21 October 2021

Level 22
530 Collins Street
Melbourne VIC 3000

Postal Address:
GPO Box 2008
Melbourne VIC 3001

T 1300 858724
F 03 9609 8080

Ms Anna Collyer
Chair
Australian Energy Market Commission
Sydney South NSW 1235

By online submission
AEMC Code: ERC0306 & ERC0290

Dear Ms Collyer,

Directions Paper – Capacity Commitment Mechanism and Synchronous Services Markets

AEMO welcomes the opportunity to provide feedback on the Directions Paper considering options to value, procure and schedule essential system services.

The Directions Paper is a thoughtful consideration of possible approaches for procuring the necessary security services to operate the power system as the system transitions to times of very high levels of inverter-based resources and low levels of synchronous generation.

In this submission AEMO discusses the AEMC's characterisation of power system requirements with reference to AEMO's Engineering Framework to highlight some of the expected future operational conditions. AEMO considers that options to value, procure and schedule essential system services may be needed to configure the power system into a secure state under these conditions.

Generally, AEMO agrees with the long-term vision for a service-based procurement model to meet the AEMC's system security objective yet suggest the system and connecting equipment needs to be considered as a whole, and the capabilities that different equipment bring to the system cannot necessarily be separated easily. This may require procuring secure configurations of the system, rather than individual services, to meet the needs of the power system. Further description of the way AEMO assesses the power system collectively to meet its obligations to maintain power system security and reliability is provided. This explains how AEMO determines which configurations can be expected to remain within the secure operating envelope, and how AEMO cannot, at this time, quantify specific services required. Notwithstanding this, over time, AEMO expects opportunity to identify requirements for separate services, and reliance on procuring secure system configurations may diminish.

The Directions Paper outlines the AEMC's characterisation of the current approach to produce dispatch schedules and ensure the power system remains secure. AEMO notes the pre-dispatch and dispatch engines can produce a result for individual intervals that are insecure, because, in its current form, the engine is unable to account for all elements of security in constraining the optimisation. This, combined with the lack of value for the provision of such capability, leads to an inability for participants to schedule generators to manage the full range of power system requirements needed for secure operation. AEMO's submission notes the ideal solution would be to include the security constraints in dispatch and institute requirements for dispatch of the security service, including bid-based clearing of these services, where it is feasible to do so. Absent this, AEMO suggests it preferable for trading to always be based on a secure calculation, so when pre-dispatch is run, the price and dispatch results for each interval represent a secure dispatch. Trading is unlikely to reach a competitive equilibrium without doing this, because the trading is based on a false assumption the system is secure and may see pre-dispatch trade in and out of security towards real-time.

As such, AEMO agrees with the Commission's recommendation of the NMAS approach. AEMO does not consider a MAS approach alone is practical nor feasible as a market-based means for procuring secure system configurations (what the AEMC has termed procurement of "system security support services"). To address the underlying problem, procurement of "system security support services" needs to account for valuing and scheduling the configuration of units to provide capability that is not energy or FCAS, producing secure results. Given the nature of the underlying requirements, the formulation of the pre-dispatch and dispatch engine, and the interaction of the broader pre-dispatch ecosystem, AEMO does not consider a MAS approach is suitable at this time.

The AEMC identified challenges for both the linear and binary MAS approaches, such as the potential for partial commitment, time to optimise, and ability to determine a price for the services. AEMO considers considerable effort will be required to overcome these before a MAS can deliver a secure dispatch. Further, AEMO is concerned that, even where these can be overcome, because the MAS approach represents trading in security services up until real-time, it may be unable to be relied on for secure operation and alternative options may be required through the transition as experience develops.

For these reasons, AEMO suggests it would be preferable to prioritise consideration of the NMAS approach. Further development of the MAS approach in parallel is likely to take considerable resources which will hamper the development of an NMAS solution. The NMAS approach is preferable to provide a market-based means for procurement of secure configurations of the system. The NMAS approach allows for the incorporation of constraints that can represent a greater range of power system requirements, commits resources ahead of time such that pre-dispatch can then solve on a secure basis, and allows for inter-temporal optimisation where this can benefit the overall efficiency of the solution. The NMAS approach also allows for operational scheduling of resources that have been contracted to provide services to support the operation of the network, such as system strength under the evolved framework, and complementary operational procurement where this is required, particularly for planned and unplanned outages.

AEMO suggests market transparency would improve under the NMAS approach because it allows trading to be based on a secure system. The NMAS approach runs an optimisation ahead on non-binding energy offers and schedules the security services. It is inescapable this may result in too much of the security service or too little when rebidding subsequently occurs, but this is no different to when a participant commits a unit and hindsight implies that decision to be wrong.

Further, the alternatives are waiting to schedule the service and trading on an insecure pre-dispatch, (like we do today); making all energy offers binding and prohibiting further rebidding; or lastly trading in security, under the MAS approach. The first two alternatives would reduce transparency and therefore trading efficiency, and the last may also, if implemented poorly. AEMO notes producing the NMAS schedule ahead of time may introduce inefficiencies due to differences between the ahead-schedule and the real-time dispatch, and looks forward to working with the AEMC to minimise these.

AEMO has considered the AEMC's view the implementation of either the MAS or NMAS approaches should ultimately transition to procuring unbundled system services. A market-based means for procurement of configurations appears a good way of learning to operate under new conditions, providing an additional tool for the market to meet the needs of secure system operation. AEMO considers it may be far easier to introduce such a tool than immediately proceeding with separating services and defining markets. AEMO would suggest developing MAS options may be so difficult it may exacerbate the scarcity of and slow the development of security services. AEMO believes the MAS approach would be an ideal solution where a service can be specifically quantified, numerous participants can compete, and it is possible to linearise the demand for the service. Yet given the range of security requirements, AEMO would suggest priority should be given to acquiring all requirements together through secure configurations by way of the NMAS approach, and then further consideration can be given to unbundling other services using linear approximations, for example for inertia, in the future. AEMO supports the NMAS approach as a stepping-stone to more optimized MAS approach based on the experience gained based on NMAS approach.

AEMO agrees with the AEMC's list of issues to be addressed and considers an important step will be to develop an end-to-end straw design of the approach. This should consider the design elements of the mechanism, how it will interact with the pre-dispatch and dispatch ecosystem, and the interactions with other existing and evolving frameworks of the NEM.

AEMO highlights the reforms considered in these rule changes form part of the ESB's NEM2025 program. This is a large program of work, which will involve significant regulatory and IT change for both market bodies and industry participants. AEMO completed a preliminary assessment of the changes required to market systems to deliver the reform agenda. This identified an opportunity to strategically sequence the IT change program for AEMO and for participants. Further work is underway to unpack and consult with industry on a roadmap to deliver the reform in an integrated, cost effective, and timely manner.

AEMO provides a comprehensive set of responses to the questions the AEMC have set out in their Directions paper in the attached appendix and looks forward to continuing to collaborate with the AEMC on these changes.

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

Yours sincerely

Tony Chappel
Chief External Affairs Officer

1. Consultation Questions

AEMO responds to the questions posed by the AEMC in this appendix.

1.1. Question 1.1 What do stakeholders think of the characterisation of power system requirements as described above?

AEMO broadly agrees with the AEMC's characterisation and in responding to this question seeks to provide additional information and context from the perspective of the system operator.

This background expands on the problem statement of the AEMC to aid stakeholders' understanding of the physical characteristics of the transitioning system and explains activities underway by AEMO to maintain system security in real-time, through the transition, and into the future.

We cover a summary of the Engineering Framework, the way in which AEMO determines the secure operating envelope, and discuss the potential gaps which may emerge between the evolved system strength framework and what is required operationally. The AEMC has presented an in-depth discussion of the changing generation mix being observed in the NEM, so we do not seek to recreate that discussion but rather further the discussion on the implications for the transitioning system.

The NEM Engineering Framework

As the AEMC references, AEMO has initiated the NEM Engineering Framework[1] (Engineering Framework) as a vehicle to deliver a roadmap to enable a secure and efficient energy transition. The Engineering Framework is a toolkit to define the full range of operational, technical, and engineering requirements needed to facilitate an orderly transition to a secure and efficient future NEM system. The intent of the Engineering Framework is to:

- Determine future operating conditions for the NEM power system with industry.
- Consolidate a common view of the current work underway across industry to adapt the power system and existing avenues for engagement.
- Collaborate on identifying where increased industry focus is needed to bridge the gap between current work and future operating conditions.

The Engineering Framework takes a holistic view of the changing characteristics of the energy system to help facilitate an orderly transition of the NEM. Through the Engineering Framework, AEMO aims to work with energy market bodies and industry to co-ordinate and harness the capability and knowledge of all to enable a smooth transition. The Engineering Framework maps current activities to the actions necessary to enable design and operation of a secure and efficient system. AEMO will collaborate with stakeholders to integrate and coordinate prioritised actions across a variety of industry workplans, both existing and new. These workplans are set based on complex regulatory and commercial frameworks and will in many cases include activities beyond

[1] Further information about the Engineering Framework can be found on AEMO's website: https://aemo.com.au/en/initiatives/major-programs/engineering-framework.

those identified by the Engineering Framework alone. The Engineering Framework will initiate additional workplans where priority actions are not covered elsewhere.

Operational conditions of the transitioning and future NEM

The NEM could reach up to 100% instantaneous renewable penetration availability by 2025 if current trends continue. This will see new operational conditions emerge, such as the system being dominated by inverter-based resources at times, and shifting to one that may be dominated by synchronous generators at others. The power system must be able to operate securely and efficiently under both these periods, and during the transition between them. Figure 1 highlights a possible day in the next five to 10 years, with a shifting generation mix over the course of the day. There is a high variable renewable energy (VRE) generation in the daytime period, with storage utilising excess generation, whereas in the evening and night time period VRE generation is much lower, with storage and thermal plants turning on to cover the change.

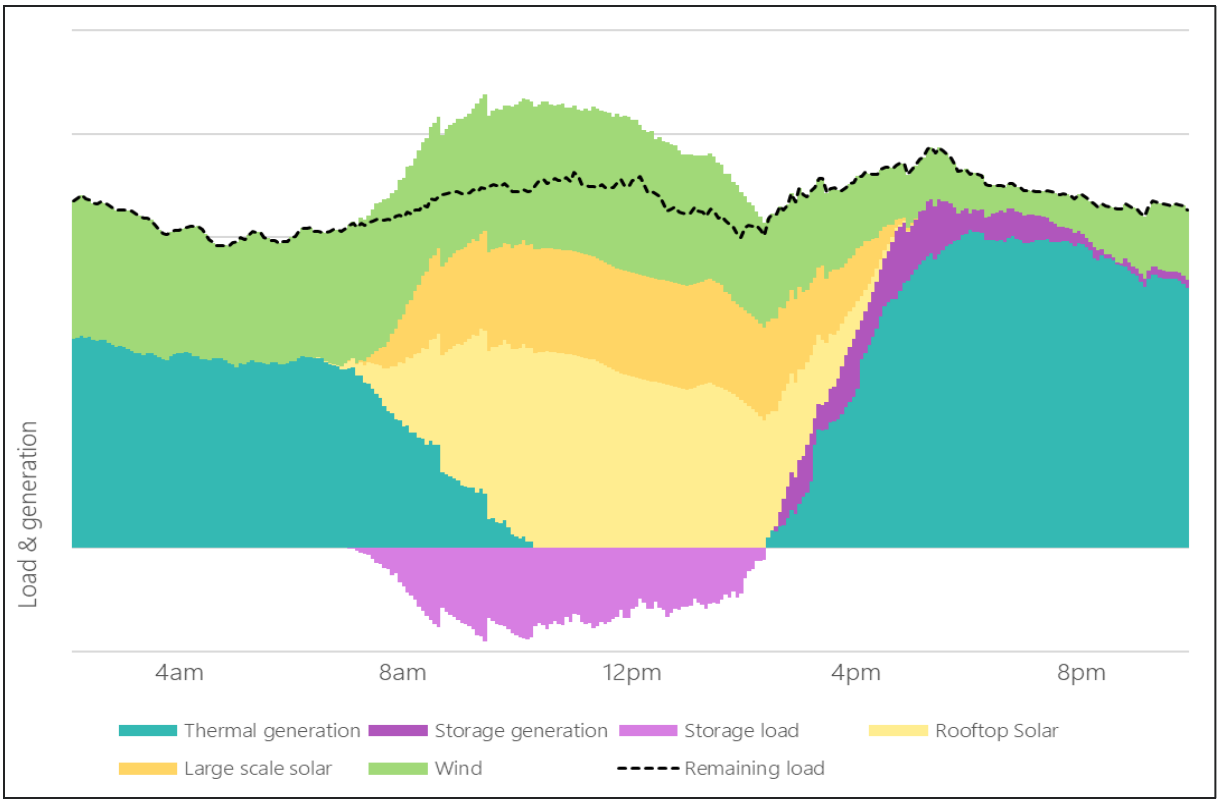

Figure 1: Source: NEM Engineering Framework, Operational Conditions Summary. Shifting generation mix in a region over a possible day in the next five to 10 years.

In July 2021, AEMO published a report summarising the operational conditions[2] to be used to help industry prepare for a secure and efficient transition, to support the work of the Engineering Framework. These conditions were identified through collaboration with industry and represent

[2] NEM Engineering Framework: Operational Conditions Summary, July 2021, https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/nem-engineering-framework-july-2021-report.pdf

the future generation mix and loading combinations that are expected to be seen in the NEM. These have been identified as the most important conditions to plan for given the expectation that these, or some combination of these, are likely to occur in the near future. The following six conditions were identified as the set that would assist in assessing the preparedness of the NEM to operate securely in future potential conditions.

	Operational condition	= Generation mix	+ Loading
1	Fewer synchronous generators online	Low/no synchronous generators online	Low or high demand
2	Ubiquitous rooftop solar	High distributed photovoltaics (DPV)	Low underlying demand
3	Extensive grid-scale VRE	High grid-scale VRE	Low or high demand
4	Structural demand shifts	Various	End-use electrification and industrial shifts
5	Responsive demand	Various	Active demand side
6	Widespread energy storage	High on-demand storage penetration	Fluctuating underlying demand

Figure 2: NEM Engineering Framework, Operational Conditions Summary

The eventual realisation of these conditions will then depend on whether it is efficient, cost effective and in the long-term interests of consumers to securely operate in those conditions. If that is the case, the ability of the system to operate in these conditions will also be driven by whether the appropriate physical and market frameworks are in place to enable this to occur.

The Engineering Framework is currently assessing the gaps associated with operating in the identified conditions. Preliminary analysis has highlighted potential gaps associated with adequate service definition and provision and whether the system will effectively schedule and coordinate to remain secure through these conditions. At a high level, those that are relevant to the discussion of a mechanism for operational procurement and scheduling of resources for a secure power system include:

- The ability to look ahead and co-ordinate for the provision of all power system requirements, understanding how the system is expected to be configured, including the status of various assets on the system (including, for example, commitment status, energy reserves, inverter configuration) and what services they can be expected to deliver based on the prevailing conditions. This understanding of the future and real-time condition of the system configuration will enable a better assessment of the operating envelope for a secure system, and from there mechanisms will need to be in place to efficiently coordinate provision of capabilities for secure, reliable operation.

- The adequacy of the definition of services and incentives for resources to provide those services in such a way to benefit the system as a whole. This includes whether the market will be incentivised to provide additional services that can unlock overall lower cost energy provision through the alleviation of particular limitations or constraints.
- Integrating new technology into the system and harnessing the full capability of new technology.
- The ability for protection systems to continue to operate under different operating conditions where the underlying real and reactive power sources will change, thus changing the assumptions of the conditions in which protection systems were designed to operate.

These gaps reflect that there is significant work to be undertaken to facilitate an orderly transition of a secure and efficient NEM and suggest that there are opportunities for market and regulatory reform to progress in parallel. In December, AEMO will publish a draft roadmap, which includes the priority actions that require urgent attention, as well as gaps that remain throughout the energy transition which will be further refined with stakeholders.

Changing Equipment

It is recognised that new equipment will be needed to support the secure operation of the NEM throughout the transition and in future operating conditions. Successful integration of new equipment into the transiting system means careful analysis is required for:

- What capabilities new equipment can deliver and how these capabilities are delivered? For example, what state does the equipment need to be in, or what trade-offs are required for delivering certain capability?
- What operating conditions does new equipment need for their secure operation?
- What are the needs of the rest of the system as a whole through the range of possible operational conditions?
- How do each of these interact with each other? That is, for example, how does the way in which new equipment delivers capabilities interact with the response of the rest of the system?

As described by the AEMC in its Directions Paper, the system was designed around synchronous generation. However, the future system may not continue to be, and it may be inefficient to continue in such a way. That is, requiring new equipment to replicate the behaviour of a synchronous generator on a one-for-one basis may limit the potential capability of such equipment, impose additional costs on the system, and reduce the flexibility in the way in which the transition can proceed.

Nevertheless, there is a need to consider old, new, and modified technology, and the operational advantages and limitations of each and how they work together. This includes the inseparability of service delivery, the trade-offs between providing different services, and the operational requirements such as start-time, minimum run-times, energy limitations that need to be accounted for in the equipment providing services and meeting power system requirements. As identified above, the system is expected to transition rapidly between various operational conditions, with dispatch increasingly affected by these operational requirements, and so the system and market design must account for these scenarios.

The Engineering Framework provides a platform for investigating how new technology can be successfully integrated. AEMO recently published a white paper on the Application of Advanced Grid-scale Inverters in the NEM.[3] The purpose of this paper was to provide recommendations toward enabling the application of this technology to support the NEM as the amount of inverter-based resources (IBR) increases and synchronous generation online reduces. It is expected that advanced inverter technology may be able to address many of the challenges facing the NEM today. However, at present this potential is not demonstrated at the necessary scale, and focused engineering development is urgently needed to address the remaining issues and realise the promise of this technology. Concurrently, AEMO considers it prudent to consider market-based mechanisms that may support the integration of this technology and provide a pathway to supporting the capability this, and other new technology, can provide for the benefit of secure system operation. AEMO considers there are synergies between the recommendations made for advanced inverters and the proposals for an operational procurement mechanism, and these should be noted as relevant factors in these deliberations – further comment is made on this through the rest of the submission.

The discussion above highlights the work underway to help facilitate a secure system into the future. This program should explain how to operate securely and efficiently into the future and provide an input to determining the reform pathway. Meanwhile, AEMO continues to fulfil its obligation operating the system.

Assessing the physics collectively

As the system and market operator, AEMO is obligated to operate the NEM consistent with its security and reliability obligations. These obligations are described as follows:

- System security:
    1. To maintain the system in a secure operating state[4] during normal operation, consistent with the power system security standards.

[3] NEM Engineering Framework, Application of Advanced Grid Scale Inverters in the NEM, August 2021, https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/application-of-advanced-grid-scale-inverters-in-the-nem.pdf

[4] The power system is in a secure operating state if it will return to a satisfactory operating state following a credible contingency or a protected event (for example trip of a transmission line or generating unit). A satisfactory operating state is a state in which all transmission network elements operate within acceptable technical limits (for example voltage, frequency and current are all within safe accepted limits). See clauses 4.2.2 and 4.2.4 of the NER for more information

2. To return the system to a secure operating state within 30 minutes following a credible contingency or protected event, consistent with the power system security standards.

- Reliability:
  1. To ensure there is sufficient generation, demand response and network capacity such that customer demand can be supplied consistent with the reliability standard.[5]

AEMO meets these obligations by dispatching generation in line with market bids, invoking and revoking constraint equations, and adjusting network equipment such as voltage setpoints and reactive plant status.

To ensure the system dispatch will be secure and define the constraint equations and applicable network equipment requirements, AEMO conducts assessments ahead of time. All power system requirements are assessed collectively, and the power system is considered as a whole. This means accounting for:

- all dynamics associated from online electrical equipment, regardless of why it is online or what other services it may be providing.
- the dependencies between components of an online equipment with other online electrical equipment and its operating state.
- the full range of requirements for the power system to remain secure.

AEMO completes this analysis through using a variety of tools and different assessment types, with dynamic and static simulations, assessing the whole of system response through a range of potential contingencies or changes in power flow on the system. AEMO must consider not only the piece of equipment in focus, nor a single power system requirement, but also the resultant dynamic response throughout the system, and needs to iterate between different models and simulations. In practice, this means that AEMO can identify which system configurations can be expected to remain within the secure operating envelope under expected operating conditions, including contingencies and changes between conditions.

As an example, consider a case where a synchronous condenser is brought online to manage voltage in a local region. This synchronous condenser also has an appreciable mass to provide an inertial response. The response of the synchronous condenser to a disturbance in a local region is plotted in Figure 3. When a disturbance is observed in this system, we can see the response of the synchronous condenser changing its reactive power output, supporting voltage management in the area. We also see the inertial response of the condenser, increasing the active power initially and oscillating from the time of the disturbance; these oscillations are dampened over time.

[5] The reliability standard is determined by the Reliability Panel and defined in the NER. In NER version 173 the reliability standard is defined in NER 3.9.3C and allows for up to 0.002 % unserved energy in a NEM region per year. This may change in future NER versions.

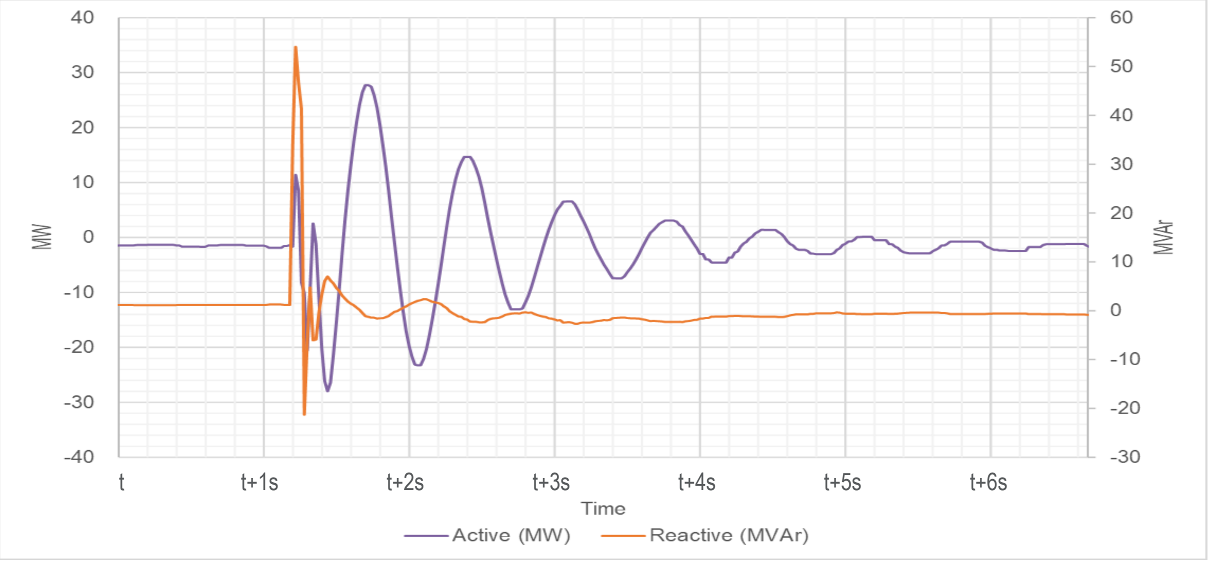

Figure 3: Active and reactive response of a synchronous condenser to a disturbance in the system

In this real-time example, we see real power oscillations emerge at the site of the piece of equipment in question, providing a useful initial signal, and then dampen as we would expect. However, this phenomenon would not even appear or could have a different response in analysis if the equipment or voltage requirement was considered in isolation. This chart also doesn't show the response of the rest of the system. The power system is a dynamic machine, each part responding in turn, and we need to also consider that response to check the system, as a whole, remains secure.

As an analogy for what may occur elsewhere in the system, imagine a mass on the end of a spring. Oscillations dampening at one end of the spring do not mean that those oscillations are necessarily dampened at the other end of the spring. This will depend on the spring constant, the nature of the masses at each end, their starting positions, and their starting motion, among other environmental factors. This phenomenon could be viewed as something similar to what can occur in a power system. We therefore need to look at the response elsewhere in the system too, and assess the response throughout the system, collectively.

The following chart represents what could be observed elsewhere in the system, depending on the configuration of the rest of the system, in the case where we had a synchronous condenser that was online to manage voltage in its local area. Figure 4 shows the observation of the active power response across the interconnector for two different system configurations. In this example, for the same disturbance with two different system configurations we see one which is acceptable, and the system remains within a secure operating envelope, where in the other it does not due to the increased oscillations (like the analogy of the mass on the end of the spring).

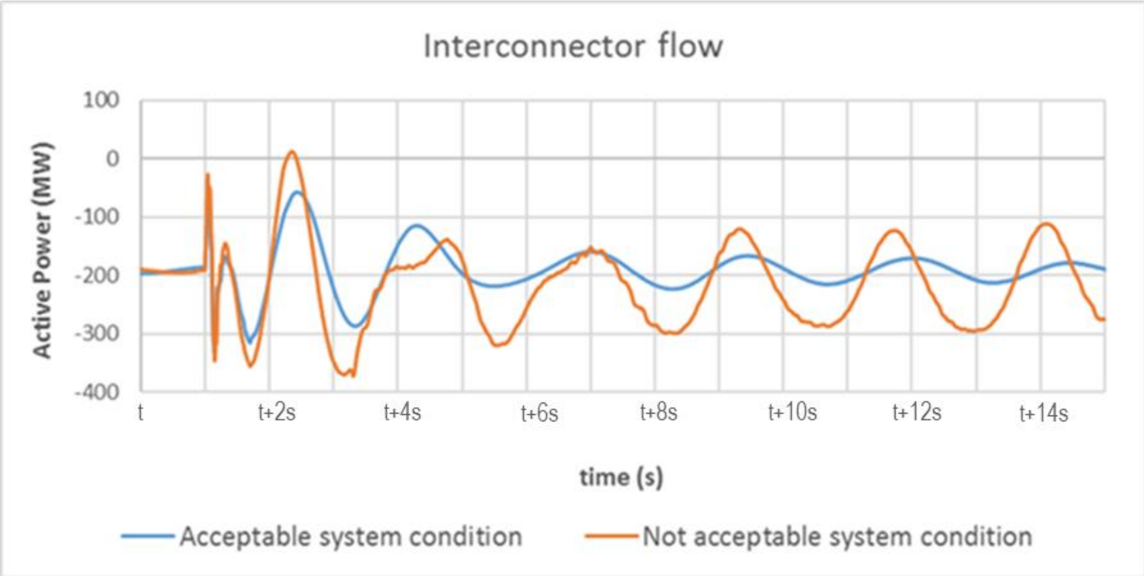

Figure 4: Response to a disturbance across an interconnector

In this example, if AEMO had considered each power system requirement in isolation, it would have been found that the voltage waveform was managed locally to the site of the synchronous condenser. However, the case where oscillations appeared elsewhere in the system due to the synchronous condenser's dynamic response and physical characteristics may not have been identified, leading to potential operation in an insecure state (oscillations of the nature observed are an example of equipment operating outside of its technical limits).

If such oscillations were found to occur elsewhere, there may be multiple ways such oscillations could be addressed: either regionally, at the site of the oscillations, or at the original source - in this example we see they are addressed through a different system configuration. It is also important to note that this is an example of a power system phenomena occurring that cannot necessarily be addressed through the supply of a quantifiable services – instead we see that in this example, AEMO has identified that one configuration leads to a secure operating envelope, the other does not.

Identifying the specific nature of what is needed to address those oscillations, and the relationship to the original source and disturbance is an important step in understanding the transitioning power system. It is not possible, at this time, to define a complete set of mathematical relationships to determine the trade-offs between bringing the synchronous condenser online to manage voltage control locally, ensuring the necessary system strength support for IBR, and what may be required to manage oscillations across the whole power system (as just one example).

Further, the analysis presented in this section is just one small component of the analysis that would be completed to determine if a configuration can be expected to be secure. The analysis highlights the response of the system in two different configurations to a single disturbance. In practice, AEMO must consider a variety of different conditions and possible disturbances and determine whether the system remains secure through the range of technical limits across the system.

This case study highlights the need to consider the system as a whole, and why at times AEMO can identify what configurations will allow the system to operate within a secure envelope, but not necessarily unpick each individual requirement. In practice, this means that, to ensure the market dispatches in a secure manner, AEMO must translate these assessments to a way in which the system can be operated in real-time. Where possible, AEMO does this by developing constraint equations for the NEM dispatch engine (NEMDE), where relationships between equipment and requirements are well enough understood to give confidence the system will remain secure if those conditions are met.

However, as was discussed by the AEMC, it is not possible to represent all relationships in NEMDE due to the nature of the requirements. As such, in those scenarios, AEMO publishes transfer limit advice which communicates the set of possible configurations in which AEMO has assessed the system is expected to remain secure. AEMO will then take action to ensure the system will dispatch in one of these configurations to maintain system security, where, without intervention, the market is not expected to do so. It should be noted that, in such scenarios, under current arrangements with the existing tools and practices, AEMO will only intervene to ensure the system is secure, choosing the least-cost solution and will not make an intervention for the purpose of alleviating constraints for market benefits. AEMO expects that as research and experience develops, it is likely that the relative contributions of various assets and the capabilities each brings will be able to be further distinguished compared to the current practice of a simple list of configurations that have been found to remain secure, allowing further progression towards a services-based model, and further sophistication in any market-based processes to secure the system.

Moving towards "unbundling" services

The importance of this approach to assessing the system cannot be understated; services cannot necessarily always be separated from the equipment delivering the services, or that which requires their delivery. The challenge in progressing towards a model where particular services can be isolated is in understanding how new and existing equipment interact with each other, with the requirements of the system as a whole, and what is needed to maintain security. In order to co-optimise between the various system requirements, a clear parametrised relationship is required whereby the interactions and trade-offs between different services and requirements can be well enough understood to allow secure operation.

In the past, energy market designers were able to unbundle Frequency Control Ancillary Services (FCAS) as a separate service. This could happen through being able to make approximations of the requirement of the headroom or footroom to be left in reserve to provide FCAS, and the specification of the response of the service which was needed to arrest and correct the change in frequency following a contingency.[6] These approximations were possible through understanding the nature of the equipment delivering and homogeneity of the rest of the system in its response. This allowed for the development of the frequency "swing" equation, which relates the inertia in the system and the provision of FCAS response to the required frequency stability of the system.

[6] Including the translation from a 3-phase model to single phasor domain, from nodal phase-angles to a central system frequency.

From this, the relevant quantification of the service and its trade-off with providing energy could be determined and a market could be formed for the procurement of the unbundled service.[7]

Through the transition, we are already seeing differences in the way we understand the provision and response of FCAS. The introduction of fast frequency response (FFR) markets is an example whereby advancements have been able to be made to take advantage of the capability of new equipment and use this to address emerging limits efficiently, leveraging the existing frameworks for procurement of FCAS. This is possible through understanding the relationship of the service and the response in the system.

International efforts are underway to further define the relationships and understand the specific nature of the needs of the power system in a way in which is technology neutral and allows for discerning between the equipment delivering the service and the services themselves. One example is the Global Power System Transformation Consortium (G-PST), of which AEMO is a founding member.[8] The G-PST is an international collaboration made up of system operators around the world who are leading research activities with a goal of ensuring global coordination of our efforts towards the achievement of cost-efficient, clean, and reliable power systems. Key pillars of this program relate to collaboration and support between the founding system operators to achieve very high penetrations of IBR on their power systems, and to support developing country operators to manage the transition.

Recent engagement with System Operators globally has identified a key challenge of the transition relates to providing the services needed for power system operations. Work is underway to understand what the system will need and how to define services to enable market procurement of those services, particularly in a landscape dominated by IBR.[9] In addition to AEMO's role with the G-PST, AEMO is collaborating with CSIRO to progress research initiatives to identify and address challenges in the Australian context.[10]

System strength as an "unbundled" service

System strength is a prime example where efforts are underway to "unpick" the requirements of the service. Being on the forefront of the transition, and with some of the highest penetrations of IBR anywhere in the world, the NEM has already seen the emergence of weak systems requiring provision of system strength and the enhancement of settings and controls to allow for stable operation in low system strength conditions to provide for a secure system.

[7] Further information can be found in the following references: Kundur, P., 2007. Power system stability. *Power system stability and control.*, Püschel-Løvengreen, S., Dozein, M.G., Low, S. and Mancarella, P., 2020. Separation event-constrained optimal power flow to enhance resilience in low-inertia power systems. *Electric Power Systems Research*, *189*, p.106678.

[8] Further information about the G-PST can be found at: https://globalpst.org/.

[9] For example, Bialek, J., Bown, T., Green, T., Lew, D. Li, Y., MacDowell, J., Matevosyan, J. Miller, N., O'Malley, M., Ramasubramanian, D., October 2021, System Needs and Services for Systems with High IBR Penetration, https://globalpst.org/wp-content/uploads/GPST-IBR-Research-Team-System-Services-and-Needs-for-High-IBR-Networks.pdf

[10] Inaugural Research Agenda, G-PST, March 2021, https://globalpst.org/wp-content/uploads/042921G-PST-Research-Agenda-Master-Document-FINAL_updated.pdf

In order to address investment in system strength capabilities, AEMO notes the AEMC's draft determination to evolve the system strength framework, with a final expected in October.[11] This framework will see TNSPs obligated to provide system strength to support forecasts of connecting IBR. As discussed in AEMO's submission to the AEMC's draft determination,[12] AEMO considers there is also a need for operational scheduling of these resources, and for co-ordination at the operational timescale.

A complementary procurement mechanism closer to real-time could address any gaps that may emerge operationally. Such gaps could arise in cases where:

- The need was not identified in the planning frameworks:
  - Different conditions emerge than those which were part of planning assessments. This could also include outage conditions that were not considered prudent to include in the conditions assessed at that timeframe, or where the system evolves differently to the assumptions that were used in planning.
  - New limits arise as experienced is gained in operating under new conditions with the transitioning system.
  - Managing unplanned outages, non-credible contingencies.
- Connection of plant occurs faster than the provision of network services.

The way in which system strength would most effectively be scheduled in the operational timeframe should therefore consider these three factors:

1. What is the optimal mix of resources to provide system strength operationally based on long-term contracts that may be have been signed, combined with potential short-term arrangements to support efficient IBR operation?
2. Different conditions that may occur in the operational timeframe than were considered in planning and may need specific solutions to address these.
3. Interaction between system strength provision and the rest of the power system requirements in the operational timeframe. This requires assessment of how system strength requirements are met collectively with other power system requirements, depending on the system configuration, as discussed above.

Each of these present an opportunity to consider an operational-based procurement for system strength, albeit each with a need to consider the relevant appropriate governance and participation framework. The first two represent an additional procurement option for system strength as it has been defined for the purpose of investment procurement. The third represents the need to consider system strength provision (for fault current and maintaining the voltage waveform) along with other power system requirements in operations.

[11] AEMC, Efficient Management of System Strength in the NEM, https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

[12] AEMO, June 2021, Submission to Efficient Management of System Strength in the NEM Draft Determination, https://www.aemc.gov.au/sites/default/files/documents/aemo_4.pdf

AEMO expects the obligations to maintain the network through system normal and plan for any required outages to remain with TNSPs, however considers that there may be an opportunity for TNSPs to make use of an operational procurement mechanism to co-ordinate the relevant resources, alongside the rest of the system requirements. When considering operational dispatch of system strength services, it will be critical to explore how system resilience is maintained and how existing generators', MNSPs' and other plant operators' contractual obligations are met, including meeting performance standards for their physical response overall.

1.2. Question 1.2 What do stakeholders think about the need to transition from system configurations to service-based procurement over time?

As a member of the Energy Security Board (ESB), AEMO agrees that a service-based procurement model is the appropriate long-term vision for the NEM, noting that the way in which these services and how they are provided and scheduled may change over time. A service-based procurement model creates signals that can drive efficient investment in the essential capabilities for secure operation of the NEM and promote efficient operation and use of those assets, aligning with the AEMC's system security objective. AEMO also notes there may be times where it may not be efficient to develop structured procurement or market services for all identified power system capabilities, where it may be more cost-effective to set a minimum standard for all equipment participating in the system.

In realising this vision, the need for the system to be configured in such a way it can operate in a secure envelope and to undertake assessments that collectively consider whether the full set of power system requirements will be met for the system as a whole, will remain. Ultimately, the dynamic characteristics of the system and connecting equipment needs to be considered as a whole, and the capabilities that different equipment bring to the system cannot necessarily be separated and treated individually even with a services-model. AEMO expects that, with further understanding and operational experience, there may be opportunity to isolate particular requirements for service-based procurement. This opportunity will arise through understanding how the requirements can be met, how equipment delivers and responds to the delivery of the service, and how other requirements interact with that delivery.

As services are and can be isolated and separately procured or provided through appropriate standards on equipment, reliance on separately co-ordinating for secure system configurations can be expected to diminish. If services can be defined in such a way that their procurement means that the market is able to deliver capability that translates to a secure power system, then there will be no need for AEMO to act outside of this process. This is similar to the coordination of the provision of FCAS under the current market structure, where FCAS can be co-optimised with the provision of energy.

1.3. Question 1.3 How can this transition be assisted or accelerated, in order to move to a service-based model as soon as practicable?

As discussed above, AEMO agrees with the long-term vision for a service-based model for the NEM, however, cautions the speed at which this can or should be done. The power system transition is occurring at a rapid pace, with knowledge and experience in operating in and planning for new paradigms developing alongside. Time is therefore required to develop this understanding.

AEMO expects that a market-based means for procurement of configurations is more likely to assist in advancing the understanding of operating in new conditions. As AEMO assesses what constitutes a secure system configuration under new conditions and with new assets, it will better understand the relationships between the capabilities, delivery, and requirements. This will also occur alongside global efforts that are being undertaken to reveal and define these relationships. This in turn will lead to being able to move towards a service-based model.

AEMO agrees that it will be important to continue to focus efforts to understand the underlying power system requirements and define these in a technology neutral way. This recognises that service-based procurement is more likely to provide stronger signals to industry for efficient investment in the required capabilities and operation of the system assets. However, AEMO considers attempting to separate out services and define markets for the individual procurement of each, before fully understanding their relationship and how the power system will operate under these new conditions, may be slow, and limit the options available through the transition.

A market-based means for procurement of configurations should instead be designed to be transparent, such that participants are able to work with AEMO to understand the potential benefit of incremental investment decision, for both new and existing participants. This is as opposed to relying on directions, which, as the AEMC characterises, do not allow for recovery of fixed costs or a commercial return, and do not support innovation in understanding how the limitations may be solved. AEMO also envisages that the introduction of a market-based process should allow for industry to work together to determine the binding limitations that mean some configurations are secure while others are not, in turn potentially leading to discovering novel ways to isolate particular services.

1.4. Question 2.1 What are stakeholders' views on the AEMC's characterisation of the current approach to produce dispatch schedules and ensuring the power system remains secure?

AEMO accepts much of the discussion in section 5.1 on the current approach, although there a few points to clarify:

Pre-dispatch "eco-system"

It is evident the AEMC sees scheduling as being the pre-dispatch schedule and all private scheduling tools, approaches, optimisations, and traders' decisions, which is described as an ecosystem. It is described as efficient where the complexity is resolved by private schedulers which price this in a "vanilla" offer, a simple dollars per MW for dispatch of their unit.

It is true generators reflect private complexities in public energy offers and they do this the best they can, yet the term ecosystem suggests it is all in natural balance. It should be noted rebidding in the NEM is subject to fixed rules and this may not allow bidders to submit offers exactly as they would like, exactly when they would like. Irrespective of this, AEMO suggests even with these bidding rules the market price can reach a satisfactory competitive equilibrium, i.e., one where no one would want to revise their offers any further, due to the process of iterative, competitive rebidding.

It is AEMO's understanding this "works" through repetition – i.e., the more trades, or rebids, then the closer we get to an optimum, when everyone is "happy enough" with their offer. This doesn't mean every private scheduling decision is correct in hindsight – scheduling decisions cannot be made on hindsight, and hindsight does not prove them wrong.

There are more extreme examples of markets prioritising continuous trading like a commodity exchange, sacrificing some security elements to improve trading. Compare this to the rebidding in the NEM where, when a rebid is made, traders wait for pre-dispatch to update, and the effect of the rebid may be "lost" with all others or other changes "batched" in that pre-dispatch run. The NEM sacrifices some trading repetition by running a security constrained economic dispatch (SCED) for each interval for the scheduling horizon at regular intervals and only clearing offers subject to the system being secure.[13]

The more trading reflects security elements such as locational limits, frequency response, reactive capability, fault current, inertia, the less homogenous is trading and repetition may be lost. AEMO considers incorporating the security of the system into trading may reduce the quantity of trades marginally, yet vastly improves quality, supporting market efficiency and effectiveness of scheduling.

Converging to an efficient outcome

There is some suggestion[14] in the paper that pre-dispatch converges to a secure and efficient outcome. It should be noted that utilisation of SCED in the NEM is intended to ensure each individual trading period represented in pre-dispatch is secure. That is, the NEM Dispatch Engine (NEMDE), and in turn, pre-dispatch engine, runs an optimisation to produce the lowest cost dispatch for that interval, in a security-constrained manner (to the extent that security can be represented in the engine – further discussed in this section).

However, because each interval is calculated largely independently of the others, the full pre-dispatch schedule across the pre-dispatch horizon may not be physically feasible when first published. For example, a unit may be off, on, then off, or a unit may be dispatched for more than it has fuel to supply. In resolving these discrepancies, generators' interests are aligned with secure operation (and therefore AEMO), because generators need dispatch targets they can comply with[15] and this should ultimately result in a feasible dispatch across time.

[13] Insofar as the SCED represents a secure outcome, where AEMO provides further comment on the incompleteness of the current dispatch engine further in this submission.
[14] Section 5.1.2 – Broader Market Scheduler Ecosystem, AEMC Directions Paper – Capacity Commitment Mechanism and Synchronous Services Markets
[15] NER clause 3.8.20(g).

To achieve this result, traders rebid unit physical constraints, usually by redistributing MW volumes to above or below the clearing price in particular intervals. In doing so, rebidding allows prices to reach a competitive equilibrium across the scheduling horizon, with offers only being accepted subject to the system being secure in each interval. In this way, it can be said, prices for each interval can converge to a competitive equilibrium and across the intervals in the scheduling horizon. That is, the pre-dispatch schedule, as a whole, converges to a feasible schedule and efficient scheduling of generators.

However, it is not the case that trading through pre-dispatch converges to a secure outcome, because, in principle, under SCED, each trade is only accepted on the condition of it being secure. That is, each trade is only accepted on the basis that the associated dispatch will lead to the system remaining within a secure envelope. Participants bid and re-bid into the market on the presumption that the constraints in NEMDE encapsulate all security requirements, and this expectation allows participants to alter their bid to ensure their plant can physically meet the dispatch schedule.

AEMO highlights this to distinguish between what the AEMC characterises as the Broader Ecosystem in section 5.1.2, and noting that the pre-dispatch engine cannot ensure that dispatch schedules would result in a secure dispatch in section 5.1.4. The latter is because the pre-dispatch engine does not represent all security constraints in solving for the optimal SCED in each interval. Under the current formulation of NEMDE each interval in pre-dispatch may be an insecure representation of dispatch, which leads to an inability for generators to schedule for system security on published prices. That is, because NEMDE does not encapsulate all security constraints, participants are bidding on a 'false' basis, i.e., on a market outcome that would never physically occur.

The ideal solution would therefore be to include the full-set of security constraints in dispatch and institute requirements for dispatch of the security services, including bid-based dispatch of these services. AEMO agrees this is the basis for the consideration of operational procurement of such services, as per the AEMC's paper, and through responding to the remaining questions in the paper discusses opportunities and challenges associated with different options for doing so.

Formulation of the pre-dispatch engine

AEMO notes the AEMC has used the term coefficients in a general manner in the Directions Paper to represent the "change to the objective function of changing a controllable variable, e.g., generators' bids".[16] AEMO would like to clarify the distinction between bids and coefficients in the formulation of the NEM dispatch engine (NEMDE), where coefficients are used in constraints to represent the relative weight of changing a particular parameter on the constraining limit of the constraint, whereas bids are used to represent the cost of the dispatch.

For example, coefficients can be used to represent that increasing the flow on one network element by 1 MW can reduce the amount that can flow on another element by 0.5 MW. Similarly, a unit being online may increase the amount of IBR that can be supported in a select region by

[16] p. 40, AEMC Directions Paper – Capacity Commitment Mechanism and Synchronous Services Markets

100 MW, whereas another unit may increase it by 200 MW. These relationships are represented by coefficients in constraints in NEMDE. On the other hand, bids represent the amount that participant has indicated it would need to be paid to produce a certain amount of generation or supply a certain amount of FCAS, and are included in the optimisation to determine the optimal SCED. Constraints used in the operational procurement for system security services will continue to require coefficients to represent the relative weights of parameters, while bid and cost information will also be used by the objective function to determine the economically efficient outcome.

Existing NSCAS Framework

As the AEMC notes, AEMO has a range of tools available to assist in undertaking actions as required to make sure the system remains secure, where AEMO is bound in the use of these tools by their specific governance framework. In particular, the AEMC notes, "the current procuring and scheduling of NMAS contracts and the use of directions remain the key tools for AEMO to ensure the power system remains secure."[17]

AEMO agrees that these are important tools that assist AEMO in its obligations to keep the power system secure. AEMO would like to clarify the use and application of the existing NMAS frameworks, particularly associated with Network Support and Control Ancillary Services (NSCAS). It is AEMO's preference that this framework is not altered materially with the potential new operational procurement and scheduling mechanism, as they have different purposes and there might be unintended consequences for doing so.

The existing NSCAS framework is designed to deliver non-market ancillary services that may be delivered to maintain power system security and reliability of supply of the transmission network, or to maintain or increase the power transfer capability of the transmission network. This framework applies for a planning horizon of at least five years from the beginning of the year for which the most recent NSCAS report applies, whereas the mechanisms contemplated through this process are expected to operate in the pre-dispatch horizon. The NSCAS process is targeted at maximising the utilisation of the transmission network, by highlighting opportunities for networks to invest. It is only if they fail to, for AEMO to use non-market ancillary service procurement.

Under NER clause 5.20.2, AEMO publishes the *NSCAS description* and *NSCAS quantity procedure*. The purposes of these documents are to describe each type of NSCAS and to detail a procedure for determining the location and quantity of each type of NSCAS required over the coming 5-year horizon.[18] NSCAS can be provided by entities including but not limited to generators, TNSPs, and market customers. In 2020, AEMO revised this procedure to divide the types of NSCAS according to the needs that would be primarily addressed – that is, maintaining system security

[17] p.45 AEMC Directions Paper– Capacity Commitment Mechanism and Synchronous Services Markets
[18] Network Support and Control Ancillary Services (NSCAS) Description and Quantity Procedure, AEMO, October 2020, https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/ncas/2020-nscas-description-and-quantity-procedure.pdf?la=en

and reliability (Reliability and Security Ancillary Services (RSAS)), and increasing net market benefits (Market Benefit Ancillary Service (MBAS)).[19]

- RSAS is procured to assist AEMO to maintain power system security of the transmission network in accordance with the power system security standards or maintain reliability of supply of the transmission network in accordance with the reliability standard. Procurement of RSAS increases the security and reliability of the transmission network while also reducing the number of instances that AEMO needs to intervene in the dispatch of the NEM.
- MBAS is procured to increase the power transfer capability of the transmission network, to maximise the present value of net economic benefit to all those who produce, consume or transport electricity in the market.

AEMO is required to publish a NSCAS report each year under clause 5.20.3 of the NER, to identify NSCAS gaps for the next five-year period. When AEMO identifies a NSCAS gap, the National Electricity Rules (NER) give TNSPs the primary responsibility for having arrangements in place to address the gap. AEMO may be required to acquire NSCAS only to ensure power system security and reliability of supply of the transmission network in cases where AEMO considers that the gap will remain after receiving advice from the TNSP about its proposed arrangements to address the gap. That is, in cases where AEMO considers the gap will remain, AEMO may acquire NSCAS to meet the gap, but only for RSAS, not for MBAS. Further information on AEMO's approach to assessing and quantifying NSCAS needs can be found in the NSCAS Description and NSCAS Quantity Procedure.

The existing NSCAS framework is an important safeguard to support the reliable and secure operation of the network, and should not be compromised for the inclusion of an operational scheduling and procurement mechanism, but could be complemented by one. For example, while the 2020 NSCAS review did not identify any gaps for the next five years, it noted the power system is rapidly changing, and operational measures are being relied upon more frequently to help manage voltages during low demand conditions.[20] AEMO expects that the power system will operate close to its limits in some areas and under some conditions, and expects a new operational procurement approach could be helpful in managing system security in these times.

As such, there may be opportunities to leverage the operation of this potential new operational framework and the existing NSCAS framework to support one another. For example, constraints binding under a new operational procurement mechanism may highlight opportunities for longer-term NSCAS arrangements. Similarly, where contracts for NSCAS are agreed between a market participant and either a TNSP or AEMO, there may be an opportunity to schedule such a contract more efficiently through the new scheduling mechanism. It is possible that, if TNSPs contract MBAS in the future, it may be able to be scheduled through the optimised scheduling tool contemplated under these rule changes. However, due to the nature of NSCAS contracts being to support the operation of the network, an optimisation approach to their scheduling may

[19] The relevant consultation material can be found on AEMO's website: https://aemo.com.au/en/consultations/current-and-closed-consultations/network-support-and-control-ancillary-services-description-and-quantity-procedure-amendments

[20] AEMO, Dec 2020, 2020 Network Support and Ancillary Control Services (NSCAS) Report, https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/Operability/2020/2020-NSCAS-Report

not always be applicable. This will need case-by-case analysis and can be considered following the implementation of a mechanism.

AEMO notes there are expected to be system strength contracts agreed between system strength providers (TNSPs) and market participants under the evolved system strength framework. It is expected that these could be signed to support the efficient operation of IBR, and so, are more likely to benefit from an optimised scheduling approach for those services.

1.5. Question 2.2 What are stakeholders' perspectives on the AEMC's view that the implementation of either the MAS or NMAS approaches should ultimately transition to procuring unbundled system services as operational and technological knowledge improves?

As per our response to question 1.3, AEMO notes that the implementation of either of these options doesn't preclude unbundling and separately procuring system services. AEMO expects that if this occurs, the reliance on procuring explicit system configurations is likely to diminish. In practice, this would result in limited binding actions undertaken through this new operational procurement mechanism, or low costs associated with any such actions (whether that is reflected in a low price for the underlying system security support services, or in limited operational contracts being struck).

While the transition is occurring rapidly, there will be much to learn and understand as the NEM enter new operating conditions and technology continues to evolve. Introduction of a market-based mechanism as soon as practicable will support the market operating securely and efficiently through this period, while this understanding develops. It is this understanding that should allow the transition to procuring unbundled system services that can be relied on to support secure operation of the NEM.

1.6. Question 3.1 What are your views on the trade-offs identified between the linear and binary formulation of constraints?

In responding to this question, we first discuss why AEMO does not consider a MAS approach alone is practical nor feasible as a market-based means for procuring secure system configurations (what the AEMC has termed procurement of "system security support services"). We then provide some further views on the specific trade-offs that have been identified between the linear and binary approaches.

Feasibility of the MAS approach

To address the underlying problem, procurement of "system security support services" needs to account for valuing and scheduling the configuration of units to provide capability that is not energy or FCAS. This will mean different things for different types of technology and could include, for example:

- Valuing the capability provided when a synchronous machine is committed (e.g., the system strength or inertia inherently provided by spinning equipment).

- Providing a signal and binding commitment for an inverter-based resource to reserve reactive power capability, where this may restrict their active power capability.

Under the MAS approach it is intended that these services are incorporated directly into the dispatch and pre-dispatch engine, and each time the engine solves it will be seeking to find a solution that maximises trade for energy, FCAS, and the new system security support services, and also delivers a secure solution (security constrained economic dispatch (SCED)).

For dispatch itself, this equates to representing the constraints and services directly within the dispatch engine, and having the engine determine the efficient schedule and price for the services. For this to work, the engine needs to:

- Have inputs (constraints) representing the demand for the services, the willingness of providers to provide the services (bids), and the relationships between the services (constraints formulated with appropriate coefficients).
- Be able to co-optimise and distinguish between the various services to determine the most efficient schedule across the system that represents a secure state. This means both representing the underlying security of the system as well as representing trade-offs between different resources for achieving that security.
- Form a price for the service to enable sufficient payments to the providers, based on their bids, and, ideally, provide a signal for investment.

Participants then need to be able to respond to the dispatch target within the dispatch interval (5-minutes), the delivery of the capability needs to be able to be verified for appropriate payments, and appropriate action needs to be able to be taken where there is non-conformance.

With a MAS approach, it is not clear how these characteristics will be formed for the system security support services:

- The engine inputs: for energy and FCAS services, each requirement can be represented as a quantity (per region), with a single constraint determining whether this requirement is met. The efficient schedule to meet this constraint is then influenced by the other constraints in the dispatch engine to ensure the dispatch remains secure, but ultimately it is a clear quantifiable demand on the system for these services.

  This is different for the new system security support services which will need to represent the physical attributes underlying the secure system configurations, which is not necessarily a quantifiable attribute. The secure state is often related to the specific configuration of the system elements including binary variables of units (e.g., on/off status) and set configurations of the system. The requirements therefore represented by system security support services cannot therefore be represented by a single constraint. Further, due to the nature of the requirement being met by binary variables, it is often difficult to linearise these relationships.

  The ability to form the engine inputs has implications across the ability to co-optimise, price, and dispatch the service, as follows.

- Co-optimisation of the schedule: The dispatch engine will seek to maximise trade (or minimise the total cost of dispatch) across the variety of markets: energy, FCAS and the new system security support services. It will need to meet the minimum level of each service, and then be able to make trade-offs between delivering more or less of one service and the costs associated with this, to deliver more or less (or vice versa) of another service, and the associated costs.

  To produce a security-constrained economic dispatch, the engine needs to have constraints representing the minimum-security levels, as well as those representing trade-offs for the associated costs. These relationships will be the basis on which the engine produces the optimal result. As discussed by the AEMC, the approach will be different under the linear or binary model, and AEMO has reservations about how an efficient co-optimised solution may work under either, as discussed under each relevant heading below.

- Pricing of the service: similar to the formation of constraints, a single or zonal marginal price for energy and FCAS can be formed as the shadow price of the balance equation. The same cannot be said for the system security support services under either the linear or binary approach due to the inability to form a single constraint, where we are considering the full range of requirements being "bundled" into the single "system security support service" category.

  The formation of consistent, understandable price that reflects the value of the services and provides a signal to market is a challenge to be managed through any operational procurement of such services. AEMO considers this is also a key topic of further consideration also for the NMAS approach and provides further comment in its response to question 5.1. As to the MAS approach, the potential implications is different under each of the linear and binary approaches and is discussed further below under each heading.

- Reliance on dispatch ultimately delivering a secure system: under the MAS approach, the NEM dispatch engine will be optimising for the delivery of the security services alongside energy and FCAS, and participants will receive a dispatch target for the delivery of the system security support service in real-time. For system security support services, this target could equate to changing the commitment status of a unit, or the way in which an inverter is configured, for example, to meet the needs of the secure configuration. Such a response usually takes more than 5-minutes to initiate, so under the MAS approach, the pre-dispatch eco-system will be relied on for participants to arrange their equipment to deliver these security services, and be in a position to meet their dispatch target, or ensure they bid in such a way to ensure they do not receive an infeasible target. As described further in the following paragraphs, AEMO has concerns as to whether this will be feasible and practical for the delivery of the system security support services, and whether this will be able to be relied on for secure operation.

- Verification of the delivery and potential non-conformance actions: AEMO has concerns that under the MAS approach, if a participant cannot, for whatever reason, meet their dispatch target to provide system security support services, the system may be left insecure, with limited options available to AEMO to secure the system within 30-minutes. There is a risk this could occur due to the binary nature of the optimisation, in that it may produce a dispatch signal that is infeasible for a participant to meet, where it was not in a position to do so because pre-dispatch had not indicated this would be likely. In some scenarios, the only options available may require AEMO to direct on a different unit that may have a lengthy start-time, or may require a significant re-configuration of the system. This is different to energy and FCAS whereby non-conformance in a particular dispatch interval is generally more incremental and thus can usually be managed through various actions immediately or over the next few dispatch intervals, including activation of regulation FCAS, re-dispatch of energy and FCAS in the next interval, and if need be, directions to participants to change their energy output incrementally.

Reliance on the pre-dispatch eco-system

As the AEMC describes, the MAS approach relies on the pre-dispatch "eco-system" enabling participants to optimise their bids such that the eventual dispatch will be feasible and produce an efficient schedule from interval to interval. In this, it is important the pre-dispatch engine continues to represent the dispatch engine, and each time it runs it solves each interval for the SCED almost independently, providing an indication of what is likely to occur in dispatch (schedule and price) based on those inputs. In this way, pre-dispatch can enable participants to make optimal trading decisions based on a projected secure outcome.

AEMC describes this as the pre-dispatch scheduling process converging to a secure schedule. This is an accurate description for the MAS approach between intervals, where under the MAS approach participants will need to bid to ensure that their eventual dispatch from interval to interval is feasible. That is, for example, they will need to bid to ensure they do not receive dispatch targets which they cannot physically achieve, such as turning on and off every 5 minutes, for example.

However, it is also useful to highlight that, under the MAS approach it is expected that each individual interval for which the pre-dispatch engine solves will also inherently solve for a SCED, as per the constraints and inputs available to the engine, and that this SCED will now represent the full range of power system requirements. However, with dispatch of the system security support services themselves within the SCED representing whether or not the dispatch will actually be secure, it is not clear whether the pre-dispatch engine will be able to resolve to a secure state each time. This could be because the linear representation does not sufficiently represent a secure system, or because the binary solve time is too long to find an optimised secure result (as discussed further below). This could also result in the market trading in and out of a secure state as it approaches real-time. Ultimately this may result in AEMO needing to continue to act outside of the market to ensure the system remains secure should it lack confidence the eventual dispatch will be so. AEMO considers that significant effort will be required to work through these challenges to find a workable MAS approach, if one exists, that can act as a market-based solution to securing the system.

Linear

The AEMC highlights that one potential drawback of the linear model is in the potential for partial commitment of a binary variable. AEMO agrees that this could undermine the approach, and notes:

- As described by the AEMC, a rule or heuristic would need to be applied to manage interpretation of a partial commitment. This could be a simple rule such that any result greater than zero is to be interpreted as a full commitment.
- In such cases, it could be that the physical schedule that results from the engine attempting to determine the best co-optimised solution is not actually that which is optimal. This would undermine the objective of the engine in seeking the most efficient SCED across all solutions.
- Depending on the heuristic applied and the relevant constraints, there could also be a risk that the interpreted dispatch may not actually result in a secure outcome. That is, there may be cases that result in a set of units being dispatched that does not actually represent a secure configuration of the system. This could occur, for example, in cases that the holistic co-optimization of the service against all other constraints that incorporate unit commitment or other binary variables (which, for example can include voltage and angular stability constraints) may result in dispatch results that have unit commitment variables in such constraints having either positive or negative coefficients (implying that the commitment of a unit could either loosen or tighten the constraint depending upon the nature of the resource (control systems etc) and system conditions). In such a situation, partial commitment may pose further challenges with respect to providing a secure feasible solution – this is, it may not be clear that increasing the partial commitment to an integer does produce a secure solution.

However, AEMO agrees that a benefit of this approach is that the risk for managing the potential partial commitment and possible insufficient payments is placed with generators. That is, participants could adapt their bids such that a partial commitment and possible partial payment still results in the participant receiving adequate payment to support their commitment. Aligning the ability for participants to receive payments which suit them (revenue adequacy) with the outcomes of the market is an important consideration in the future market design.

As described above, AEMO also queries how to best form a price in a linear model. The AEMC discusses the potential for marginal pricing under a linearised model, but AEMO notes that there will be complexities in forming a marginal price without a single constraint for the service. As described above, there is likely to be multiple constraints that are used to set the demand for system security support services, and a single constraint is unlikely to accurately represent the full security requirement. The commitment or configuration of a particular unit may also appear in multiple constraints. As such, each unit's contribution to each constraint would need to be taken into consideration in forming a price for the unit, similar to principles that are applied under locational marginal pricing models. While this approach represents the value the unit provides, it means that there is unlikely to be a single, simple price for the service. The implications for this are that pricing of the services is difficult to understand, and may not encourage the behaviours it is expected to support.

Binary

Under the binary approach to a MAS solution, the expectation is that the dispatch of the NEM would take into account the binary nature of the variables of commitment and in configurations. Given the inclusion of the binary variables is incompatible with marginal pricing as it introduces non-linearities, there is an expectation that there would be two optimisation runs for dispatch under this approach. The first run would be to find the optimal commitment, the second would be to determine the marginal pricing of energy and FCAS, setting the commitment of the first run as fixed, with further consideration to be given to the pricing of the new service – discussed below.

The AEMC describes a possible approach to the inclusion of binary variables as adding an additional binary optimisation engine that is run just ahead of the existing NEMDE, where NEMDE would take the outputs of the binary optimisation engine as inputs for the relevant binary variables. An alternative approach could be to replace NEMDE with an engine that runs the binary optimisation internally, and then runs a second linear run to determine the marginal price of energy and FCAS.

Under either of these approaches, a binary optimisation run is required to determine the optimal commitment or configuration of units, and could be configured to co-optimise with the delivery of energy and FCAS. As the AEMC discusses, this introduces challenges as to whether such an optimisation can be run in the time required for dispatch (5-minutes). Further information regarding binary optimisation processes, including run-times, was discussed by the ESB in their NEM2025 reports.[21] Under the MAS methodology, the optimisation would occur at the time of dispatch, and it is also not clear whether participants would be able to respond to the signals and change their commitment to meet such dispatch targets even if these were able to be provided (as discussed above).

Moreover, under the MAS methodology, it would be expected that the pre-dispatch engine should be configured to represent the dispatch engine with corresponding required changes in inputs to address forecasts or pre-dispatch bids as opposed to actuals. As such, under the MAS approach, it should be expected that the pre-dispatch engine is similarly either replaced or paired with a binary optimisation approach, which would assess the pre-dispatch period interval by interval as per current practice. Again, it is therefore likely the pre-dispatch run-time would increase exponentially, which would reduce the frequency with which it could be run, and also the relevance of the outputs as more time would have passed since the latest inputs were

[21] See for example, Section 2.2, p18-34, Energy Security Board, Post 2025 Market Design Options – A paper for consultation, Part B, https://esb-post2025-market-design.aemc.gov.au/32572/1619564172-part-b-p2025-march-paper-appendices-esb-final-for-publication-30-april-2021.pdf

provided. As such, the ability for participants to utilise the pre-dispatch process to converge to a feasible and efficient schedule inter-temporally would be diminished.

It could be said that the MAS binary approach is attempting to use an optimisation engine to determine the optimal commitment, but at real-time. It appears to AEMO that this approach would be better applied at the time of commitment decisions, as would occur under the NMAS approach. Similarly, by running this optimisation at real-time the potential benefits of using an optimisation that can consider binary variables is diminished. That is, such an approach cannot consider the intertemporal aspects that a mixed-integer program that is solving intertemporally would be able to consider, like that which could be applied in the NMAS approach.

As indicated, price formation will also be difficult in the MAS binary approach. Similar to the discussion on the linear model above, while energy and FCAS prices can remain set through a marginal pricing methodology even with a binary optimisation, the nature of the system security support services would remain such that it would be difficult to form a single price for the service. This is true also of the NMAS approach, but AEMO considers that an NMAS approach has more options available for price-setting than under a MAS "spot-market" approach due to its ahead nature being more akin to the contract market. Price formation is a key topic AEMO has identified requires further consideration for progression of the NMAS approach.

MAS as a future solution

Notwithstanding the discussion above, AEMO does consider there is merit in considering how potential linear MAS solutions, particularly those for specific unbundled services, may be able to work in tandem with a possible NMAS solution in the future. Inertia is one potential candidate for consideration in this manner. AEMO agrees with the ESB's pathway for consideration of inertia, whereby initially scheduling and operating procurement of inertia could be considered under the NMAS approach, and in the future spot markets could be considered for inertia (a MAS approach). This would also take into account the learnings from the implementation of the Rate of Change of Frequency services in the reform of the Wholesale Energy Market in Western Australia.

1.7. Question 3.2 Would the transparency of the market improve under this MAS approach, and how important of a consideration is this?

AEMO considers that the MAS approach to the "bundled" system security support services is unlikely to result in improved transparency, as the inherent complexity and potential infeasibility of the approach is likely to outweigh any gains by separately procuring such a service.

AEMO considers the MAS approach would be an ideal solution where a service can be specifically quantified, there are numerous participants that can compete to provide the service, and it is possible to linearise the demand for the service. If, for example, the only service that was required was to address concerns regarding falling inertia provision, AEMO would support further consideration of an inertia MAS solution more fulsomely. However, given the nature of the range of requirements that need to be accounted for in providing a secure system through the transition, AEMO considers priority should be given to managing how to address the full set requirements first, which is best suited to an NMAS solution, as further described below. Further consideration can then be given to unbundling other services as a MAS (for example, inertia) in the future.

1.8. Question 4.1 Would the transparency of the market improve under this [NMAS] approach, and how important of a consideration is this?

AEMO considers that the transparency of the market would improve compared to status quo under this approach, and this is one of the main reasons that it supports proceeding with consideration of this option. This approach provides an option to procure what is required to support configuring a secure system in the operational (pre-dispatch and dispatch) timeframe, before turning to out-of-market directions. An NMAS optimisation solution run ahead of time would give sufficient confidence for participants to be able to trade on a secure outcome, and for AEMO to fulfil its obligations to maintain a secure and reliable system.

Improving the pre-dispatch process

AEMO's response to question 2.1 highlighted that under pre-dispatch, each interval should converge to a competitive equilibrium, but it shouldn't be the case that each individual interval converges to a secure state through iterations of pre-dispatch. Instead, it should be that each interval solved in pre-dispatch should already represent a secure dispatch. The NMAS approach can provide the elements that are currently missing in the SCED of NEMDE, because it sees the necessary security services scheduled by running an intertemporal optimisation over a defined period, ahead of time, in-line with pre-dispatch processes.

The reason NMAS is transparent is because it allows trading to be based on a secure system – a premise that we have with SCED. As the NMAS approach requires running an optimisation ahead on unfirm energy offers; it is inescapable that at times this will result in too much of the security service or too little when these energy offers subsequently change. But the alternatives are having none of the service scheduled and trading on an insecure pre-dispatch, (like we do today), or when the final NMAS optimisation is run, also then making all energy prices firm, and prohibiting further rebidding. These options are inferior.

This interaction between pre-dispatch and the NMAS optimisation is further explored by the AEMC in section 5.3.2 of the Directions Paper. It suggests that, because the NMAS optimiser is not run every time pre-dispatch is run, it will systematically procure an inefficient amount as opposed to a MAS approach. The paper implies that with a well-functioning MAS approach, the private scheduling ecosystem would always "buy" the right amount, but this isn't necessarily true – it returns a competitive equilibrium, not a hindsight optimum. Even in a MAS approach like that for energy, there are many times when an extra unit may have been committed on by the trader, it wasn't needed, but that doesn't stop it being optimal from a trading perspective, and the same should be true of security services.

AEMO agrees, that if the NEM could price and dispatch security services like energy, have 288 runs a day and multiple iterations of PD encouraging rebidding then it would likely have a better chance to get the optimum. Absent this, where a MAS option is not practical for the reasons covered in response to question 3.1, the NMAS allows the security services to be scheduled first, with energy (and FCAS) bidding to follow. AEMO recognises that it may be the case that, at times under the NMAS approach, with the benefit of hindsight, more (or less) may be scheduled than would have been optimal, but this will still result overall in better outcomes than the status quo.

NMAS approach will be more transparent than directions

Under the current framework and with existing tools, directions are the only tool AEMO has available in the pre-dispatch and dispatch timeframe to secure the system if the market dispatch is expected to be insecure. Directions are an important component of the market framework, acting as a last-resort mechanism for AEMO to secure the system.

It has been well-documented that the number of directions seen in the last five years highlight that directions have been relied on to manage system security as system strength limits arose in South Australia. While the reliance on directions is expected to reduce as the new synchronous condensers are commissioned, there are substantial lessons to be learnt from the experience of the period between when the issue was identified, the solution was proposed, and when the solution has become available operationally.

The Directions Paper notes "directions are intended to be an out-of-market last-resort mechanism - consistent with the market design principle set out in clause 3.1.4(a)(1) of the Rules", which minimises AEMO decision-making to allow market participants the greatest amount of freedom to decide how they will operate in the market.[22] The NER, clauses 4.8.5A[23] which determines the latest time for AEMO to intervene, reflects the principle in NER clause 3.1.4(a)(1). 3.1.4(a)(1) is very useful if all security requirements are included in dispatch and pricing, because it is hoped prices will eventually encourage adequate supply. For services where the energy price does not support its provision, it can be argued that, waiting for the latest time to intervene simply prolongs the period where pre-dispatch is producing insecure results. During this period trading is based on inefficient prices and an insecure dispatch outcome, therefore prices are unlikely to converge to a competitive equilibrium.

Where directions are required to maintain security, participants can only recover costs, and not make a commercial return on the services they have provided. Further, AEMO will not direct to improve the overall efficiency of the market if the system is otherwise secure.

A formal, market-based procurement can be expected to be more transparent than existing practices so long as it operates with an appropriate overarching governance framework. A market-based procurement will require demand to be set and published ahead of the time of procurement, with participants given the opportunity to provide market-based offers to supply the needs of the system. It can be used to inform the longer-term frameworks, and as an additional tool for configuring the system for a secure outcome. AEMO provides further comments on how it expects the NMAS approach can be established to be more transparent than current arrangements in response to the remaining of questions.

[22] p. 46 AEMC Directions Paper– Capacity Commitment Mechanism and Synchronous Services Markets

[23] 4.8.5A(a) requires AEMO to publish notices of any foreseeable circumstance that may require AEMO to direct. 4.8.5A(c) requires AEMO to estimate and publish the latest time to intervene.

1.9. Question 5.1 Do you think that either option would result in a more efficient, secure dispatch? Weighing up the inherent limitations of both approaches, which is likely to be more efficient, and why?

AEMO considers that the NMAS solution is more likely to result in an efficient, secure dispatch, both compared to the current framework, and compared to the MAS solution. The NMAS approach allows for:

- Incorporation of constraints that represent a greater range of power system requirements, including consideration of the status or configuration of units, which may be binary in nature and therefore require a mixed-integer program for optimisation. The limitations of applying a binary optimisation in a MAS approach (discussed in response to question 3.1) are reduced in an ahead optimisation, as there is more time to allow for the solution to solve to an optimal result.
- Setting the solution ahead of time supports pre-dispatch trading on secure outcomes and aligns with the commitment timeframe of many resources that may be competing to provide these services. This could allow for greater competition between possible solutions. Even where there is reduced competition (due to, for example the locational nature of the service), the NMAS approach allows for further flexibility in the pricing and payments associated with binding commitments.
- Inter-temporal optimisation whereby the NMAS solution can have a scheduling approach that can take advantage of running in the ahead timeframe across multiple intervals to find the most efficient option across the relevant horizon.
- Optimisation for an efficient market outcome – insofar as possible given the ahead timeframe of the NMAS approach. As discussed in the AEMC's paper, it is expected that this operational scheduling will consider where additional procurement or additional scheduling of units procured under long-term arrangements should be activated in order to produce an overall lower cost of dispatch, and produce market benefits, based on the prevailing pre-dispatch conditions.
- Co-ordination with the longer-term frameworks for provision of system strength and NSCAS. The NMAS approach allows for resources that are contracted to provide network support or system strength to be scheduled in line with operational needs, with an avenue for complementary operational procurement if required. By occurring ahead of time, this allows for other activities such as planned maintenance to be more efficiently scheduled.

AEMO acknowledges that there are also limitations associated with the NMAS solution, as have been described by the AEMC. These include the potential inefficiencies observed through scheduling and making binding commitments ahead of time, where the energy and FCAS schedule may change into real-time, and therefore the lack of ability to co-optimise with the energy and FCAS schedule. Further, as described in response to question 3.1, there is no clear way to determine the pricing that should be associated with these services, even in the NMAS approach, and the design of the pricing framework and how it interacts with the eventual dispatch needs further consideration. AEMO looks forward to further collaborating with the AEMC, AER, and industry to determine the most effective way to resolve any limitations within the NMAS approach. On the other hand, the drawbacks the AEMC has described of the MAS solution, and the impracticalities of that solution that AEMO has described in response to question 3.1, mean that a MAS solution is not a feasible approach for secure system configurations.

However, AEMO does not consider the MAS and NMAS options are necessarily mutually exclusive, acknowledging that this is not necessarily the intent of the AEMC either. AEMO appreciates the AEMC's efforts to present clearly distinguished models to support further consideration of an operational procurement of system security support services. It should be noted that these represent bookends of possible solutions and there may be middle-ground or combined solutions available. In this, it could also be that the description of each characteristic for each approach in Table 5.1 of the directions paper may not necessarily only pertain to that option, and there may be the potential to adapt particular features for applicability under an alternative model.

As discussed in question 3.2, AEMO considers that an NMAS solution for system security support services could work alongside MAS solutions for unbundled services, and in fact is expected to do so for energy and FCAS. AEMO also considers there may be merit in considering in the future how a MAS solution may work in conjunction with a possible NMAS solution to address improving the efficiency of the schedule. In such a scenario, the NMAS would be used to procure secure system configurations, and then the MAS could be utilised to trade from this basis. This could feature as part of possible future consideration of ahead market options as put forward by the ESB, following the consideration of an NMAS solution.

1.10. Question 5.2 Which option might better address concerns relating to the exercise of market power by service providers?

AEMO considers that market power concerns are best addressed through mitigation measures applied to a best-practice design, rather than selecting an option that better addresses market power. Given the nature of the system security support services it is possible introducing a mechanism for such procurement will require appropriate market power mitigation measures to be considered. This is true also where investment or planning timeframes frameworks are used to address these constraints. Notwithstanding these comments, the intent of introducing a mechanism to procure the required amount of the services should allow entry, encourage competition, and reduce market power.

1.11. Question 5.3 Do you think that either option would be result in greater market transparency? Which option would be more transparent?

As discussed in question 3.2 and 4.1, AEMO considers that the NMAS option is more likely to result in greater market transparency.

1.12. Question 5.4 Which option might provide more efficient long-term signals to market participants, better influencing their investment and disinvestment decisions?

The introduction of any operational procurement for system security support services should improve upon the status quo for long-term signals to market participants to influence their investment and disinvestment decisions. An operational procurement provides:

- Information for the investment and planning frameworks to leverage in their assessments and proposals; for example, which constraints may be binding, and what payments are being made in the operational timeframe. This is similar to how the energy spot-market informs longer-term contracting and investment decisions for energy.
- Access to an additional revenue stream; where participants can bid for a commercial return to provide security to the system.

Each of these improves upon the current situation by providing signals for market participants that may influence their investment and disinvestment decisions with regards to system services, particularly as a signal for incremental investment. A well-functioning framework should influence participants' activities and actions for how they may provide a benefit to the system, or reduce the need for the system to provide additional services to counteract their behaviour. For example, where a resource may be making a choice to invest in an advanced inverter for their connection to the NEM, ideally an operational procurement for system services will provide an avenue for that participant making a return on that investment.[24] AEMO recognises that for this to work well, a framework whereby participants can understand how they may be included in secure system configurations which set the demand for the procurement will be required, and looks forward to working with industry as to how best to implement such a framework.

AEMO considers the NMAS option is more likely to provide better signals for these decisions, particularly due to its improved transparency, as discussed in response to question 4.1. However, it should be noted that neither solution is likely to provide a complete case for market participants to make investment and disinvestment decisions, particularly in isolation. Hence, it is important to consider this mechanism as part of a complementary package of reforms being sought to address the transition, and further consideration should be given to how these interact and combine to influence these decisions.

1.13. Question 5.5 Which option might better promote the evolution of our knowledge of the power system?

AEMO considers introduction of a practical operational procurement and scheduling mechanism will be a useful tool for operating the system securely and efficiently throughout the transition and beyond. With or without it, AEMO will continue the work it is progressing under the Engineering Framework to prepare to operate in the expected future operational conditions, and will continue to participate in international efforts such as the G-PST to progress overall understanding and development.

[24] See AEMO's response to Question 1.1 for a reference to its white paper on the Application of Advanced inverters in the NEM.

There is a risk that the introduction of an overly complicated or impractical mechanism could distract and "use up" resources that would be better focussed on "evolving the knowledge of the power system". AEMO considers immediately proceeding with a MAS approach would likely exacerbate this risk, given, as it has identified, there are numerous challenges that would need to be overcome to make this approach work.

AEMO supports progression of the NMAS option that allows for a market-based process to operationally secure the system, reduce reliance on directions if new limits emerge, while leveraging our current understanding of the system and working alongside the engineering efforts to understand the future system. AEMO is committed to approaching the introduction of such a mechanism in a way that enhances the overall transparency of the market operation, and seeks to harness industries' capabilities and knowledge in how to best operate the system of the future.

1.14. Question 5.6 Which option might more easily transition away from bundled system services as represented by constraints relating to specific system configuration to one based on unbundled services?

As discussed under question 5.1, AEMO considers that the NMAS could best support further unbundling of services, which may, in-turn, then be best suited to a MAS approach.

1.15. Question 5.7 What are the likely implementation costs and timeframes, for AEMO and market participants, for each approach? Are there additional implementation considerations that we should take into account?

As discussed in the AEMC's Directions Paper, the reforms considered in these rule changes form part of the ESB's NEM2025 program. This is a large program of work, which will involve significant regulatory and IT change for both market bodies and industry participants. As an input to the final ESB recommendations for ministers in mid-2021, AEMO completed a preliminary assessment of the changes required to market systems to deliver the reform agenda. This identified an opportunity to strategically sequence the IT change program for AEMO and for participants. Further work is underway to unpack and consult with industry on a roadmap to deliver the reform.[25]

With respect to an operational procurement for system security support services, AEMO notes following key components are likely to be required for implementation, with further elements likely identified as the design is progressed:

- detailed design for implementation,
- creation and amendments to operational procedures, including relevant consultation,
- a prototyping phase to design the scheduling engine,

[25] Energy Security Board Post 2025 Market Design: Final Advice to Energy Ministers, Part B, July 2021, https://esb-post2025-market-design.aemc.gov.au/32572/1629945809-post-2025-market-design-final-advice-to-energy-ministers-part-b.pdf

- process amendments to develop the inputs for the new mechanism, including publication and relevant change processes,
- build of and integration of the new scheduling engine with existing systems,
- amendments to existing systems such as settlements to incorporate any changes,
- process amendments to consider any additional publication or reporting requirements for the new mechanism,
- user-acceptance and end-to-end testing of the above components,
- a market trial for participants.

A more detailed assessment will be required to determine the appropriate implementation timeline in tandem with the development of further design, and with consideration to the delivery of the broader reform package. This must also take into account the relevant changes for participants.

AEMO considers that the implementation of an NMAS approach is likely be less costly and take less time than the MAS approach, given the increased complexity associated with resolving the identified challenges. The MAS approach would also see the dispatch engine replaced or significantly altered which would require additional prototyping, testing and integration considerations for the solution. Further, such a change is likely to have increased impact on all market participants immediately, even those not interested in participating in the new operational procurement mechanism. From an implementation point of view, this can also therefore be expected to have increased trial and cutover impacts for participant systems.

1.16. Question 5.8 Do stakeholders consider there are additional merits or drawbacks to either approach that are not explored in this paper?

The paper discusses each option at a high level, and AEMO commends the AEMC on providing a solid framework for further analysis. AEMO has provided comment throughout this submission on additional considerations and merits and drawbacks of each approach, and looks forward to further engaging on this additional detail.

1.17. Question 6.1 What are stakeholders’ views on the Commission’s recommendation of the NMAS approach?

AEMO agrees with the Commission’s recommendation of an NMAS approach.

Moreover, given the large program of reforms that are currently on the agenda, AEMO considers it would be best to focus future consideration on the NMAS option at this stage. Continued progression of a full end-to-end design of all options would take considerable effort and resources. AEMO considers it clear the MAS approach alone will require significant effort to make workable, and these efforts may be unsuccessful.

Further, as previously discussed, AEMO would also support future progression of a MAS approach for unbundled services in the future.

1.18. Question 7.1 What are stakeholders' views on the issues that need to be examined further to inform this analysis

AEMO agrees with the list of issues the AEMC will seek to address in the future analysis. Each has various priority and requirements, and AEMO looks forward to continuing to work closely in collaboration with the AEMC in moving towards an end-to-end design, understanding the changes required to the rules, and for implementation of the eventual changes.

1.19. Question 7.2 Do stakeholders consider that here are additional issues that need to be examined in future analysis?

AEMO considers a complete end-to-end straw design will be the next step for understanding how an additional operational procurement could work, how it will interact with the dispatch of the system, and how it will integrate with, and complement, the existing and evolving planning frameworks that feature in the NEM. This will facilitate further progression of the design as identified above. As discussed, AEMO encourages this to focus on the NMAS proposal, and to leave further consideration of a MAS proposal to the future. As a starting point, the NMAS proposal could leverage the design of the system security mechanism (SSM) put forward by the ESB.[26]

An end-to-end straw design should include consideration of the following elements, among those identified by the AEMC:

- How the "demand" for the operational procurement will be set, what form it will be when inputted to the optimisation, and for participants to understand how they may contribute.
- Participation frameworks – both for how a participant can understand what they can supply to meet the demand, and what form their offer to supply the capability should take.
- The objective function of the optimisation and interaction with the energy and FCAS markets.
- The timing of the NMAS scheduling tool, when binding commitments would be made, and over what horizon.
- Obligations associated with commitment, and the consequential impact on pre-dispatch and dispatch.
- The pricing framework that should apply to the commitments of the NMAS, based on the optimisation tool, and any contract or obligations of the counterparties.

[26] The SSM was described in Part B of the ESB's Options Paper published April 2021, https://esb-post2025-market-design.aemc.gov.au/32572/1619564172-part-b-p2025-march-paper-appendices-esb-final-for-publication-30-april-2021.pdf.

- Settlement of any contracts or obligations through the NMAS approach, i.e., who costs should be recovered from.
- Interactions with other existing or evolving frameworks such as system strength, NSCAS, and directions.

AEMO looks forward to continuing to work with the AEMC on these items as it progresses consideration of these rule changes.