy Market
NEMDE	National Energy Market Dispatch Engine
NEL	National Electricity Law
NEO	National Electricity Objective
NER	National Electricity Rules
NSCAS	Network Support and Control Ancillary Services
OSM	Operational Security Mechanism
PFR	Primary Frequency Response
RAM	Resource Adequacy Mechanism
RoCoF	Rate of Change of Frequency
RSSR	Reliability Standards and Settings Review
SSM	System Security Mechanism
SSSP	System Strength Service Provider
ST PASA	Short Term Projected Assessment of System Adequacy
TNSP	Transmission Network Service Provider
UCS	Unit Commitment for Security
VRE	Variable Renewable Energy