RULE

Australian Energy Market Commission

DIRECTIONS PAPER

CAPACITY COMMITMENT MECHANISM AND SYNCHRONOUS SERVICES MARKETS

PROPONENTS

Delta Electricity
Hydro Tasmania

9 SEPTEMBER 2021

INQUIRIES

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ABOUT THE AEMC

The AEMC reports to the Energy Ministers' Meeting (formerly the Council of Australian Governments Energy Council). We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the Energy Ministers' Meeting.

EXECUTIVE SUMMARY

1 This directions paper considers two rule change requests received by the Commission from Hydro Tasmania and Delta Electricity (Delta).

2 The rule change requests both concern valuing, procuring and scheduling essential system services.

3 Hydro Tasmania's rule change request is to create a market for "synchronous services", including inertia, voltage control and fault level/system strength.[1]

4 Delta's rule change request is to introduce a capacity commitment mechanism to provide access to operational reserve and other system security and reliability services.[2]

5 These rule changes formed part of the Energy Security Board's[3] (ESB's) essential system services (ESS) and scheduling and ahead mechanisms (SAM) workstream.[4]-The rule change processes dovetail with the ESB's post-2025 market design process by advancing these urgent issues.

Context and background of the rule change proposals

6 The NEM in transition

7 The generation mix in the NEM is undergoing a significant transformation. This is driven by a number of factors, including the decarbonisation of the sector, and changing technology costs and consumer preferences.

8 Both large- and small-scale renewable generation and batteries is entering the system rapidly and in high volume. At the same time, the thermal generation fleet has started to retire from the system or operate less frequently due to the influx of resources with lower short run marginal costs.

9 These changes are likely to continue over the coming decades as the power system continues to transition away from traditional operating conditions and practices.

10 Effect on essential system services

11 As this transition continues, the changing energy mix will have implications for how essential system services are provided and, as a result, how power system requirements are satisfied now and in the future.

12 Essential system services include inertia, frequency control and system strength. They are critical to maintaining overall power system security.

13 The NEM's regulatory and market frameworks were originally designed based on a power

1 AEMC, Synchronous services markets, https://www.aemc.gov.au/rule-changes/synchronous-services-markets

2 AEMC, Capacity commitment mechanism for system security and reliability services, https://www.aemc.gov.au/rule-changes/capacity-commitment-mechanism-system-security-and-reliability-services.

3 The ESB was tasked by the former Council of Australian Governments Energy Council, to develop advice on reforms to the NEM to meet the needs of the transition and beyond 2025.

4 ESB, Post 2025 market design options - Final advice to Energy Ministers, July 2021.

system consisting primarily of synchronous generators (coal-fired, gas-fired and hydro generators) which are electromagnetically coupled to the power system. These generators inherently provide essential system services like inertia, reactive power support and system strength as a by-product of energy generation when they are committed, in operational timeframes, into service.

14 Non-synchronous generators (which typically include solar PV, wind generators and batteries), are connected to the power system through power electronics. This means that while these inverter-connected generators could be configured to provide some services that were provided by synchronous generators, they do not necessarily do so automatically as a by-product of their generation.

15 Because these essential system services were historically provided in abundance by these generators, there was little need in the original market design to explicitly value them so that market participants had an incentive to provide them. While some efforts have been made to explicitly value some of these services (e.g. system strength), this is not the case for all services.

16 Consequently, under the current market design, which does not explicitly value all essential system services, the changing generation mix is providing fewer of these services. This is pressing the limits of current system security and operational experience.

17 A symptom of this is that the Australian Energy Market Operator (AEMO) is increasingly having to direct generators that provide essential system services to be online that would otherwise not be, in order to ensure the system is secure.

18 Directions are a tool primarily intended to be used as a last resort mechanism. Reliance on this and other of AEMO's operational tools increases costs to consumers, and also, places increased risk on the ability of the system to be secure. Relying on these last resort mechanisms also does not send appropriate and transparent investment and operational signals to participants about what equipment, resources and services are needed at a particular point in time.

19 Throughout and beyond this transition, a better approach is needed, which provides secure outcomes but at lower costs to consumers, as well as incentivising parties to provide these services.

The rule change requests

20 The two rule change requests that are the subject of this paper broadly identify the problems outlined above. They propose two different solutions to better value essential system services so that a secure system is delivered more efficiently.

21 Delta proposes the introduction of a day ahead, ex-ante capacity commitment mechanism and payment to provide access to operational reserve and other required system security and reliability services. Delta proposes that AEMO would determine system service requirements, and, through a market operating ahead of read time, would procure these services from market participants.

22 Hydro Tasmania proposes an approach which would explicitly value the provision of services in real time, in much the same way that energy is valued. The pre-dispatch and dispatch engines, which currently provides forecast and actual dispatch targets and prices for energy and frequency control ancillary services, would be altered so that they also determine forecast and actual dispatch targets, and prices for other essential system services.

The long-term vision for the power system

23 The long-term vision for the power system is an efficient, secure and reliable power system. Consistent with the ESB, the AEMC considers that the best way to achieve this, where possible, is to unbundle essential system services from one another so that they can be individually and explicitly valued, priced and scheduled. In turn this would provide adequate investment and scarcity signals for participants to deliver these services at least cost to consumers.

24 However, the extent to which it is possible to completely separate all power system requirements and translate these requirements to individual services is currently unknown. Currently, from an engineering knowledge perspective, there is no direct translation from a number of power system requirements in order to create specific services.

25 To date, AEMO has been able to identify and develop specific system configurations that represent a secure technical operating envelope within which a secure power system can be modelled and operated. These system configurations are predefined combinations of units that collectively are known to correspond to a secure power system.

26 Indeed, it is these system configurations that inform AEMO's direction of generators to maintain system security.

27 Given the current understanding of power system engineering, the continued use of system configurations will continue to be required transitionally, as opposed to fully unbundling and individually valuing essential system services. In the near term, a drawback of this is that more efficient, innovative means to contributing to a secure system that are not consistent with, or fall outside of, the current known system combinations that keep the system secure may not be recognised or rewarded at this point in time. This may stifle the development and innovation of the provision of essential system services, increasing overall system costs over the long term.

28 The reforms proposed in this paper would, broadly speaking, introduce the architecture for valuing, scheduling and procurement of ancillary services in operational timeframes. Therefore, over time, as engineering knowledge improves, essential system services may be unbundled and individually valued, addressing this concern.

29 Despite this limitation, it may nevertheless currently be possible to improve the efficiency by which essential system services are delivered. It is in this context that the AEMC is considering the two rule change proposals.

Approaches to considering the problem

30 This paper sets out a framework for considering the two broad options for how these can be

procured:

- **market ancillary services (MAS) approach** – which would introduce new services to be scheduled through the pre-dispatch engine to allow it to produce dispatch schedules that result in secure dispatch, and
- **non-market ancillary services (NMAS) approach** – which would introduce new services to be procured and scheduled in an optimisation approach outside of the spot market, to ensure secure dispatch in a more efficient manner.

31 These approaches are broad, overarching frameworks through which more detailed proposals can be examined.

32 The solution proposed by Hydro Tasmania is to create a new market for the procurement of 'synchronous services' such as inertia, voltage control and fault level/ system strength and this can be considered to be consistent with the MAS approach.

33 The solution proposed by Delta is to introduce a capacity commitment mechanisms to the NEM to address shortfalls in system security and reliability services and this can be considered to be consistent with the NMAS approach.

34 The unit commitment for security (UCS) and system security mechanism (SSM) mechanisms proposed by the ESB in its final advice to Ministers are also consistent with the NMAS approach. The UCS mechanism would schedule resources providing services under structured procurement arrangements. Over and above this, the SSM would be a short-term procurement option, which could provide an adaptable operational tool to complement planning-based solutions to provide the system configuration needed to maintain security.

35 As noted above, given the state of engineering knowledge, both the MAS and NMAS approaches may require the continued procurement of secure system configurations as a transitional measure, as opposed to valuing unbundled essential system services.

36 Overall, the Commission notes each approach has a number of merits and drawbacks and that trade-offs based on the characteristics of the two approaches will need to be considered.

37 At this stage, the Commission regards the NMAS approach as its preferred approach to confidently support efficient scheduling and dispatch by AEMO. The Commission considers this structured procurement approach is more likely to result in a more efficient scheduling and dispatch of generators, and provide AEMO with greater confidence that the system will be secure, ultimately lowering costs to consumers.

38 However, the Commission will continue its evaluation of both the MAS and NMAS approaches, taking into account stakeholder feedback provided to this directions paper and so it particularly welcomes views on the merits and costs associated with each approach.

Interaction with AEMC's draft determination on system strength

39 The draft determination for the AEMC's Efficient management of system strength on the power system rule change (System strength draft rule) proposes evolving the existing system strength framework.

40 Among other things, the changes would require transmission network service providers (TNSPs) to meet a new system strength planning standard. In doing so, the TNSP may choose to enter into contracts with generators or other market participants which would be able to provide services which enable the TNSP to meet its obligations under the standard.

41 The options set out in this paper build on this draft determination, by developing solutions that would enable any contracts entered to under the system strength framework in planning timeframes to be better utilised in operational timeframes, meaning that consumers would get the most value out of these contracts.

42 The options set out in this paper also consider a wider range of essential system services than just system strength.

Engaging with our process

43 This directions paper has been prepared to facilitate public consultation on the rule change requests and to seek stakeholder submissions on the issues presented. The Commission invites stakeholders to make submissions for a period of 6 weeks, with submissions due by 21 October 2021. Submissions can be lodged online via the Commission's website, www.aemc.gov.au, using the "lodge a submission" function.

44 The Commission will hold a webinar briefing on this directions paper as part of our consultation and engagement with stakeholders on these rule changes. This briefing will be held on Monday, 20 September 2021. Interested stakeholders are invited to register via the Commission's website.

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FIGURES

1 INTRODUCTION

The Australian Energy Market Commission (AEMC or Commission) is currently considering two rule changes related to system security and, more specifically, the provision of essential system services:

- On 19 November 2019, Hydro Tasmania submitted a rule change request to the AEMC to create a market for "synchronous services", including inertia, voltage control and fault level/system strength.[5]
- On 4 June 2020, Delta Electricity (Delta) submitted a rule change request to the AEMC to introduce a capacity commitment mechanism to provide access to operational reserve and other system security and reliability services.[6]

This paper discusses both of these rule change requests. These rule changes were initiated by the AEMC in a consultation paper in July 2020, as part of a set of seven "system services" rule changes, all of which relate to the provision of services that are necessary for the secure and reliable operation of the power system.[7]

These rule changes formed part of the Energy Security Board's (ESB) Essential System Services (ESS) and Scheduling and Ahead Mechanisms (SAM) workstream.[8] The progression of the rule changes allow us to advance issues that are more urgent in nature, and the rule change processes dovetails with the ESB's post-2025 market design process.

The provision of essential system services is an important component of this work given that the NEM currently has over 17GW of wind and solar capacity installed. By 2025, even under the current ISP's central scenario, this is expected to increase to 27GW of wind and solar capacity (including grid scale and domestic rooftop solar). Coupled with the exit of large ageing thermal synchronous plant, this changing generation mix will press the limits of current system security and operational experience. There is a need to appropriately value essential system services in order to continue to maintain system security.

The AEMC is progressing the Delta and Hydro Tasmania rule change processes in this joint directions paper given the interrelationships between the two rule change proposals.

This paper is structured out as follows:

- **Chapter 2 Context and background -** Provides context for the consideration of the rule change requests
- **Chapter 3 The rule change proposals -** Summarises the rule change proposals and the Commission's approach to considering them

5 AEMC, Synchronous services markets, https://www.aemc.gov.au/rule-changes/synchronous-services-markets

6 AEMC, Capacity commitment mechanism for system security and reliability services, https://www.aemc.gov.au/rule-changes/capacity-commitment-mechanism-system-security-and-reliability-services.

7 See: AEMC, System services rule changes, https://www.aemc.gov.au/sites/default/files/2020-07/System%20services%20rule%20changes%20-%20Consultation%20paper%20%E2%80%93%20%202%20July%202020.pdf

8 ESB, Post 2025 Market Design final advice to Ministers, July 2021, https://energyministers.gov.au/energy-security-board/post-2025

- **Chapter 4 Assessment framework -** Presents an assessment framework and requirements for the consideration of the proposals, and
- **Chapter 5 Approaches to addressing the problem -** Outlines the Commission's current approach to the issues raised in the rule change requests.

This directions paper has been prepared to facilitate public consultation on the rule change requests and to seek stakeholder submissions on the issues presented. The Commission invites stakeholders to make submissions for a period of 6 weeks, with submissions due by 21 October 2021. Submissions can be lodged online via the Commissions website, www.aemc.gov.au, using the "lodge a submission" function and selecting the project reference code ERC0290 or ERC0306.

The Commission will hold a webinar briefing on this directions paper as part of our consultation and engagement with stakeholders on these rule changes. This briefing will be held on Monday, 20 September 2021. Interested stakeholders are invited to register via the Commission's website.

Please contact project leaders David Reynolds (David.Reynolds@AEMC.gov.au) or Stuart Morrison (Stuart.Morrison@AEMC.gov.au) in relation to any queries you may have about the topics covered in this directions paper.

2 CONTEXT AND BACKGROUND

This section sets out the relevant context and background for this directions paper:

- It first outlines the drivers of the changing generation mix, how this is affecting the operational decisions of certain types of generation to be ready to generate energy in the spot market, and what the implications of these changes mean for the availability of essential system services.
- The long-term vision for the power system is presented which, broadly speaking, is to ensure an efficient, secure power system. The best way of achieving this - as set out in the ESB's post 2025 market design work - is to explicitly value and price essential system services where possible such that they provide adequate investment and scarcity signals for participants.
- There is then an exploration of the core power system requirements as they are understood today alongside noting the difficulty in directly translating core power system requirements to service specification. The evolution to a full service-based model involves further work - being undertaken internationally as well as here - to "unbundle" and define the core fundamental physical requirements that keep the power system secure. It also discusses the work AEMO has underway to "unbundle" core power system requirements.
- Finally, it sets out that in the interim, AEMO has been able to identify and develop specific system configurations that represent a secure technical operating envelope within which a secure power system can be modelled and delivered. This is a necessary step in the evolution towards a services-based model as further work is done to unbundle the specific essential system services and explicitly value and price these services.

2.1 The NEM in transition

The generation mix in the NEM is undergoing a significant transformation. This is driven by a number of factors, including changing technology costs and consumer preferences. At the core of the transition is the following trends:

- Both large- and small-scale renewable generation is entering the system rapidly and in high volume with ever-increasing inverter based solar photovoltaic (PV), wind resources coming online, as well as batteries.
- At the same time, the ageing thermal synchronous fleet[9] that traditionally delivered a significant proportion of the grid supply, has started to retire from the system or operate less frequently due to the influx of lower short run marginal cost resources.

These changes are likely to continue over the next two decades as the power system continues to transition away from traditional operating conditions and practices, technology and generation resources continue to evolve and become more cost competitive, and the sector continues to decarbonise.[10] The changing nature of the demand side (e.g. advent of

9 Synchronous generators produce power through the circular motion of a rotor that is electromagnetically coupled and synchronised to the NEM frequency. These include coal- and gas-fired generators.

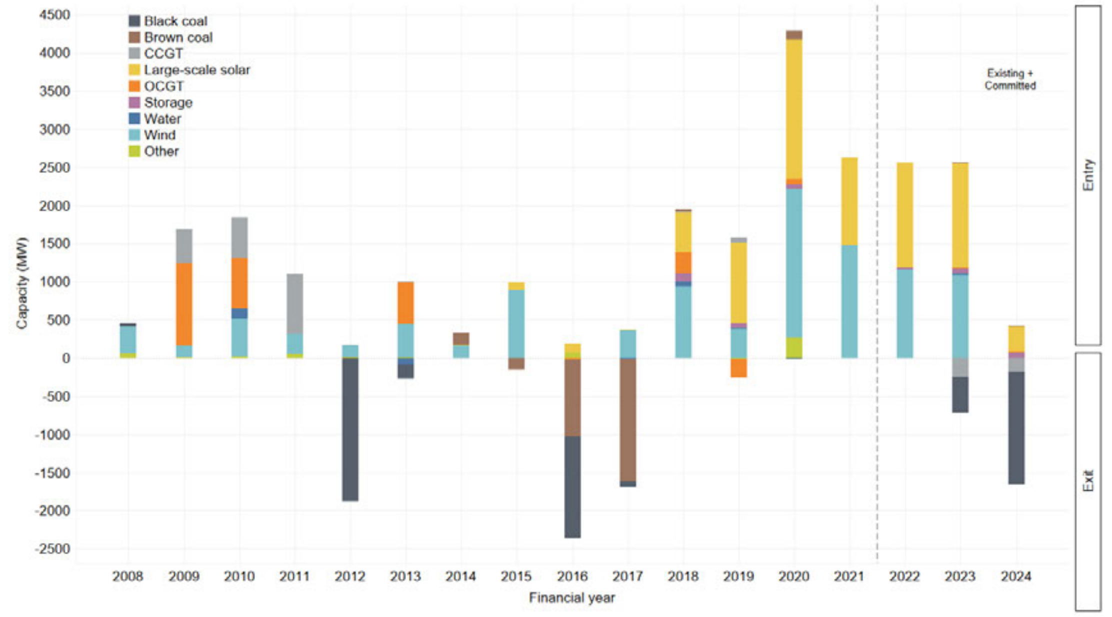
10 Energy Security Board, *Post-2025 Market Design Directions Paper,* January 2021.

hydrogen, electrification of the transport sector) will also play a significant role in this changing generation mix.

2.1.1 A changing generation mix

As outlined in Figure 2.1, there has been significant entry of large-scale, inverter based generation.[11] Figure 2.1 shows that around 4,540 MW of large-scale solar and 4,760 MW of wind were commissioned between FY 2018 and FY 2021. A further 3,095 MW of large-scale solar and 2,248 MW of wind are committed to enter over the next three financial years.

Figure 2.1: Entry and exit of large-scale generation in the NEM



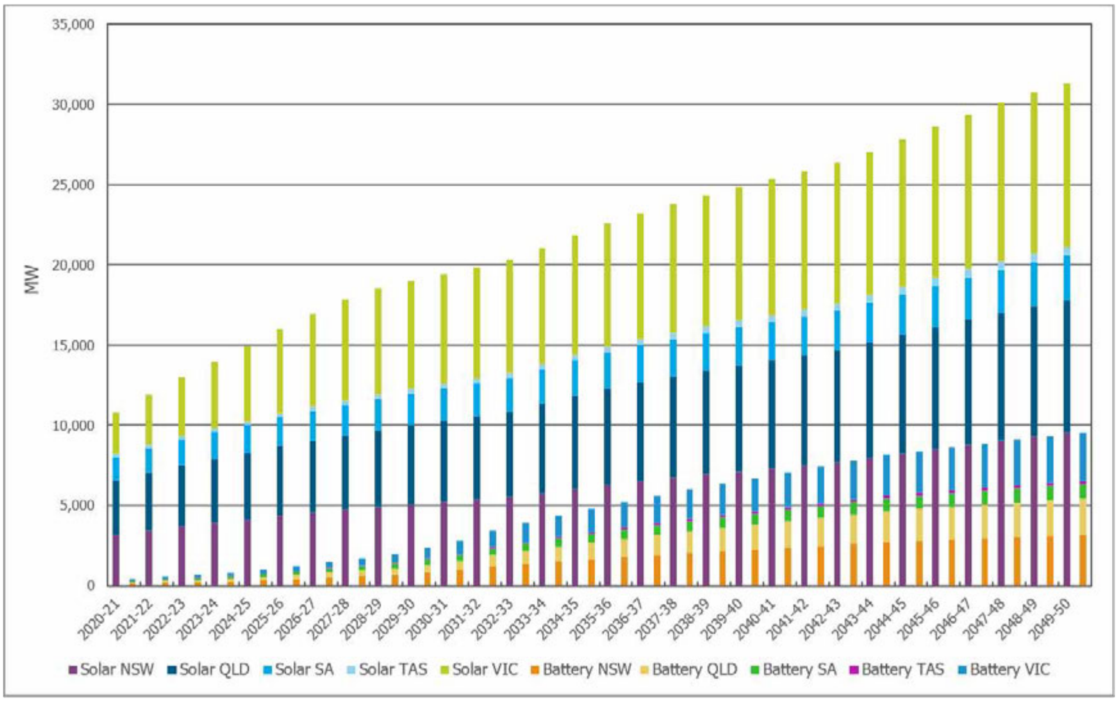
Note: Analysis of AEMO data.

Note: Information is based on AEMO NEM Generator Information as of May 2021. CCGT is closed-cycle gas turbine; OCGT is open-cycle gas turbine.

Additionally, there is continuing rapid uptake of small-scale, inverter-based generation at the distribution level, mainly made up of residential rooftop PV, and residential batteries. According to the Clean Energy Regulator, as at 30 April 2021, there were around 2.4 million small-scale PV systems in the states covered by the NEM. As shown in Figure 2.2, the capacity of residential rooftop PV is expected to continue to grow significantly over the coming decades.

11 Inverter based generators produce power without being electromagnetically coupled to the NEM frequency. This includes include generation resources such as wind, solar PV and batteries.

Figure 2.2: **Forecast rooftop PV capacity**



AEMO, *Electricity Statement of Opportunities 2020: Inputs and assumptions workbook* (ESOO), November 2020.

2.1.2 Existing generation

The rapid entry of inverter-based generation including batteries, and resulting periods of low wholesale prices are putting increasing pressure on the existing large synchronous thermal generation fleet, particularly coal generators. The faster that new, more economic renewable and inverter-based generation comes into the market, putting downward pressure on energy spot and contract prices, the less often the existing thermal generators will operate, creating higher pressures to exit for these less economic generators.

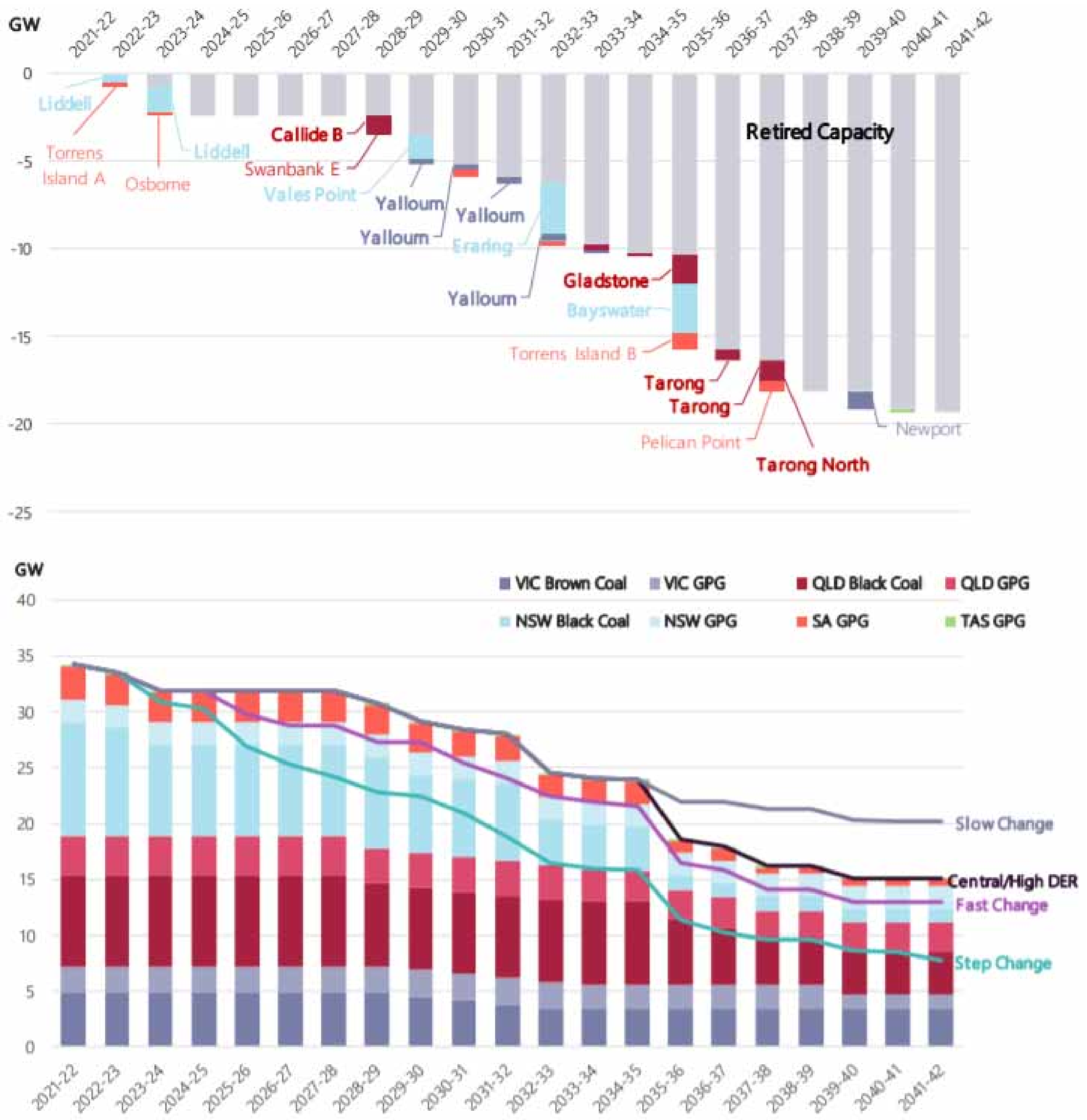
It is expected that over half of ageing synchronous thermal generation will exit over the next two decades.[12] Figure 2.3 shows the expected unit retirement dates from AEMO's 2020 Integrated System Plan.

This shows that AEMO expects nearly 20GW of synchronous thermal retirement over the coming 20 years under their "Central" scenario. In addition, the performance of coal plant may deteriorate over time as the plant ages. Thermal generators will also consider cycling their output by coming on and off more often, rather than remaining online at their minimum generation levels, in response to low prices on sunny days with high levels of solar PV.

12 AEMO Electricity Statement of Opportunities, 2020, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo

Technical limitations on ramping and cycling may affect the financial performance and viability of coal-fired power stations. This may encourage plants to move away from the traditional base load operation to load cycling.

Figure 2.3: Coal-fired generation and gas-powered generation (GPG) retirements (top) and capacity (bottom)



Note: AEMO 2020 ISP, Figure 11, p. 44.
Note: The announced retirement dates of some units shown above have changed since the ISP was prepared in early 2020.

Synchronous generators (coal-fired, gas-fired and hydro generators) are electro-magnetically coupled to the power system, and inherently provide system services like inertia, reactive power support and system strength as a by-product of energy generation when they are committed into service. Inverter-based generators (which typically include solar PV and wind generators), are connected to the power system through power electronics. This means that while inverter-based generators can be configured to provide some services that were provided by synchronous generators, they do not necessarily do so automatically as a by-product of their generation. Inverter-based generators can also provide some services separately to producing energy which is a capability different to that of many synchronous machines.

2.1.3 Effects of these trends

To maintain a secure and stable grid system, a number of core power system requirements need to always be met, through the provision of certain technical capabilities. These requirements are critical to maintaining overall power system security and reliability.[13]

Satisfying these power system requirements is a complex exercise. These requirements interact with each other as a function of the capabilities of the equipment delivering the requirements and the operational conditions of the day.

In addition to satisfying a broad range of system requirements outlined above, AEMO must also satisfy a number of operational prerequisites.[14] These operational prerequisites primarily relate to dispatchability, which refers to the ability to dispatch and configure the power system to maintain security and reliability, and predictability of the power system, which refers to the ability to measure or derive accurate data to inform planning and operational decision-making.

Satisfying these operational prerequisites enables AEMO to confidently maintain the power system within the defined technical envelope to enable AEMO to operate the power system securely and reliably.

The existing NEM was designed based on a power system consisting primarily of synchronous generation, and the inherent characteristics of these machines. Historically, large, synchronous generating assets played a central role in maintaining power system security. These combinations of assets provided various system services as a by-product of generation, thereby securely maintained the key power system requirements. . The delivery of these services was dependent on the specific technical design characteristics of the asset, such as the mass of the rotor.

These physical asset characteristics also determined how the power system is developed and operated, reflecting both the technology and location of these assets:

- Individual synchronous generating assets tended to respond in a specific, predictable way to given disturbances on the power system, eg, the way that a particular synchronous generator responds to a fault will then be used to determine other key system limits, such as transient stability limits.

13 AEMO has designated broad categories of system requirements which the power system needs to remain secure. These are: resource adequacy, frequency management, voltage control and system restoration.

14 Operational prerequisites should not be confused with the operational conditions outlined in AEMO's Engineering framework which consider broader future operational "scenario" conditions. These operational prerequisites reflect the current needs of the power system.

- The specific location of these synchronous assets was also relevant to support power transfer from one part of the system to another, eg, a synchronous asset located at one end of a large interconnector will have a direct impact on how much power can be transferred reflecting its particular location and physical characteristics, including its inherent provision of inertia and system strength.

In recognition of the transition of generation type to inverter-based resources, AEMO has determined a range of secure system configurations for current operation while continuing to work on defining power system requirements such that the power systems needs can be confidently met with system services. Assessments of secure system operation requires significant power system analysis to understand how the system needs to be configured in order to remain secure. These assessments are carried out by AEMO as the system operator and the Network Service Providers (NSPs) and are translated into constraints and transfer limit advice to define the secure technical envelope for dispatch of the market under different conditions. Due to the nature of existing technology and current understanding of power system requirements, these assessments must take into account the commitment, in operational timescales, of different assets connected to the power system. The assessments determine whether each configuration, collectively, will deliver a secure power system under a series of contingency analysis and operational conditions, and through considering all power system requirements together. The result is a set of secure configurations of the power system within which the power system must be dispatched – the secure technical envelope.

As discussed above, the generation mix is changing. The power system is transitioning from these types of assets to more flexible, dispersed, smaller, inverter-based resources, such as wind, solar and batteries. These resources do not necessarily demonstrate the same innate physical interactions with the power system as synchronous generators. Instead, the interactions are defined by the particular control software used to manage their operation. This is making it harder to define the operating conditions that are needed to operate the system.

As the generation mix continues to transition and there are higher penetrations of inverter-based plant, the needs of the system and how it is operated therefore need to evolve. In particular, the following has been observed in recent years:[15]

- higher wind and solar penetrations - maximum levels rose from 38 per cent in 2018, to 47 per cent in 2019, and to 52 per cent in 2020. There were 23 days with penetrations above 40 per cent in 2019 and 109 days in 2020, and
- lower minimum synchronous generation - decreased from 13.7GW in 2018 to 10.8GW in 2020.

This means that we are already in the realm of new and challenging operational conditions. AEMO's Renewable Integration Study identified that for wind and solar penetrations greater than 50 per cent, coordinated action was needed to support a secure transition. This

15 AEMO, NEM Engineering Framework, March 2021 report.

changing generation mix is pressing the limits of current system security and operational experience.

To date, the lack of markets or other means of valuing the system services essential system security means AEMO is intervening in the market to procure these essential capabilities. The ESB's Health of the NEM report noted that system security remains the most critical issue at present, and that AEMO's interventions have increased markedly in recent years. This occurs because once the number of synchronous generators reduces below a certain level, AEMO must then direct units online to provide system security. Based on the current level of analysis and knowledge of operating the transitioning generation fleet and power system, AEMO intervenes to ensure that particular units and generating resources are online to maintain a secure and stable grid. To date, these interventions have been location specific (e.g. in South Australia) and steps have been taken to address immediate challenges (e.g., via investment in synchronous condensers). However, similar challenges are emerging across the NEM and are likely to increase in future given the changing composition of resources on the grid.

As can be seen in the box below, instances of directions for system security have increased significantly in recent years, particularly in South Australia, leading to higher costs for consumers.[16] Additionally, the continual reliance on a tool that is primarily intended to be used as a last resort mechanism places increased risk on system operation, as well as not sending the appropriate investment and operational signals to participants about what equipment, resources and services are needed at a particular point in time.

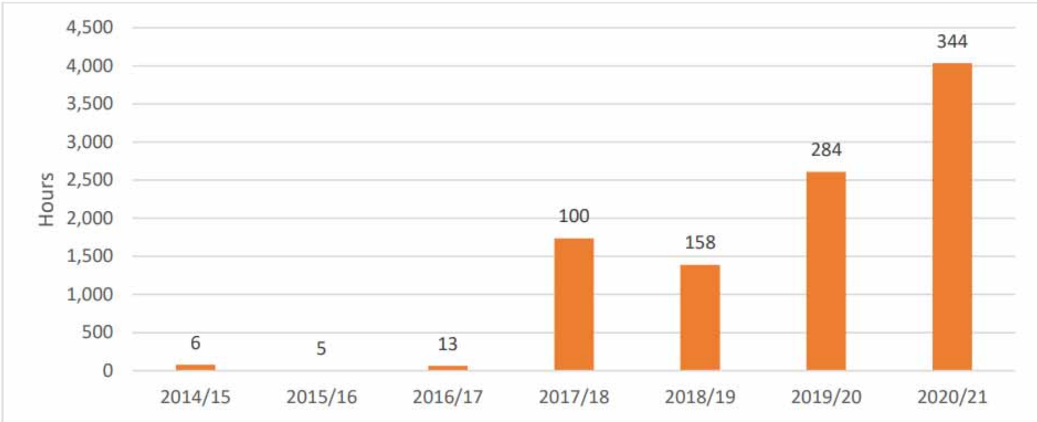
BOX 1: AEMO DIRECTIONS FOR POWER SYSTEM SECURITY

AEMO may issue directions to participants to maintain or re-establish the power system to a secure operating state. Currently in the NEM, the majority of directions are made by AEMO to synchronous gas-fired generators to ensure that there is adequate system strength in South Australia. This trend started in December 2016, when AEMO announced that at least two large synchronous generating units should be online at all times to maintain system strength in South Australia.

Over the period of 2016-17 until the present, the number of directions issued in the NEM has been increasing significantly. During the 2019-20 financial year, AEMO issued 278 power system directions. Of these, 273 were issued in South Australia, and the remaining five were issued in Victoria. The historical instances of directions can be observed in Figure 2.4.

16 Reliability Panel, 2020 Annual Market Performance Review, Page 113, https://www.aemc.gov.au/sites/default/files/2021-05/Final%20report.pdf

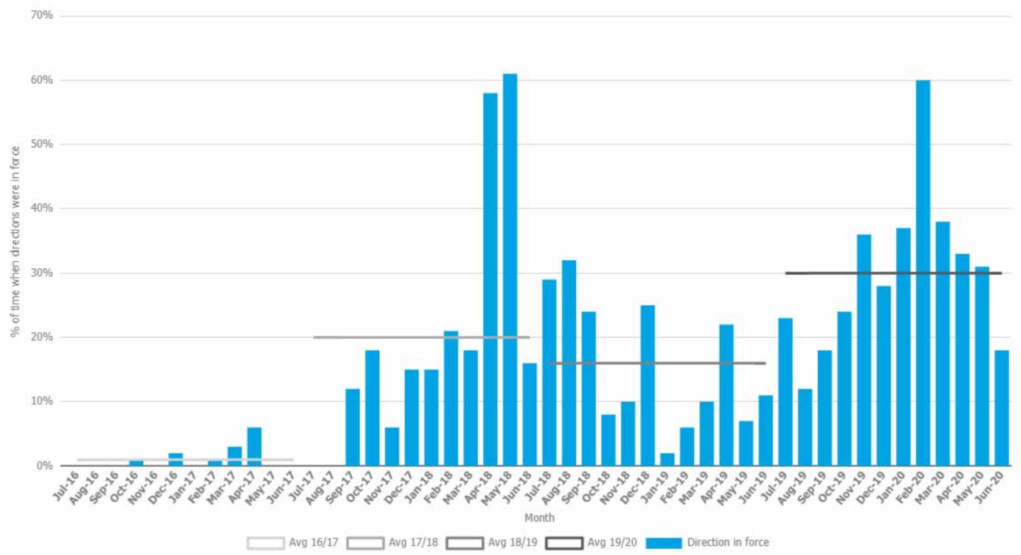
Figure 2.4: Number of directions issued in the NEM



Source: ESB, Post-2025 market design final advice to Energy Ministers: Part A, July 2021, p 30.

The proportion of time that a security direction is in place in the NEM has also been increasing over this period as presented in Figure 2.5. Security directions were in place across the NEM for approximately 30 per cent of the 2019-20 financial year. This is a significant increase from the 2016-17 financial year.

Figure 2.5: Proportion of time with directions in place across the NEM



Source: Reliability Panel, 2020 Annual Market Performance Review, https://www.aemc.gov.au/market-reviews-advice/annual-market-performance-review-2020

These effects - which are being seen on the power system - are symptomatic of a market design where some aspects relating to provision of essential system services are not fit for purpose. Improving the regulatory framework and, in turn, the market design such that essential system services are appropriately valued, procured and scheduled is a priority for this work program. This will also have the effect of relieving these symptoms.

New technologies (both demand- and supply-based) can provide services that meet some of these essential capabilities. This includes large-scale batteries and flexible demand. Large customers, through demand response, may be able to provide essential system services, where they are able to build flexibility into their commercial processes.

Australia is leading the way to provide a pathway to operate a system with high-levels of inverter based resources. New technologies are being tested through projects funded by the Australian Renewable Energy Agency (ARENA), trials and demonstration projects.

Nevertheless, mechanisms are required in the transitional period to support the continued secure operation of the system while knowledge of operating the power system with these new technologies continues to develop. It is also necessary to think about how to manage the retirement, or changed operation, of the synchronous assets that have traditionally played a key role in system operation, due to their specific location in key parts of the grid.

There is significant value where resources can provide flexibility and essential capabilities, allowing system needs to be met through a different mix of resources to what is used today. Acting now to incentivise service providers to offer these capabilities to market will realise this value and be delivered at least cost outcomes for consumers.

Security is critical, and stakeholder feedback through both the AEMC and ESB processes suggests that addressing missing system services cannot wait until 2025.

Below, the long-term vision for the power system is set out, followed by the work that is underway to address these issues.

2.2 ESB's long-term vision for the power system

The long-term vision for the power system is an efficient, secure and reliable power system. As set out in the ESB's post 2025 market design advice, the best way to achieve this includes explicitly valuing and pricing essential system services where possible such that they provide adequate investment and scarcity signals for participants.

The long-term vision for the power system in relation to essential system services has been developed by the ESB (including AEMO, AER and AEMC) as part of its post-2025 market design advice. This work was to develop a long-term reform package with the focus on providing advice on long-term, fit for purpose market design options that could apply from the mid-2020s. One key area of this work was on essential system services, and scheduling and ahead mechanisms. The ESB set out that in order for the power system to be stable and secure, a number of core system requirements need to always be met through the provision of certain technical capabilities, which can be described as "essential system services". The four key essential system services that are being considered as a priority are: frequency control, inertia, system strength and operating reserves.

This vision is to unbundle the provision of essential system services, to provide ways to procure individual essential system services. This is because the current market arrangements, which do not explicitly unbundle individual essential system services, consequently do not appropriately value them. We therefore need new ways to actively source these essential system services as the power system continues to transition.

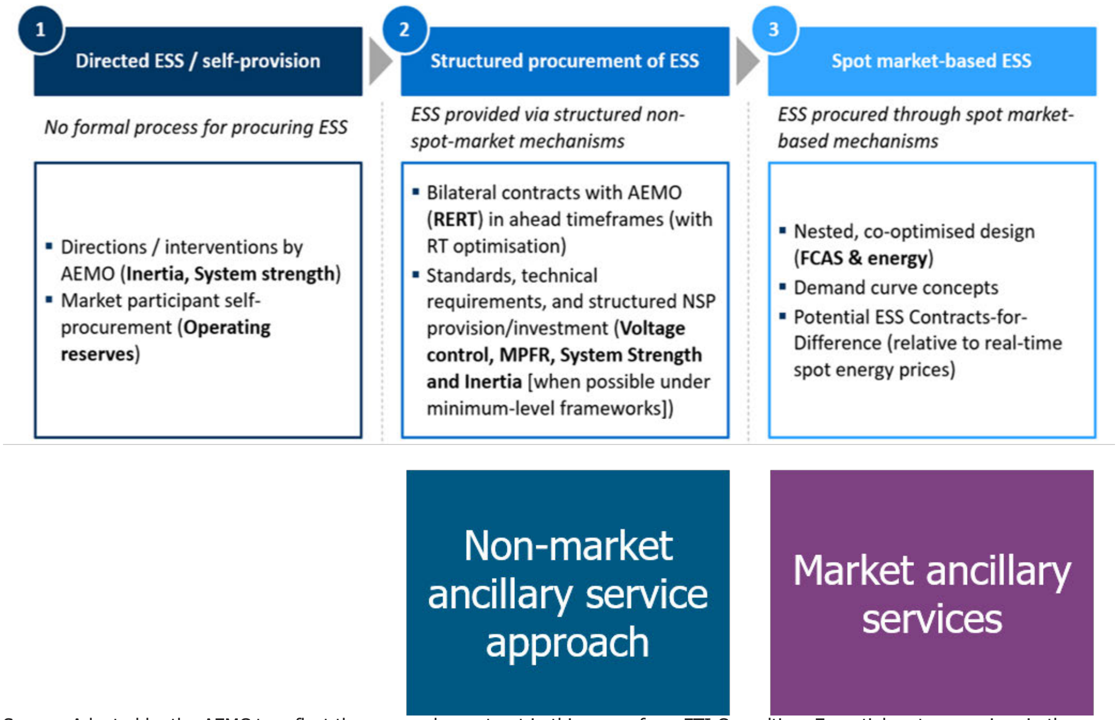
Going forward the vision is to move towards a model of providing system security outcomes based on the provision of specific services, rather than specific assets as noted earlier in section 2.1.2 and discussed further in section 2.2.3. This will help establish clear procurement mechanisms for the critical system services that are needed to manage the system, and allow the system needs to be met through a different mix of resources compared to what is used today.[17] This will also allow AEMO to have the right tools to manage the greater complexity and uncertainty to schedule these resources so that they are available when they are needed. It will also allow for appropriate investment and disinvestment signals to be provided to market participants that provide these services.

As outlined in the previous section, services that were traditionally provided as a by-product of synchronous energy generation have been sourced increasingly through AEMO interventions. This clearly reflects the fact that these services have not been unbundled from the provision of energy, resulting in a lack of clear signals for participants to provide these in the operational and investment time frames. Without having arrangements that clearly and specifically procure these services, the continued reliance on directions will continue to result in higher-costs for consumers and not facilitate the transition in the most optimal way.

In 2020, the ESB engaged FTI Consulting to develop a framework for consideration of Essential System Services and approaches for procurement. FTI Consulting proposed a categorisation of procurement options for essential system services (ESS) shown in Figure 2.6.

17 ESB, Post 2025 Market Design - Final advice to Energy Ministers Part A, p. 33, July 2021.

Figure 2.6: Procurement options proposed in the ESB market design process



Source: Adapted by the AEMC to reflect the approaches set out in this paper from FTI Consulting, Essential system services in the national electricity market, August 2020, p 6. The non-market ancillary service and market ancillary service options are further explained in Chapter 5.

Under this framework, FTI Consulting considered that, where possible, the NEM should shift from providing system services through directions through to explicit valuation via:

- spot market procurement, where possible, consistent with the MAS approach, discussed in chapter 5, and
- structured procurement through bilateral contracts - consistent with the NMAS approach, also discussed in chapter 5.

2.2.1 Unbundling of services for the future of the NEM

The shift to a service-based model involves further work to unbundle and define the core fundamental physical requirements that keep the power system secure, and what system operators need to do in order to keep the power system stable and operable. As understanding grows, it may become necessary to refine existing service definitions as well as potentially define other new services.

As outlined previously, a long-term objective is to understand the core power system requirements such that they can be translated into specific services that can be explicitly valued and procured where appropriate, noting that in some cases it may be more efficient and effective to have power system requirements reflected as standards. Understanding these core requirements, in addition to understanding the capability of new emerging technologies, will enable progress towards a services based future, where essential system services can be provided from a range of technologies with confidence.

The ESB's post 2025 work has set out that the direction for essential system services is to use co-optimised, market-based procurement where possible, and where not possible, structured procurement approaches. What is most appropriate for a particular system services depends on their underlying physical characteristics.

A services model for security services helps to support innovation in the provision of system services. Given the transition described above, services are no longer being delivered based on the specific characteristics of a given asset, but instead on the specific requirements of the system. Moving away from provision by specific assets allows new parties to provide the service, opening up scope for innovation and competition in the provision of services. For example, services that were once produced only as by-products of synchronous generation could be provided in the future by a diverse range of resources including batteries, synchronous condensers, and advanced inverters[18].

This creates opportunities for market participants to benefit from explicit alternative revenue streams, which in turn provides incentives for market participants to provide the required power system attributes. Pricing system services will signal an immediate potential revenue opportunity to participants capable of supplying them. Resources currently in the market, such as synchronous generators or condensers, can engage in these revenue streams to provide the services that had previously been systematically undersupplied and may otherwise continue to be undersupplied in the future.

Explicit procurement and valuation of system services will not only promote the economically efficient entry of these new technologies, but also the efficient exit of thermal synchronous generators. By accurately valuing their contribution to the market beyond generating energy output, these resources would not prematurely exit the market before the security services they provide can be efficiently replaced by new technology into the future.

A services-based model therefore encourages greater diversity of supply, delivering a more resilient and flexible power system. Increased options for supply of these services will also help to reduce the cost, when compared to the current situation which relies on limited number of system configurations.

Working to translate the requirements of the power system and characteristics of current technology into separate system services will serve the long-term vision of the power system. It will enable the market to progress towards a services-based model to meet the full set of requirements for secure power system operation, and away from one which relies on assessments of how configurations of the available assets meet those needs.

By unbundling system requirements from the assets that produce them and explicitly valuing them through defining specific system services that can be valued and procured, market participants will have the opportunity to provide and earn revenue from them in a flexible and technology-neutral way.

18 AEMO, Application of Advanced Grid-scale Inverters in the NEM, White Paper, August 2021

2.2.2 More work is required to define the fundamental physical requirements of the power system

The extent to which it is possible to completely separate all power system requirements and translate these requirements to services is unknown. As work is undertaken to better understand these requirements it may be determined that some requirements are most efficiently and effectively provided by way of power system standards and/or specifications.

As noted previously, the current framework and operation leans on certain system configurations to satisfy power system requirements. Going forward, the vision is to move towards a model where services are specified and valued such that they meet power system requirements.

Service specification requires the specification of a requirement and product characterisation. Currently, from an engineering knowledge perspective, there is no direct translation from power system requirements in order to create specific services. That is to say, service specification represents a degree of approximation in the delivery of some requirements, and as a result, services may not take into account all the needs of operating a secure power system. This is particularly apparent in the case of services like system strength, which approximates fault level to the provision of the service, and so does not necessarily capture the dynamics of the physical phenomena that underpin the engineering understanding of system strength.

To date, AEMO has been able to identify and develop specific secure system configurations that represent a secure technical operating envelope. Given the trends occurring and the need to keep the system secure through the transition, explicitly procuring these configurations will be a necessary step in the evolution towards a services-based model as further work is done to unbundle the specific essential system services and explicitly value and price these services.

Specifically, it may be necessary to procure specific system configurations, when and where they are needed, to maintain system stability and provide operational flexibility through the transition.

More work is required to define the core fundamental physical requirements of the power system that satisfy operational prerequisites in a technologically-neutral manner. Achieving this it will require improved understanding of:

- the evolving capabilities of new equipment
- how new technology can meet system needs, and
- modelling, analysis, and operational experience of how new technology connected to the grid contributes to a secure power system.

Particularly core to this understanding is AEMO's Engineering Framework.[19] This is working to understand the operational requirements for the power system as it continues to change. AEMO's approach is described further in Box 2 below.

19 AEMO, NEM Engineering Framework Report, March 2021

BOX 2: AEMO ENGINEERING FRAMEWORK

The Engineering Framework seeks to provide a map to help stakeholders stay informed of the changing technical needs of the power system, the work underway to meet these changing needs, how the different pieces fit together, and how stakeholders can engage on topics of interest.

To provide the map for stakeholders regarding the changing technical needs of the power system, AEMO has outlined three key steps in the work program. These steps are:

1. Facilitate a discussion to identify possible future operational conditions for the NEM power system.
2. Consolidate a common view of the current work underway across the industry to adapt the power system and existing avenues for engagement.
3. Collaborate on identifying where increase industry focus is needed to bridge the gap between current work and future operational conditions

AEMO's Engineering Framework March 2021 report presented a consolidated view of work underway and existing avenues for engagement.

In July 2021, AEMO released the Operational Conditions summary, which addresses the first step in the Engineering Framework program. AEMO presented six operational conditions, which are generation and load combinations that may occur five to 10 years in the future that necessitate changes to current operational practices.

Figure 2.7: Operational conditions identified in AEMO's Engineering Framework

	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

Of these operational conditions, AEMO and stakeholders acknowledge that the first operational condition, fewer synchronous generators online, was the highest priority condition.

The next step of the Engineering Framework uses the selected operational conditions to identify missing activities needed to enable a secure and efficient power system transition. The operational challenges identified in relation to having fewer synchronous generators online include:

- Lower system strength, static and dynamic reactive power, inertia, primary frequency response and frequency control and frequency control ancillary services as synchronous generators go offline.
- Fewer options for black start units as synchronous generators retire, unless other black start sources are acquired.

AEMO plans to work with stakeholders to identify key activities for each of the operational conditions. Collaboration with stakeholders will identify priority actions that address gaps and opportunities to achieve the defined operational conditions. AEMO also plans to collaborate with stakeholders to integrate, align and co-ordinate prioritised actions across a variety of industry work plans, both existing and new.

Source: AEMO, Engineering Framework, Operational Conditions Summary, July 2021.

AEMO's work plan is timely and relevant to the rule changes under consideration in this paper. AEMO is working to identify and define the required system services needed to maintain a stable power system, as well as on implementing rule changes to govern the procurement of these services. Given the pace of the transition underway in the NEM to date, it is important that the Engineering Framework and existing regulatory processes can complement each other. The Commission is working with closely as part of the ESB with AEMO and the AER on these matters.

Procuring specific system configurations will, in the interim, ensure that the system remains secure. As further work is done to unbundle these power system requirements this will allow for an evolution towards a services-based model.

The ESB also noted that regulatory and market arrangements will need to become increasingly adaptive in order to deliver the lowest cost solutions to consumers, such arrangements will need to recognise the changing system needs, address emerging risks and take advantage of technological innovation.[20]

2.2.3 Transitional nature of the need for system configurations

As the power system transitions, a degree of uncertainty exists in that we have to navigate a number of unknowns stemming largely from the changing generation mix. The long-term objective is to understand and explicitly value the specific power system services required for safe operation of the NEM during and after the transition as outlined earlier in section 2.2. However, unbundling and defining the core fundamental physical requirements of the power system requires further work, as discussed previously in section 2.2.1 and section 2.2.2.

This work is currently under way by AEMO through its engineering framework as described above.

In the interim, AEMO has been able, and will continue to identify, specific secure system configurations that represent a secure technical operating envelope within which a secure power system can be operated. The time and work required to assess and determine secure power system configurations should not be underestimated, particularly through the fast-paced transitioning system. AEMO has noted in its Corporate Plan that it has a goal of being able to operate a system of 100 per cent instantaneous renewables by 2025; noting this will require significant efforts and progression of understanding, harnessing the capabilities of all industry.[21]

The Commission understands that these system configurations are likely not the result of a reliance on an additional yet undefined system service inherent to one technology type (ie, synchronous machines), although additional service definitions and requirements may be defined in the future. Rather, power system requirements are provided by a range of different technologies. However, the operational knowledge, capability and understanding of some technologies providing some or all of these services is still evolving.

20 ESB, Post 2025 Market Design Options - A paper for consultation Part A, p. 42, April 2021.

21 AEMO, Corporate plan, FY2022.

Therefore, system configurations represent an approximation of a complex mix of system services and standards satisfying the broad categories of power system requirements discussed earlier in section 2.2.3. The reliance on system configurations providing a secure and reliable power system stems from the experience and confidence AEMO have in certain system configurations satisfying:

- the technical attributes of the power system by ensuring the **appropriate mix** of system services and inherent technical characteristics are available **in the locations needed**, and
- **several operational prerequisites** which must be satisfied with a high degree of confidence.

In the interim a necessary step in the evolution towards an enduring services-based model will be the efficient management of the provision of system configurations.

The two rule changes that are the subject of this paper are considering mechanisms to procure and schedule essential system services. In the short-term, these mechanisms could be used to procure and schedule system configurations that are needed to satisfy AEMO's operational prerequisites and technical requirements in the short-term. Over time, they could also be used to procure and schedule additional amounts of system services where those services are known and defined, such as in the case of system strength. This could be used to bridge the gap between the planning and operational timeframes. This is discussed further below.

For the market to meet the power system requirements, a parameterised service will be required, where the relationship between a services definition and the power system requirements and their interrelated relationships with other services can be represented.

The Commission understands from AEMO that, while system configurations will be required in the near term to maintain a secure technical operational envelope, the need for procuring these system configurations will be transitional as the technical and operational knowledge and understanding improves. For example, there is an expectation that the system configurations will be determined in additional or further service specifications to the degree possible, reducing reliance on procuring system configurations that are not already provided for through procurement of specific services.

The Commission are interested in stakeholder views on this transition and the ways that we can advance towards this long-term vision of providing essential system services.

QUESTION 1: STAKEHOLDER QUESTIONS

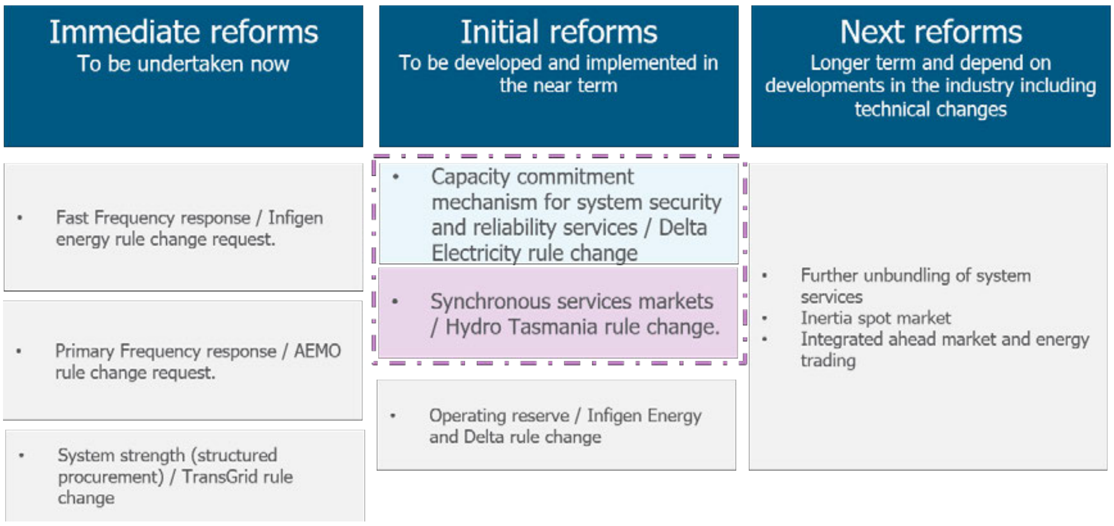
- What do stakeholders think of the characterisation of power system requirements as described above?
- What do stakeholders think of about the need to transition from system configurations to service-based procurement over time?

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

2.3 AEMC has received rule changes to establish new system services

As part of the ESB's work, the AEMC is currently progressing a suite of system services rule changes addressing several important elements of system security, including the rule changes proposed by Delta and Hydro Tasmania that are the focus of this paper. Processing these rule change requests allow the AEMC to advance issues that have been identified by the ESB as urgent in nature.[22] This work also allows the AEMC to complement the thinking and assessment done in the ESB work program and dovetail with the process undertaken by the ESB. An overview of these rule changes and how they interact with the ESB process is outlined in Figure 2.8 below.

Figure 2.8: Interaction with ESB process as set out in the ESB's Final advice to Energy Ministers July 2021 paper



As highlighted in Figure 2.8 above, the unit commitment for security and the system security mechanism rule changes are the subject of this directions paper.

Other work that is underway at the AEMC in relation to essential system services include:

- **Fast frequency response market ancillary service**: The AEMC recently made a final determination to introduce two new market ancillary services to help control system frequency and keep the future electricity system secure when there is reduced system

22 ESB, Post 2025 Electricity Market Design Options Paper, p. 44, https://esb-post2025-market-design.aemc.gov.au/32572/1619564199-part-a-p2025-march-paper-esb-final-for-publication-30-april-2021.pdf

inertia. The new services will foster innovation in faster responding technologies and deliver lower costs for consumers. These services will be introduced in October 2023.[23]

- **Primary frequency response:** Following an earlier rule change to mandate all scheduled and semi-scheduled generators to provide primary frequency response[24] The Commission is now considering what the enduring arrangements are in relation to primary frequency response, including how parties can be incentivised to provide this service. The Commission plans to make a draft determination for the *PFR incentive arrangements rule change* by 16 September 2021.
- **Operating reserve market**: Considering whether the implicit provision of operating reserves in the NEM should be explicitly unbundled. A draft determination is due to be published on 9 December 2021. The directions paper was published in January 2021, which:[25]
  - considered the ability of the current market frameworks to address variability and uncertainty in power system conditions.
  - outlined high-level designs for four options to procure reserve services.
- **Efficient management of system strength on the power system**:[26] The AEMC is considering a rule change request from TransGrid that is seeking to evolve the existing arrangements regarding the provision of system strength in the NEM. A draft determination was published in April 2021, with submissions closing in June. The Commission is working its way through issues raised, with a final determination due in October 2021. This is described in more detail in the next section given the close interactions with these projects.

2.3.1 Relationship with AEMC's Efficient management of system strength on the power system draft rule

The draft determination for the AEMC's Efficient management of system strength on the power system rule change (System strength draft rule) set out proposed ways to evolve the existing system strength framework. These look to provide a stronger power system and a more streamlined connection process, resulting in lower cost energy for consumers. System strength is a critical service in the power system that keeps the grid stable.

Historically, it has been supplied by synchronous generators, such as coal, gas and hydro. However, as these generators leave the market or reduce their operations the supply of system strength has reduced. Current inverter based resources, such as wind, solar and batteries, demand system strength and are connecting to the grid in significant amounts. The combination of these two trends means that system strength has been declining in the system in recent years, which means we need to rethink the way the service is provided in the NEM.

23 AEMC, Fast frequency response market ancillary service, https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

24 AEMC, Mandatory primary frequency response, https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response .

25 AEMC, Operating reserve market, https://www.aemc.gov.au/rule-changes/operating-reserve-market

26 AEMC, Efficient management of system strength on the power system, https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

There are already frameworks in the NEM to provide system strength. These were introduced by the Commission in 2017. However, these frameworks have been shown in practice to be reactive and slow to provide system strength, resulting in a lack of this essential system service.

Not having enough system strength can cause major problems, both in terms of managing the security of the system and of how electricity is supplied, both increasing costs to consumers.

The draft determination had three key elements:

- Supply side: A new obligation on transmission network service providers (TNSPs), working closely with AEMO, to provide system strength when and where it is needed. System strength would be provided as a prescribed transmission services, with the TNSP required to meet a system strength standard at certain locations on its network. Of notable importance for these rule changes is that the TNSP may enter into contracts with generators in order for the TNSP to meet its regulatory obligations (ie, so-called non-network solutions). In turn, this raises the question about how these contracts might be operationalised on the day - part of the subject of these rule changes.
- Coordination: A charging mechanism, so that those parties who use the service pay for it. This would provide connecting parties with a choice between paying to use the system strength provided by the TNSP, or providing their own system strength to remediate their impact.
- Demand side: New access standards for relevant generators, loads and market networks service providers, to ensure that future connecting parties' plant have a minimum level of system strength performance.

This draft determination was consistent with the ESB's work, and the direction outlined above. In particular, the Commission defined system strength as a specific system service (see below), which is consistent with general shift towards a services-based model, and is based around creating a framework for how to 'supply' and 'demand' system strength.

The draft rule provided clarity about what a system strength service is, and what it is used for, enabling AEMO and TNSPs to effectively plan and procure efficient volumes of the service relates the system strength service to specific system needs meaning that TNSPs can consider a wide range of solutions to manage inverter driven instability in order to procure tailored solutions to meet those needs.

The draft rule introduces a new system strength planning standard that consists of two limbs – 1) a requirement to maintain minimum fault levels; and 2) a requirement to maintain a stable voltage waveform to host inverter based resources (IBR) above minimum fault levels.

The system strength draft rule maintains the ability for AEMO to enable system strength services for the minimum three-phase fault level required to maintain system security. This is the level of system strength as described in the first 'limb' of the new system strength standard in S5.1.14.[27] AEMO's ability to manage or intervene in the market for the first limb is already part of the Rules from the *Managing Power system fault levels rule change* (*2017).*

Some non-network solutions such as collective inverter retuning, or network solutions such as installation of synchronous condensers, do not require instructions from AEMO or the TNSP to be enabled. These can therefore be used in the operational time frame to provide system strength services to meet both limbs of the standard.[28]

However, some non-network solutions will require instruction. For example, in addition to inverter retuning and the installation of synchronous condensers to meet the second limb of the standard as outlined above, TNSPs can enter into contracts with resources to provide system strength.

The system strength draft rule makes it possible for TNSPs to enable the system strength services in operational timeframes. However, the draft rule does not explicitly include the ability for AEMO to enable system strength contract services for the stability of the voltage waveform required to host forecast IBR as determined by AEMO – being the second limb of the S5.1.14 standard.[29]The system strength draft determination noted that the second limb of the standard could be used through resources that were contracted by the TNSP including arrangements in the contract itself that incentivise or require generators to make themselves available in dispatch and so self-commit in the wholesale market in order to deliver system strength above minimum levels in operational timeframes. In effect this means the system strength arrangements set out in the draft rule for that rule change can be provided above the minimum to meet the second limb of the standard. However, this was not more fulsomely addressed because there were ongoing parallel processes that are considering the most efficient and effective ways for operational arrangements for unit commitment and other required services that are essential for power system security i.e. these rule changes as well as the ESB's post 2025 work.[30]

The efficient management of system strength rule change and the two rule changes that are the topic of this discussion paper are therefore related in that the scheduling of contracts to meet the second limb of the standard will be considered through the rule changes that are the topic of this discussion paper. These rule changes will explore how system strength service contracts are scheduled efficiently to host IBR such that a net market benefit can be realised.

More generally, while there is a relationship between the projects, there are also differences. These include:

- Firstly, the system strength rule change is focusing on the procurement of single service, namely, system strength. The rule changes which are the subject of this paper have a broader remit with respect to service provision. These rule changes will consider not only

27 AEMO, Efficient management of system strength Draft Rule Determination, p. 85, April 2021

28 Ibid, p. 85.

29 Ibid, p. 85.

30 Ibid, p. 85.

the provision of system strength, but also the provision of other services such as inertia and voltage control.

- Second, the implementation time frames for the system strength draft rule is the order of magnitude of around ~3 years. This means it will not only take time to implement, but also time to its effect to be felt. The mechanisms that are being considered in this paper are addressing needs in the power system today, as set out above.
- Third, there is an interaction between the planning and operational timescales. There will necessarily be differences in the amount of essential system services planned for, and what is required on the day, reflecting that the needs of the power system are dynamic. The system strength draft rule is largely focused on the planning time frame; whereas this work is largely focused on the operational time frames.

As discussed in Chapter 4, the preferred option would mean that the system strength contracts procured for the second limb of the system strength standard could be scheduled through the proposed mechanism. It also means that to the extent there is a disconnect between system strength required in operational timeframes and the planning timeframes that AEMO could procure more system strength in order to keep the system secure.

3 THE RULE CHANGE PROPOSALS

As outlined in Chapter 2, the generation mix in the NEM is undergoing a significant transformation. Both large- and small-scale renewable generation is entering the system and the ageing thermal synchronous fleet that traditionally delivered a significant proportion of the grid supply has started to retire or operate less frequently. This changing generation mix is pressing the limits of current system security and operational experience. The current market design is not adaptable to the current transition. The lack of markets or other means of valuing the system services essential system security means AEMO is intervening in the market to procure these essential capabilities. The Commission has received two rule change requests to address the scheduling and provision of essential system services and is using these rule changes to consider solutions to this problem.

The following section will synthesise the key concepts introduced in each of the rule change requests, incorporating a summary of the:

- Delta Electricity rule change request, which proposes the introduction of a capacity commitment mechanism to the NEM to address shortfalls in system security and reliability services, and
- Hydro Tasmania rule change request, which proposes the creation of a new market for the procurement of 'synchronous services', including inertia, voltage control and fault level/system strength.

Given the issues raised in the rule change requests, the chapter will then outline the approach that the Commission is taking to considering them.

3.1 The Delta Electricity rule change request

On 4 June 2020, Delta submitted a rule change request relating to capacity commitment for system security and reliability services in the NEM.[31]

This rule change request was part of seven rule change requests received by the AEMC that relate to the arrangements in the National Electricity Rules (NER) for the provision of services that are necessary for the secure and reliable operation of the power system. These are outlined in the System Services rule changes consultation paper, published by the AEMC on 2 July 2020.[32]

This rule change proposes changes to the NER to introduce a day ahead, ex-ante capacity commitment mechanism and payment to provide access to operational reserve and other required system security and reliability services.

31 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

32 AEMC, System services rule changes, https://www.aemc.gov.au/sites/default/files/2020-07/System%20services%20rule%20changes%20-%20Consultation%20paper%20%E2%80%93%20%202%20July%202020.pdf

3.1.1 Background and rationale of the rule change request

As discussed in Chapter 2, in order to maintain a secure and reliable system, a range of technical and operational needs must be met at all times. This involves the continuous matching of supply and demand, as well as the constant provision of essential voltage and frequency management services and ensuring sufficient reserves so the power system is robust enough to cope with unexpected events and stay within the power system operational design limits.[33]

The NEM is an energy-only, real-time market with a co-optimised real-time market for frequency control ancillary services (FCAS).[34]

Historically, system security services have been provided by synchronous generators as a by-product from generating electricity. The NEM is now transitioning to a power system with a higher number of non-synchronous generators, and fewer synchronous generators. These non-synchronous generators do not, without modification, produce all of these system services as a by-product of energy generation, mainly because they are connected by inverters to the NEM. Therefore, there needs to be specific mechanisms to procure and schedule these essential system services.

At the moment, for most of these services, AEMO only has the ability to direct generators to run in order to ensure system security needs are met.

The NEM saw wholesale prices in 2020 decrease from historic highs in 2019, driven by changes in fuel costs and other supply conditions.[35] Delta suggested that these lower prices, and particularly periods of low demand and low wholesale prices due to high output from inverter-based resources are providing strong signals for "conventional generators in the NEM […] to decommit for short periods".[36]

As a result of this, instances of directions for system security have increased significantly in recent years, particularly in South Australia. This is because synchronous generators are making the rational decision to decommit when energy prices are low and the system services they provide go unpaid for, leading to directions and higher costs for consumers. [37] Delta also notes that it expects other regions in the NEM, including Queensland, New South Wales and Victoria to encounter increasingly frequent occasions of insufficient system services to maintain system security and reliability.[38]

33 AEMO, Power System Requirements, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security and Reliability/Power-system-requirements.pdf

34 AEMO, Guide to ancillary services in the NEM, https://aemo.com.au/-/media/files/pdf/guide-to-ancillary-services-in-the-national-electricity-market.pdf

35 AER, Wholesale electricity market performance report, p. 1, https://www.aer.gov.au/system/files/WEMPR%202020%20-%20Wholesale%20electricity%20market%20performance%20report%20%E2%80%93%20December%202020%20-%20Publication%20version%20%283%29.pdf

36 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, p 3, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

37 Reliability Panel, 2020 Annual Market Performance Review, Page 113, https://www.aemc.gov.au/sites/default/files/2021-05/Final%20report.pdf

38 Delta Electricity, NEM rule change request - Capacity Commitment Mechanism for Operational Reserve and other System Security Services, p 8, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

As set out in its rule change request, Delta considers that the current tools for managing the procurement of system services are not sufficient.

Delta sets out in its rule change request its view that current market design is therefore incomplete, with increasing levels of intervention from AEMO to achieve or maintain a required level of generation investment. Delta considers that a key question is how the market can deliver efficient price signals to deliver the optimal level of system security services and reliability while allowing for the continuation of the evolution in the generation fleet of the NEM.

3.1.2 Solution proposed in the rule change request

Delta propose to introduce a "day-ahead ex-ante market for capacity commitment" mechanism to address any or all of the system services for which AEMO has forecast a shortfall.[39]

Delta considers that the proposed solution offers a number of benefits over the status quo, including technology neutrality, price transparency, price discovery and competitive pressures in relation to the procurement of system services.

Delta proposes that as part of the day-ahead pre-dispatch process, AEMO should determine the amount of operational reserve and other system services required to meet regional stability and reliability standards.

The day-ahead timetable that would allow all current providers of system services to participate. Eligible generators under Delta's proposal are scheduled generators, irrespective of technology type, that can provide the required system services. Delta also proposes that eligible generators are most likely (in the absence of the proposed rule change) to be subject to a direction.

Delta considers that these are "more likely to be generators that cannot fast start and have a non-zero minimum load on their primary fuel source but could be any generator type".[40] The proposed changes would allow slow-start thermal generators to take into account the value of the system services they provide in their operating decisions, and may allow them to remain committed and dispatched at their minimum stable operating level (MSOL), avoiding consequences for system security and reliability.

Under Delta's proposal, operators of generators may classify one or more of their generating units as a capacity commitment generating unit. Delta proposes that the ability of this generating unit to provide the relevant system security services would be assessed by AEMO at the time of registration.

Delta proposes that AEMO would monitor the short-term projected assessment of system adequacy (PASA) and pre-dispatch schedule outcomes to identify the system services

39 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, p 10, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

40 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, p 10, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

requirements on a regional basis. Delta does not expect that market participants would be required to provide any additional information to this process.

Delta proposes that market participants that have registered generating units as capacity commitment generating units would have "the opportunity but not the obligation to provide operational reserve offers". Delta is of the view that offers would fall into two fundamental categories:

- offers to commit capacity for the entire day (slow start), and
- offers to commit capacity for specific trading intervals in the day (fast start).

The offer to commit capacity for the entire day would "allow AEMO to secure grid formation security services that span the entire day"[41] well in advance of system needs. The offer to commit capacity for a specific trading interval could provide AEMO with access to system security services at particular times when shortfalls are identified.[42]

The combination of the offers accepted would provide a clearing price for capacity commitment for each trading interval in the day ahead. Delta proposes that any offer accepted by AEMO would obligate the following:

- the generator to remain committed and available for dispatch for the entirety of the period to which the offer applies
- generators committed under this process would not re-bid energy offers for the entirety of the period to which the offer applies
- AEMO would dispatch the generator at no less than its minimum stable operating level (MSOL) for all trading intervals in the period of the offer, and
- AEMO would pay to the generator the trading interval clearing price for the operational reserve capacity for all time intervals in the period in the offer.

Delta proposes that each capacity commitment generating unit would provide an offer to participate in the operational reserve market that represents the minimum price in $/MWh that a market participant is prepared to accept to maintain the electrical output of that generating unit at the MSOL during the entire period to which the offer applies. Delta notes that the generators would face the risk that the actual prices clear at lower levels than forecast.[43]

Delta proposes that AEMO would select the capacity commitment generating units that would deliver the required capacity commitment at lowest cost. This would occur in the following fashion. Firstly, AEMO would consider the time frame of the system services shortfall. If system services, including grid formation services, are required for the entire day, AEMO would first consider the "all day" offers to commit capacity and select the offers in order of

41 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, p 14, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

42 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, p 14, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

43 Delta Electricity, NEM rule change request – Capacity Commitment Mechanism for Operational Reserve and Other System Security Services, p 15, https://www.aemc.gov.au/sites/default/files/2020-06/ERC0306%20Rule%20change%20request%20pending.pdf

lowest cost to highest cost until the system security objectives are met for all trading intervals where no specific offers are made.

For all trading intervals where system services shortfalls remain, AEMO would then select specific trading interval offers from lowest cost to highest cost until system security objectives are met for each trading interval.

Delta notes that in the event that more than one specific security service is needed for a day, then AEMO would co-optimise a solution to meet all required system services at least cost. Delta notes that offers to provide other security services would reflect the cost to provide the service in appropriate units, for example, inertia offers would be on a $/unit basis for the period of the offer, given the particular properties of that service.

Delta also notes that no intervention pricing would apply to capacity commitment generating units dispatched under the proposed mechanism. Instead, the clearing price of the mechanism would be applicable to the MW capacity that is successfully bid into the ex-ante operational reserve market.

3.2 The Hydro Tasmania rule change request

On 19 November 2019, Hydro Tasmania submitted a rule change request to address the shortage of inertia and related services through the creation of a new market for the procurement of 'synchronous services'. These synchronous services include inertia, voltage control and fault level/system strength.

As with the Delta rule change request, Hydro Tasmania's rule change request was part of seven rule change requests that the AEMC is progressing that relate to the arrangements in the NER for the provision of services that are necessary for the secure and reliable operation of the power system. These are outlined in the System Services rule changes consultation paper, published by the AEMC on 2 July 2020.[44]

3.2.1 Background and rationale for the rule change request

Hydro Tasmania noted that system services have historically been provided by synchronous generators in abundance and without compensation as a by-product of electricity generation through synchronous machines being online. It also noted the transformation of the power system is seeing a reduction of these services being provided.

Hydro Tasmania noted that, while these system services are currently not valued explicitly, they are still required for the secure operation of the power system. As such, there have been a corresponding increase of directions for generators to come online and provide these services to address the shortfall, which Hydro Tasmania noted is not a long-term solution that is consistent with the NEO.[45] Hydro Tasmania also noted that more efficient outcomes for the utilisation and operation of resources could be achieved if a mechanism was introduced to incentivise the provision of synchronous services.[46]

44 AEMC, System services rule changes, https://www.aemc.gov.au/sites/default/files/2020-07/System%20services%20rule%20changes%20-%20Consultation%20paper%20%E2%80%93%20%202%20July%202020.pdf

45 Hydro Tasmania, *Synchronous services markets (including inertia) rule change proposal,* September 2019, p 1.

3.2.2 Solution proposed in the rule change request

Hydro Tasmania's proposed solution is to introduce a mechanism that would:[47]

- explicitly value the provision of these system services
- provide dispatch targets for resources to provide these services, and
- coordinate the provision of these services along the dispatch of the energy and FCAS markets.

Specifically, Hydro Tasmania's proposed solution would:[48]

- alter the NEM dispatch engine (NEMDE) to shift generators' online status from the input side (the right hand side - which is currently exogenous and cannot be optimised) of system security constraint equations to the output side (the left hand side) to allow NEMDE to produce commitment targets for resources
- require resources to provide two additional bid parameters indicating the cost and availability to commit to be online, and
- allow NEMDE to produce dispatch targets for resources to commit online in an efficient manner.[49]

BOX 3: PROPOSED DISPATCH OF COMMITMENT TARGETS THROUGH NEMDE

NEMDE constraint formulation

NEMDE is a constrained linear optimiser, that is used by AEMO to find the most efficient clearing of the energy and FCAS markets, given a set of mathematical constraints that represent the physical attributes of the system, for example, that generator maximum output limits and thermal ratings on the transmission network.

A simple constraint equation, that may represent the thermal rating of a transmission line which hosts two wind farms, may have the form:

Wind generator output A + Wind generator output B <= 100 MW

NEMDE would then find the lowest cost dispatch of the energy market subject to the sum of the output from Wind generator A and Wind generator B being less than 100 MW, in order to satisfy the thermal rating that this constraint represents. In this formulation:

- NEMDE is able to adjust the output of the variables on the left-hand side of the constraint equation, here the wind output variables, known as decision variables, in order to optimise output and ensure this constraint holds, and

46 Hydro Tasmania, *Synchronous services markets (including inertia) rule change proposal,* September 2019, p 4.

47 Hydro Tasmania, *Synchronous services markets (including inertia) rule change proposal,* September 2019, pp 2-3.

48 Hydro Tasmania, *Synchronous services markets (including inertia) rule change proposal,* September 2019, p 2.

49 Hydro Tasmania's rule change proposal noted that a resource would be efficiently committed if it lowered the regional reference price. However the current objective function of the dispatch engine is to maximise the gains of trade of dispatch. See NER, clause 3.8.1(a) and (b). Conversations with staff from Hydro Tasmania subsequent to the submission of the rule change request have confirmed that its preferred objective function of the proposed mechanism is maximising the gains of trade of dispatch, consistent with the current objective function of the dispatch engine.

- NEMDE is unable to change the right-hand side of the constraint equation, here the thermal rating of the transmission line, which represents exogenous inputs.

Status quo of system security constraints in NEMDE

System security constraints aim to reflect underlying physical phenomena of operating the power system, including the provision of system services and the topology and unique operating characteristics of resources. The right hand side of system security constraints can relate to the energy output of plant, as well as the online status of other resources in the network that can provide system security and allow the output of other resources. For example, Hydro Tasmania in its submission provide an example constraint that has the form:

0.5 x Wind generator output <= 60 + 10 x Synchronous generator online status

In this example:

- If the *Synchronous generator online status* was off (equal to 0), the wind generator would be able to output up to 120 MW (equal to 60 divided by 0.5), and
- If the *Synchronous generator online status* was one (equal to 1), the wind generator would be able to output up to 140 MW (equal to 70 divided by 0.5).

However, given the formulation with the *Synchronous generator online status* on the right-hand side of the constraint equation as an input, NEMDE is unable to provide a commitment target for this synchronous generator even if it would provide an overall lower cost dispatch.

Hydro Tasmania's proposed solution

Hydro Tasmania's proposed solution would allow the *Synchronous generator online status* to also be optimised by NEMDE, for it be optimised and provide a commitment target. This would see the constraint formulation change to:

0.5 x Wind generator output - 10 x Synchronous generator online status <= 60 - 10 x Synchronous generator online status from last period

In this formulation, *Synchronous generator online status* appears twice in the constraint so that if the synchronous generator were to be online to provide energy without this commitment target, it would not be compensated for providing system services. This is an approach similar to AEMO's feedback constraints.

In this formulation, NEMDE would be able to co-optimise the wind generation output *and* the synchronous generator online status to maximise the gains of trade, based on the offers for energy and the additional bid parameters of the cost and availability to commit to be online.

Source: Hydro Tasmania, Synchronous services markets (including inertia) rule change proposal, September 2019, pp 2-3.

Hydro Tasmania proposes that generators that come online be paid based on a pay-as-bid framework based on each resource's individual bid, rather than on a market clearing price (that is used for energy and FCAS markets).[50]

50 Hydro Tasmania, Synchronous services markets (including inertia) rule change proposal, September 2019, p 3.

Hydro Tasmania states that, through this proposed approach, the cost of implementation could be minimised by focusing on the system security constraints that bind most frequently in the initial implementation, with the change to the remaining constraints occurring on an ongoing basis.[51]

Hydro Tasmania notes that its rule change proposal contributes to achieving the NEO by supporting a more efficient utilisation and operation of resources, with less need for AEMO to manage system security through directions.[52]

3.3 Considering the rule change proposals

In an evolving market where existing, traditional providers of essential system services are retiring, where newer technologies can now provide existing services and where the need for new services is being uncovered, existing mechanisms are not fit-for-purpose.

This is because a broad range of essential system services were historically provided in abundance by synchronous generators and there was little need in the original market design to explicitly value them so that market participants have an incentive to provide them. While reforms have been made to explicitly value some of these services (eg, system strength), this is not the case for all essential system services.

Therefore, the existing frameworks are not adaptable to the current or future needs of the power system as resources' contributions to the security of the market are not being valued. The lack of markets or other means of valuing the essential system services has resulted in undersupply of these services in the market. This is pressing the limits of current system security and operational experience. As a result, AEMO is increasingly intervening to achieve or maintain security which are costly and inefficient.

For the market to help deliver the desired outcomes to maintain system security (otherwise the responsibility of AEMO as the system operator), investors need confidence that the revenue they earn from the energy markets (including system service, market and non-market ancillary service markets) will be adequate to cover investment and operating costs. If not, security and reliability issues can arise:

- in operational timeframes - because market participants are not incentivised to make the services they could provide available to the system
- in investment timeframes - because market participants are not incentivised to make investments (or not make disinvestments) in assets that can provide the services.

In the rule change proposals, the problems presented by both proponents note that the current market design is incomplete and market interventions are inefficient. The Commission is considering both the Delta Energy and Hydro Tasmania rule change proposals as specific solutions that may provide opportunities for more efficient provision of existing and future system security services in the NEM.

51 Hydro Tasmania, Synchronous services markets (including inertia) rule change proposal, September 2019, p 3.

52 Hydro Tasmania, Synchronous services markets (including inertia) rule change proposal, September 2019, p 4.

This paper sets out a framework for considering the two broad options for how these can be procured. These are:

- **market ancillary services (MAS) approach** – which would introduce new services to be scheduled through the pre-dispatch engine to allow it to produce dispatch schedules that result in secure dispatch, and
- **non-market ancillary services (NMAS) approach** – which would introduce new services to be procured and scheduled in an optimisation approach outside of the spot market, to ensure secure dispatch in a more efficient manner.

These approaches are broad, overarching frameworks through which more detailed proposals can be examined.

As explained in chapter 2, the solution proposed by Hydro Tasmania is to create a new market for the procurement of 'synchronous services' such as inertia, voltage control and fault level/ system strength and this can be considered to be consistent with the MAS approach.

The solution proposed by Delta is to introduce a capacity commitment mechanisms to the NEM to address shortfalls in system security and reliability services and this can be considered to be consistent with the NMAS approach.

These approaches are discussed in further detail in Chapter 5.

4 ASSESSMENT FRAMEWORK

This chapter sets out the AEMC's framework for assessment of the rule change requests, and discusses a system services objective as a means of applying the National Electricity Objective (NEO) to system services trade-off decisions.

4.1 Achieving the NEO

Under the National Electricity Law (NEL), the Commission may only make a rule if it is satisfied that the rule will, or is likely to, contribute to the achievement of the NEO.[53] This is the decision-making framework that the Commission must apply.

The NEO is:[54]

> To promote efficient investment in, and efficient operation and use of, electricity services for the longer term interests of consumers of electricity with respect to -
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system.

The relevant aspects of the NEO that apply to this rule change are the price, security and_ reliability of supply of electricity.

When considering whether a rule will, or is likely to, contribute to the achievement of the NEO, the Commission will consider the factors outlined in section 4.4, as well as any other factors that it considers relevant.

4.2 The system services objective

As part of the seven system services rule changes consultation paper, the Commission developed a specific approach to assessing the implications for the variables defined in the NEO – the price, quality, safety, reliability and security of supply— in a manner that is robust and relevant to the particular considerations arising in these rule change requests.[55] This is the 'system services objective', which the Commission will use in relation to the assessment of these rule change requests, including the two considered in this directions paper. It reflects the trade-offs that are expected when considering issues related to the provision of system services.

The system services objective seeks to:

> Establish arrangements to optimise the reliable, secure and safe provision of energy in the NEM, such that is it provided at efficient cost to consumers over the long-term, where 'efficient cost' implies the arrangements must promote:

53 Section 88 of the NEL.

54 Section 7 of the NEL.

55 AEMC, System services rule changes, Consultation paper, 2 July 2020.

- efficient short-run operation of,
- efficient short-run use of, and
- efficient longer-term investment in,

generation facilities, load, storage, networks (i.e. the power system) and other system service capability.

In clarifying the system services objective:

- **Promoting efficient operation** refers to factors associated with the ability of the service design option to achieve an optimal combination of inputs to produce the demanded level of the service, at least cost i.e. for a given level of output, the value of those resources (inputs) for this output are minimised.
- **Promoting efficient use** refers to factors associated with the ability of a service design option to allocate limited resources to deliver a service, or the right combination of services, according to consumer preferences (or system need). This may include allocating resources between the provision of multiple services, to achieve an efficient mix of overall service provision. It may also require consideration of meeting multiple system needs, including security, reliability, and resilience.
- **Promoting efficient investment** refers to factors associated with the ability of the service design option to continue to achieve allocative and productive efficiencies, over time. This means developing flexible market and regulatory frameworks, that can adapt to future changes. This involves the following considerations:
  - It is likely that the technologies that provide system services, as well as the technologies that drive the need for these services, will change significantly overtime.
  - Technical understanding of these services will also change over time.
  - The robustness of service design options to climate change mitigation and adaptation risks will also contribute to dynamic efficiency over time.

Achieving dynamically efficient outcomes, given these attributes, will require flexible regulatory frameworks. The design of these frameworks should show explicit regard for how best to facilitate investment in the operation and use of system services over time, and how allocative and productive efficient outcomes in the short run can be maintained into the future.

4.3 Making a more preferable rule

Under s. 91A of the NEL, the Commission may make a rule that is different (including materially different) to a proposed rule (a more preferable rule) if it is satisfied that, having regard to the issue or issues raised in the rule change request, the more preferable rule will or is likely to better contribute to the achievement of the NEO.

Chapter 3 of this paper sets out the rule changes as proposed by the proponents and the Commission will analyse and consider these in addition to alternative solutions to the issues raised.

4.4 Assessment principles

When undertaking its consideration of the rule changes that are the subject of this directions paper, the Commission will have regard for a number of assessment principles:

- **Promoting power system security and reliability:** The operational security of the power system relates to the maintenance of the system within pre-defined limits for technical parameters such as voltage and frequency. System security underpins the operation of the energy market and the supply of electricity to consumers. Reliability refers to having sufficient capacity to meet consumer needs. It is therefore necessary to have regard to the potential benefits associated with improvements to system security and reliability brought about by the proposed rule changes, weighed against the likely costs. These costs are likely to be minimised through workably competitive markets; where this is not the case, that is where providers of these services lack viable competition resulting in inefficient prices that exceed the marginal cost of providing these services, regulatory arrangements will be required to limit the exercise of market power.
- **Appropriate risk allocation:** The allocation of risks and the accountability for investment and operational decisions should rest with those parties best placed to manage them. The arrangements that relate to system services should recognise the technical and economic characteristics and capabilities of different types of market participants to engage with the system services planning, procurement, pricing and payment. Where practical, operational and investment risks should be borne by market participants, such as businesses, who are better able to manage them. Risks, where allocated to market participants, are often managed through contracts. The impact of regulatory changes on the contract market, and the resulting ability of market participants to manage risk, is an important consideration.
- **Technology neutrality:** Regulatory arrangements should be designed to take into account the full range of potential market and network solutions. They should not be targeted at a particular technology, or be designed with a particular set of technologies in mind. Technologies are changing rapidly, and, to the extent possible, a change in technology should not require a change in regulatory arrangements.
- **Flexibility:** Regulatory arrangements must be flexible to changing market and external conditions. They must be able to remain effective in achieving security outcomes over the long-term in a changing market environment. Where practical, regulatory or policy changes should not be implemented to address issues that arise at a specific point in time. Further, NEM-wide solutions should not be put in place to address issues that have arisen in a specific jurisdiction only. Solutions should be flexible enough to accommodate different circumstances in different jurisdictions. They should be effective in facilitating security outcomes where required, while not imposing undue market or compliance costs.
- **Transparent, predictable and simple:** The market and regulatory arrangements should promote transparency and be predictable, so that market participants can make informed and efficient investment and operational decisions. Simple frameworks tend to result in more predictable outcomes and are lower cost to, administer and participate in.

- **Implementation costs:** Regulatory change typically comes with some implementation costs for regulators, the market operator and/or market participants. These costs are ultimately borne by consumers. The cost of implementation should be factored into the overall assessment of any change.

The Commission will evaluate likely outcomes through these assessment principles when considering:

- whether these rule changes will likely contribute to achieving the NEO, relative to the status quo, and
- whether any alternative solutions better contribute to achieving the NEO, relative to the proposal in the rule changes.

5 APPROACHES TO ADDRESSING THE PROBLEM

This chapter explains how the AEMC is approaching the Delta and Hydro Tasmania rule change proposals within the context of the transitioning NEM. The sections within this chapter explore the key considerations underpinning the design of our framework to evaluate these proposals.

In the first section we present the current method of scheduling the market and ensuring that the power system is secure. This explores how the pre-dispatch engine currently works, and its inability to produce optimised dispatch schedules that necessarily converge to and result in secure dispatch outcomes, the actions taken by AEMO to make operational decisions in the market to ensure secure dispatch is achieved (such as directing a generator to be on), and the limitations of these actions in achieving efficient outcomes. It then describes how both the pre-dispatch engine and AEMO's operations in the market fit within the broader ecosystem of market scheduling in the NEM.

AEMO, as system operator, already has a number of tools that it can use to make sure that the power system is operating within secure operating limits means. Section 5.1 below discusses a number of the drawbacks of the current tools.

As discussed in the chapter 2, the exercise to manage power system requirements is complex, with the existing NEM market design based around a system consisting primarily of synchronous generators, where essential system services were provided as a by-product of producing energy. As the generation mix is transitioning, there needs to be explicit arrangements to value, procure and schedule essential system services. In practice, this means evolving the existing regulatory framework in order to provide for this to happen.

Chapter 2 also established that there is a need to provide a mechanism that is able to schedule contracts procured by TNSPs to meet particular system requirements (such as for system strength as discussed in section 2.3.1) to both meet minimum system requirements as well allowing for efficient dispatch of the energy market as there are currently there are no tools available to do this. For example, this might involve allowing additional output of IBR by calling on additional contracts, lowering total dispatch costs. This is consistent with the Hydro Tasmania rule change proposal, described in chapter 3, which proposes allowing for efficient dispatch to be achieved by procuring additional system security levels in the operational timeframe.

In the context of each of these factors in the market, the Commission proposes that it should implement a mechanism to:

- Allow the procuring of resources to ensure that all system security requirements
- Facilitate the optimised scheduling for contracts procured by TNSP in the planning timeframe (eg, those procured to meet system strength standards).
- Allow the procuring of resources for system security purposes to allow for more efficient dispatch of the energy market.

Given this, we outline two broad approaches as ways of addressing these issues:

- a **market ancillary services (MAS) approach** – which would introduce new services to be scheduled through the pre-dispatch engine to allow it to produce dispatch schedules that would be guaranteed that it would result in secure dispatch, and
- a **non-market ancillary services (NMAS) approach** – which would introduce new services to be procured and scheduled in an optimisation engine outside of the spot market, to ensure secure dispatch in a more efficient manner and allowing the operational actions that AEMO undertakes to be more transparent and lower cost[56]

Both of these approaches are market-mechanisms designed to meet system requirements not currently procured through existing ancillary service categories to support the security of the system (hereafter, system security support services). Both approaches involve explicitly valuing the system security support services provided by market participants, but would do so in different ways.

This chapter concludes with analysis comparing the options. At this point in time, the Commission's preference is the NMAS approach given that it is more likely to result in a more efficient scheduling and dispatch of generators, relative to current arrangements, while providing AEMO with greater confidence that the system will be secure, ultimately lowering costs to consumers.

5.1 Current arrangements to ensure the system is secure

This section describes the current arrangements for both scheduling dispatch and the tools available to ensure that resulting dispatch is secure.

5.1.1 Pre-dispatch engine

The scheduling of dispatch occurs ahead of time through the iteratively-run pre-dispatch engine. Information is provided to market participants by AEMO about forecasts of demand as well as the expected supply/demand balance. On the basis of this centrally-provided information, as well as their own forecasts and information (discussed more below), market participants position assets by controlling their physical status and bid into pre-dispatch to maximise their own profit and manage risk using their own scheduling tools and algorithms to inform decisions. Each market participant makes these decisions in parallel and independently of one another, although taking in expectations of other participants' decisions, which are then co-ordinated through the pre-dispatch engine, to produce a dispatch schedule incorporating all of the market information.

The pre-dispatch engine is a centrally-operated optimisation engine, that, as far as possible, mirrors the dispatch engine that is used to send binding dispatch instructions. For a given

56 Note: AEMO already schedule NMAS contracts to meet some power system needs. See, for example: AEMO, Network support and control ancillary services (NSCAS) description and quantity procedure.

interval in the near future,[57] it considers the latest offers from resources and demand forecasts from AEMO and produces as output for that interval:

- a schedule that shows the expected set of generation resources[58] based on the collection of individual bids (in effect, a forecast of dispatch), subject to constraint equations that limit the possible solutions, and
- a forecast of energy and FCAS spot prices associated with the given dispatch schedule.

The NEM's pre-dispatch engine itself is relatively 'simple' in that it optimises each interval over the pre-dispatch horizon with limited regard to neighbouring intervals. That is, the pre-dispatch engine, in and of itself, does not inter-temporally optimise generation schedules over multiple intervals (known as "inter-temporal optimisation" where decisions are made that take into account multiple time periods). Instead, it only produces interval-to-interval schedules based on individual generator decisions and bids.

As with most optimisation algorithms, there are four key components that are needed for the pre-dispatch engine to produce the dispatch schedule:

- an **objective function** - which is a mathematical expression describing the purpose of the algorithm, eg, to maximise the value of energy and FCAS traded in the market
- a set of **controllable variables** - which the optimiser adjusts in order to meet the objective function subject to constraints, eg, generators' power outputs
- a set of **coefficients** associated with controllable variables - which represent the change to objective function of changing a controllable variable, eg, generators' bids, and
- a **formulation of constraints** - which limits the feasible set of possible solutions that the optimiser could select, ie, that represent physical limitations of the electricity system.

Each of these are discussed in turn.

Objective function

The objective function of the pre-dispatch engine is to maximise the value of energy and FCAS traded in the spot market in the NEM for a particular interval, ie, in the case of no scheduled load, to find a solution that minimises the total dispatch cost to the market based on cleared offers.

The selection of the set of resources that provides the optimal value of the objective function needs to satisfy the set of constraints within the pre-dispatch engine, which represent some - although importantly, as discussed below, not all - of the physical constraints of the system.

Controllable variables

57 The pre-dispatch scheduling horizon varies across the day but typically covers the current and proceeding trading day. Further information on long-term market expectations are published by systems used to assess resource adequacy, ie, the short term and medium term projected assessment of system adequacy outputs are used to evaluate the supply/demand balance of the proceeding six days and two years, respectively. See: AEMO, Pre-dispatch process description, July 2010, pp 12-14; and AEMO, PASA outputs, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/market-management-system-mms-data/projected-assessment-of-system-adequacy-pasa.

58 This also includes scheduled load, and will also include demand response resources once the wholesale demand response mechanism commences operation in October 2021. See: AEMO, Wholesale demand response mechanism, https://aemo.com.au/en/initiatives/trials-and-initiatives/wholesale-demand-response-mechanism.

To achieve the optimal objective function, the pre-dispatch engine is able to select the energy output and FCAS provision of available resources to meet both energy and FCAS requirements.

Typically, constraints relating to system security are affected by the online status of a resource, rather than its energy output. However, the pre-dispatch engine cannot control the online status of a resource, which is controlled by its owner through its energy bids. The participant is compensated for providing energy, rather than its contribution to meeting system requirements and so reflects this in its bids. As such, in certain circumstances, the pre-dispatch engine cannot select resources to be online to meet all system requirements (for example, to ensure the power system is in a secure system configuration).

Coefficients

Coefficients represent the change in the objective function from a change in a controllable variable.

In the pre-dispatch algorithm, the coefficients are bids for a resource to provide energy and FCAS during a particular interval, which represent the cost to the market in the objective function. These bids are submitted ahead of time.

For example, if a resource bid to generate electricity at $100 per MWh, then increasing the output of the generator by 1 MWh, would increase the objective function value by $100.

Formulation of constraints

The pre-dispatch engine contains a set of constraints that represent mathematical approximations of the feasible and secure envelope of the physical NEM, including:

- the physical capacity of generators
- the energy balance constraining supply and demand in the NEM to be equal to each other
- constraints relating to transmission infrastructure, eg, the maximum flow of electricity across transmission lines, and
- some system security constraints such as the trade-off between inverter based resource output and inertia levels.

Constraints limit the values that controllable variables[59] in relation to non-controllable values[60]. There are three mathematical operators that can be used to define the relationship between controllable and non-controllable values, ie:

- greater than or equal to - for example, the controllable energy output of a generator needs to be greater than or equal to 0 MW
- less than or equal to - for example, the controllable energy output of a generator needs to be less than or equal to its maximum output capacity, and
- equal to - for example, the controllable supply of energy needs to be equal to the demand in the system.

59 That in the current NEMDE design are represented on the left hand side of the constraint.

60 That are represented on the right hand side of the constraint

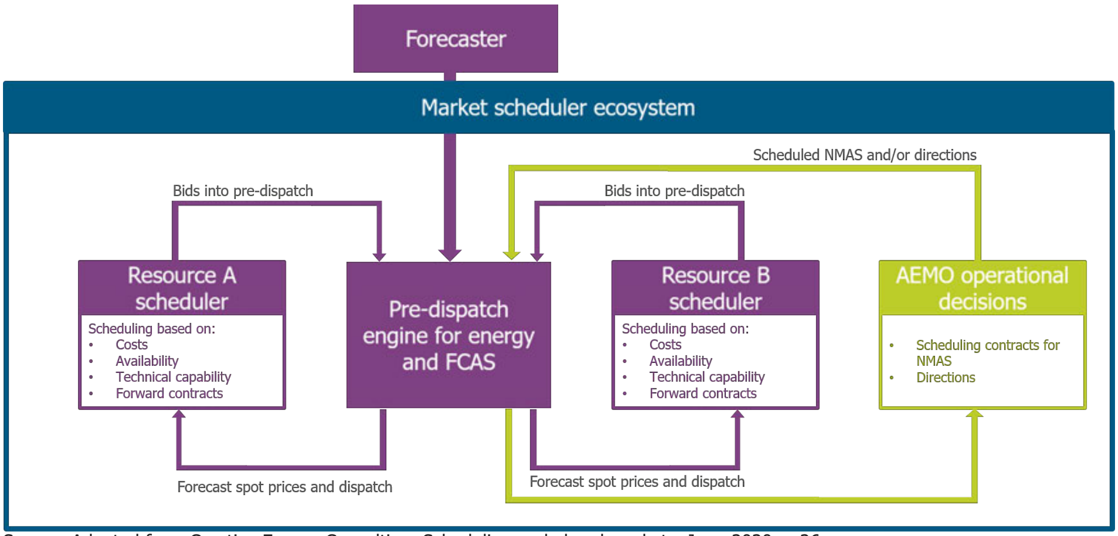
Most of the constraints fed into the pre-dispatch engine are 'linear', which means that:

- controllable variables within constraints are continuous, ie, discrete on/off decisions are not included[61]
- the marginal effect of changing a controllable variable on a constraint is constant – ie, non-linear effects are not included within the constraints.[62]

5.1.2 Broader market scheduler ecosystem

Alongside the central pre-dispatch engine, within the NEM, each generator is likely to also have their own private scheduler to inform their own inter-temporal scheduling decisions. Both the centrally-operated (dispatch and pre-dispatch) and private (whatever market participants use) schedulers in combination form a broader ecosystem that schedules the market. This is represented in the following figure.

Figure 5.1: Market scheduler ecosystem



Source: Adapted from Creative Energy Consulting, Scheduling and ahead markets, June 2020, p 26.

Inputs into the generators' own schedulers are the pre-dispatch engine's latest forecasts of spot prices and dispatch, as well as the generator's private information relating to its cost; availability; technical capability such as ramp rates, time to physically commit [63]and minimum generation levels; forward contracts; its own forecasts about demand; private knowledge; local complexity and risk limits. Given the complexity, inter-temporal scheduling decisions and

61 A continuous variable, say, a generator's energy output, could take any MW value between 0 MW and its maximum capacity. Discrete variables, which may represent online/offline decisions would be required to equal a discrete set of values, eg, 0 for offline and 1 for online.

62 For example, a linear constraint, which could be included within the pre-dispatch engine, containing variables X and Y would take a form similar to $X + Y < Z$. Non-linear effects include higher-order polynomials and other more complex mathematical relationships, for example, the constraint $X^2 + Y^2 < Z$ could not be included within the pre-dispatch engine in its current form.

63 That is, the time for a resource to transition from being offline to being at a stable generation level.

associated bidding decisions are likely informed by a mix of computer algorithm and human (trader) judgement, which aim to maximise profit.

Resources in the market cannot respond instantly to dynamic changes (for example, due to start up times) and so there is a requirement to make decisions ahead of time based on expected future conditions, and for these decisions to be co-ordinated with other resources which also cannot make instantaneous changes.

Importantly, offers submitted during pre-dispatch by generators can be considered as a summary of all the complexities involved in making these decisions. Generators aim to make inter-temporal decisions that maximise forward-looking profit, including from contract positions, by placing bids over multiple consecutive intervals. For example, during times of relative supply surplus, a generator that is inflexible and cannot turn off and on easily may bid to remain in the dispatch schedule even when spot prices are lower than its operating cost. In doing so, it seeks to remain online to generate during expected future periods of relatively high prices in a manner than maximises its expected profit over time.

The pre-dispatch process is iterative, and the pre-dispatch engine is run a number of times up until dispatch. This iterative process enables generators to see the effect of their and others' decisions on the dispatch schedule and spot prices, alongside the effect of updated forecasts. Generators can then respond, via re-bids reflecting their own scheduling decisions, to the updated information, with each generator bidding and re-bidding based on the latest information in order to maximise their profit (both in relation to from the spot market, but also from the accompanying contract market) over time. Generators must not re-bid in a manner which is false or misleading to ensure the that market scheduler converges to an efficient dispatch schedule.[64]

It is the combined, iterative processes of the individual decisions of generators, co-ordinated through the regular information (i.e. the publication of results from the pre-dispatch engine), which (it is hoped) converges towards an efficient scheduling of generators, meaning that energy is priced at lowest cost to consumers given the physical limits of the system.

Inter-temporal optimisation therefore happens organically by participants through the iteration between the generators' schedulers and the pre-dispatch engine. While the pre-dispatch engine only considers each interval individually, the bids of market participants, which the pre-dispatch engine utilises, reflect a strategy of maximising profits over time.

5.1.3 Interactions with dispatch

After the pre-dispatch process, and moments before dispatch itself, the dispatch engine (as opposed to the pre-dispatch engine) is run to produce binding dispatch instructions (eg, energy output) that resources must meet. The dispatch engine is an optimisation that contains the same features as the pre-dispatch engine described above, although it uses real-time information on demand and system requirements, rather than forecasts, in order to set binding instructions and price outcomes.

64 National Electricity Rules, clause 3.8.22A.

The pre-dispatch engine produces dispatch schedules that provide participants expectations of dispatch instructions so that they are able to ensure that their resources are positioned to be able to meet their obligations. This is important as resources cannot respond instantly to dispatch instructions and may require time to start up or ramp between two energy output levels. As discussed above, the iterative nature of the pre-dispatch process allows the dispatch schedule to converge to be close to what actual dispatch instructions will be.

As resources cannot respond instantly to dispatch instructions, any shortfall in system requirements must be identified prior to dispatch in order for it to be provided in time and factored into the decision-making of other participants in the market.

5.1.4 The pre-dispatch engine cannot ensure that dispatch schedules would result in secure dispatch

Due to the changing nature of the generation mix, system requirements are no longer always provided as a by-product of producing energy in sufficient quantities to keep the system secure. This means that there is another set of constraints that need to be taken into account by the pre-dispatch and dispatch engines in order to make sure that the dispatch outcomes are resulting in a secure system.

In some instances this is not possible, because essential system services can not always be 'linearised' as for energy. For example, for some essential system services it is either provided in full or not at all, depending on the status of the resource..

The pre-dispatch engine optimises the controllable variables given the constraints, bids and forecasts. However, as the pre-dispatch engine does not include all system security requirements of the NEM (for example, secure system configurations are not included), the resulting dispatch schedules may not be guaranteed to produce dispatch schedules that meet all system security requirements. For the system requirements that are included, the pre-dispatch engine is unable to produce price signals for resources to provide system security support services to explicitly value their provision.

Resources only have the incentive in their scheduling decisions to provide services for which they would earn revenue (eg, energy and FCAS). The lack of price signals for providing system security support services means that there is no incentive for resources to make scheduling decisions to provide these. This may cause individual resources to remain offline based on its expectations of priced services (energy and FCAS) where its online status would provide system security support services that would be valued by the market, leading to situations where the dispatch schedule would result in insecure dispatch. This also means that resources are not incentivised to either invest or operate in such a way that promotes the provision of these services.

5.1.5 The system operator needs to ensure that dispatch will be secure

AEMO, as system operator, needs to make sure that the power system is operating within secure operating limits. This means that AEMO needs to make operational decisions, such as directing a participant, to make sure that the system remains secure.[65] AEMO can and will make operational decisions in advance of dispatch with a range of actions, varying by degrees, when it identifies a shortage of supply or that system requirements are not met in order to keep the power system operating within those limits.

These tools include:

- **Procuring and scheduling contracts for non-market ancillary services (NMAS):** Non-market ancillary services exist to resolve some of the operating requirements not specified in current market ancillary services. These services are essential to the management of power system security. There are currently two types of NMAS that AEMO may acquire in its capacity as market and system operator: System Restart Ancillary Services (SRAS); and Network Support and Control Ancillary Services (NSCAS) with these acquired under bilateral contracts.[66]
- **Directions:** AEMO may issue directions to participants to perform a specific action if AEMO determines it necessary to ensure the power system is secure. Directed generators must be compensated, along with participants who are dispatched differently due to the intervention.
- **Reliability and reserve trader (RERT):** While AEMO can only procure out-of-market reserves[67] to maintain reliability (for example, where there is a breach of the reliability standard), once these reserves have been procured, they can be used to maintain system security.

In particular, 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.

In their application of these tools, AEMO is bound by a number of governance frameworks, both in the Rules and in guidelines, which limit their use for specific purposes.[68]

The current use of NMAS is a market-based method[69] to procuring services ahead of time that can be used by to support the secure operation of the power system, such as network support, and can also be used to improve the efficiency, for example by increasing power transfer limit to displace relatively higher cost generation.[70] However, AEMO has no formal optimisation engine to aid in its scheduling of NMAS contracts, ie, a way of understanding the relative benefits of possible choices, and so can lead to market outcomes that may be inefficient, and may result in higher cost outcomes for consumers over the long-term.

65 NER, cl 4.3.1.

66 AEMO, Non-market ancillary services (NMAS) cost and quantity report, p.4, February 2021

67 That is, resources that do not participate in the market but can be on 'stand by' if needed.

68 See, for example: NER cl 4.8.9; and AEMO, Procedures for issues of directions and clause 4.8.9 instructions, September 2019.

69 The "non-market" nomenclature refers to AEMO's provision of these services outside of the spot market but can be provided through other market structures, as opposed to "an ancillary service that is not provided through a market". See: NER, cl 3.11.1.

70 AEMO, Network support and control ancillary services (NSCAS) description and quantity procedure, pp 7-8.

Directions are used by AEMO to call on a generator, which can ensure system requirements would be met, to come online. The Commission notes that 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.[71]

Although out-of-market, resources that are subject to directions must be compensated. At worst, they are compensated for operating costs, and so this compensation does not provide investment signals nor sufficient revenue to cover fixed costs. This compensation could be considered reflective of cover for missing markets where the services are not compensated as a current ancillary service. However, this mechanism does not, nor was ever intended to, provide efficient operation or long-term investment signals.

Market participants need transparent information on potential future cash flows to help them manage risk and to make efficient investment decisions. The current arrangements do not provide transparency on how, or for what reasons, AEMO would use directions in the future in order to allow a participant to position an asset to benefit from them. In addition, the compensation frameworks do not necessary compensate an asset for fixed costs, which could allow a participant to make an investment to contribute to system requirements currently met through directions. As such, the Commission considers that the directions framework would not allow for participants to make efficient investment and disinvestment decisions, which will lead to increased costs to consumers in the long term.

So, while these tools can be used to ensure that the power system remains in a secure system configuration, the Commission considers that each of these current tools do not effectively utilise current resources in an efficient manner (resulting in higher cost outcomes for consumers), nor provides efficient and technology-neutral investment signals.

5.1.6 Implications of current arrangements in meeting long term vision

As outlined in section 2.2, the long-term vision for the power system is to maintain an efficient, secure and reliable power system.

While AEMO currently has tools available to allow it to ensure the power system remains in a secure system configuration, the Commission considers that each of the current tools do not effectively utilise current resources in an efficient manner nor provide efficient and technology-neutral investment signals as:

- AEMO has no formal way of understanding the relative benefits of making operational decisions in this regard and this is leading to inefficient market outcomes.
- AEMO's use of directions provide little transparency for participants to make investment decisions, nor do they always provide sufficient compensation that would cover the fixed costs of investments.

As the NEM transitions to a new operational environment, achieving a secure dispatch schedule is becoming increasingly complex, inefficient and challenging as the availability of security services is becoming increasingly reliant on generator commitment decisions. AEMO

71 This principle is to minimise AEMO decision-making to allow market participants the greatest amount of freedom to decide how they will operate in the market

is increasingly having to make operational decisions, such as directing on generators, to maintain system security. These decisions resulting in high long-term costs to consumers and provide limited transparency to the market.

Therefore, the current regulatory framework needs to evolve to address these concerns to contribute to the achievement of the long-term vision of the power system. A new market mechanism to value system services and support efficient scheduling and dispatch to avoid the problems that are occurring today.

In this light, the Commission proposes two broad approaches to explicitly value and schedule system security services in a manner that may better contribute to the achievement of the NEO, ie:

- a **market ancillary services (MAS) approach –** which would introduce new services to be scheduled through the pre-dispatch and dispatch engines to allow it to produce dispatch schedules that result in secure dispatch, and
- a **non-market ancillary services (NMAS) approach** – which would introduce new services to be procured and scheduled in an optimisation approach outside of the spot market, to ensure secure dispatch in a more efficient manner.

These two approaches are intended to achieve a secure system in a way that lowers costs for consumers and should reduce the current reliance on directions through the scheduling of contracts that have been procured by TNSPs to meet planning timeframes, as well as meeting the needs of the power system in the operational timeframe.

Consistent with current engineering knowledge, these two approaches would value and procure bundled essential system services as represented by system configurations. While not strictly consistent with the AEMC's and ESB's long term-vision for system security, this may nevertheless be an important improvement on the status quo arrangements. The Commission considers that it is important that the implementation of either of these models can ultimately transition to procuring unbundled services, as and when engineering knowledge improves. It will be important that any design promotes the transition to unbundled services, as opposed to unnecessarily embedding the procuring specific system configurations into the future.

The two options are discussed in more detail in section 5.2 and section 5.3 below. These two options should be considered as overarching approaches to procuring and scheduling system security support services. The Commission considers that presenting these overarching approaches at this stage will facilitate a fulsome understanding of more detailed mechanisms (such as the ESB's unit commitment for security (UCS) and system security mechanism (SSM) proposals, and the rule change proposals by Hydro Tasmania and Delta), and the relative merits of each approach. Further work is needed to consider any specific design details of any detailed mechanism under these two overarching approaches, and will be considered by the Commission during its ongoing evaluation of the rule change proposals.

At this point in time, the Commission's preference is the NMAS approach given that it is more likely to result in a more efficient scheduling and dispatch of generators, relative to the current arrangements, while providing AEMO with greater confidence that the system will be secure, ultimately lowering costs to consumers.

QUESTION 2: QUESTIONS ON THE CURRENT ARRANGEMENTS

- What are stakeholders views on the AEMC's characterisation of the current arrangements to produce dispatch schedules and ensure the power system remains secure?
- 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?

5.2 The MAS approach

Under the MAS approach, the scheduling and procurement of system security support services would be brought into the pre-dispatch and dispatch engines to allow their explicit valuation in addition to energy and FCAS.

This would allow a resource that is able to provide system security support services to make scheduling decisions within the market scheduler based on the expected price signals of providing these services. In addition, it would allow resources that have a TNSP-procured contract (eg, for system strength) to be scheduled for this purpose via the current market scheduler.

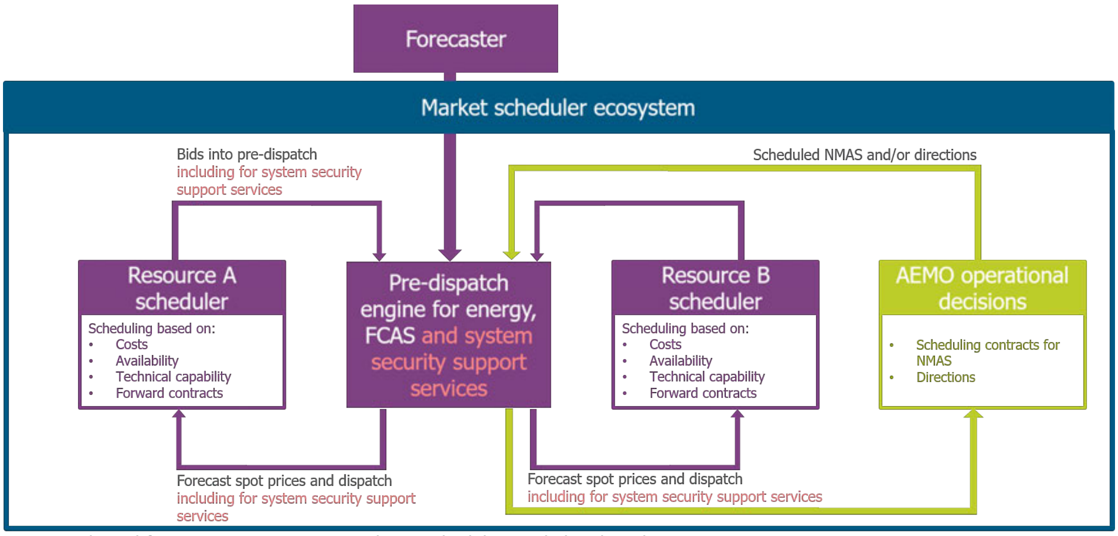
This would create an explicit valuation for providing system security support services within the spot market to supplement contracts procured in the planning timeframe. These could include contracts for system strength, as well as potentially other services that might be procured by TNSPs in the future.

The pre-dispatch and dispatch engines would be updated to:

- include constraints that better reflect the physical requirements of the system, so that the solution derived by the pre-dispatch engine is likely to result in secure dispatch outcomes
- for a given interval, determine optimal dispatch targets not only for energy and FCAS but also for the provision of system security support services, and
- base the optimisation not only on existing energy and FCAS bids, but also on bids for the provision of system security support services.

The structure of this approach is added and highlighted within the market scheduler ecosystem in the figure below.

Figure 5.2: The market scheduler under the MAS approach



Source: Adapted from Creative Energy Consulting, Scheduling and ahead markets, June 2020, p 26.

5.2.1 Details of the optimisation engine

To implement this approach, the pre-dispatch optimisation engine would need to be modified in order to encompass the system requirements.

Objective function

Under this approach, the provision of system security support services would be optimised alongside the provision of energy and FCAS. As such, the optimised procurement of system security support services meet energy, FCAS and system service requirements in order to maximise the value of dispatch less the cost to provide that dispatch, including the cost of system security support services based on offer prices.

As such, under this approach, the optimiser would explicitly recognise the trade-off between the cost of procuring more system security support services and the benefit of potentially relaxing constraints on the dispatch of lower-cost generation.

Controllable variables

The pre-dispatch engine optimiser would determine the online status of resources capable of providing system security support services.

The procurement of system security support services would be on the same basis as current pre-dispatch, without consideration of inter-temporal optimisation of resources across multiple dispatch intervals. As per the current arrangement, any inter-temporal decisions would be undertaken by each resource's own scheduler and affect their bids.

Coefficients

Resources would submit bids for their system service status alongside bids for energy and FCAS, ahead of time in a manner consistent with the existing pre-dispatch process.

The bids would represent the minimum price that the generator is willing to receive for that service and would be the costs to the market in the objective function for that resource to be providing energy, FCAS and other system security support services during a particular dispatch interval.

The bid to provide system service commitment would be for each individual dispatch interval and could be of a number of forms, for example:

- a $ per hour value at its minimum generation interval for each dispatch interval, or
- a $ per MWh value paid for its minimum generation level, and a value of its minimum generation level for each dispatch interval. For technologies that could provide system security support services without providing active power, the level of the minimum generation level would be 0.

Formulation of constraints

Constraints within the pre-dispatch engine would be updated to reflect:

- that the online status of resources that can provide system security support services is controllable (and so by convention should be on the left-hand side of constraint equations), and
- additional constraints that reflect all system requirements, eg, secure system configurations, would be included within the set of constraint equations.

The inclusion of these constraint equations would allow the pre-dispatch engine to make optimal dispatch of energy, FCAS and system security support services to meet system requirements as represented within these constraints.

However, as described in section 5.1.1, the pre-dispatch engine can only include linear constraints, and so may inaccurately represent system requirements that include non-linear phenomena (such as meeting a secure system configuration) or that rely on discrete on/off choices (such as the online status of a resource). As such:

- Even if system requirements are included within the pre-dispatch engine as linear approximations, they may not accurately reflect the underlying physical requirements of the system (for example, where a certain configuration of generating resources and other network assets could satisfy power system requirements) and so may not ensure that the pre-dispatch engine produces secure dispatch schedules. This means it is possible the pre-dispatch engine may remain an incomplete reflection of the system requirements and AEMO would still need to rely on its existing ways of making operational decisions such as directions in order to ensure the power system remains secure.
- The pre-dispatch engine may determine the efficient combination of resources is to partially turn on a resource, even though the online status of a resource is in practice an on/off decision. Rules would be required to decide what physically happens in this case (for example, generators which are determined should be partially online by the pre-

dispatch engine could always be required to be physically online, although this raises questions as to whether this physical dispatch would be efficient).

An alternative method to the linear construction of system security constraints would be to represent these constraints as discrete binary choices through mixed-integer linear programming (MILP), that allows the controllable variables to represent discrete on/off decisions. This would allow for all system requirements to be captured, including transitional system configurations, and would better represent the true physical nature of on/off decisions of resources that provide system security support services. This is discussed more in Box 4 below.

BOX 4: OPTIMISATION WITH LINEAR OR BINARY CONSTRAINTS

Formulation of constraints

Under the formulation of constraints in the MAS approach, NEMDE would optimise the online status of resources that supply system security support services. For example, it would optimise the 'Synchronous generator online status' variable below in the system security constraint below, which would relax the constraint on the Wind generator output.

Wind generator output - 10 x Synchronous generator online status <= 60

Under a linear formulation, variables that can be optimised are continuous and can take any value within their feasible bounds. In this case, the 'Synchronous generator online status' variable could be optimised to have a value anywhere between 0 and 1, representing partial commitment decisions, which would not reflect the physical nature of a resource committing.

Under a binary formulation, variables that can be optimised are binary and can only take the value of 0 or 1, representing the resource is offline or is online, reflecting the underlying physical phenomena.

Run times

Under the linear method, due to a number of mathematical characteristics, optimisation algorithms exists that can find the optimal value of variables in a timely manner.

However, under the binary method, to find the optimal dispatch, algorithms need to individually test a set of possible, and likely optimal, combination of variable values, which means that the complexity of the optimisation problem grows exponentially with number of variables.

Marginal pricing

One feature of optimisation with linear constraints, and corresponding continuous decision variables, is the existence of a 'shadow price', which is the change in the marginal cost of the optimal solution by relaxing the constraint by an infinitesimal amount.

Marginal pricing has desirable characteristics in that it incentivises the efficient provision of, and use of, services. Indeed, marginal pricing is already applied in the NEM, where the price of energy is the shadow price of the constraint dictating that supply and demand must be equal.[a]

In the provision of system services, there would be a shadow price produced for each system security constraint that could be relaxed by committing a resource. Each resource that forms the constraint could then be paid that price.

The calculation of marginal pricing requires decision variables to be continuous as it relies on evaluating the marginal cost from an infinitesimal change. However, because under the binary formulation of constraints the decision variables are binary, so there is no concept of an infinitesimal change and marginal prices cannot be estimated.

Note a: National electricity rules, clause 3.9.2(d).

Binary variables could not be incorporated within the current linear pre-dispatch engine. The implementation of this binary approach would require a new or modified optimisation engine to work in parallel with the current pre-dispatch engine, in order to optimise system service status controllable variables.

The binary approach itself has drawbacks relative to the linear approach, ie:

- It would not be co-optimised with the energy and FCAS schedule, and, as such, may produce relatively inefficient operational outcomes.
- Binary optimisation problems can grow increasingly difficult for computational algorithms to select the best resources as the number of binary controllable variables grows. As such, it may not be possible to run a binary optimisation in the same timeframe as the current linear pre-dispatch engine and may then distort operational signals in the pre-dispatch process, potentially hampering convergence to an efficient and secure outcome.
- It is not possible to produce marginal prices from an optimisation problem with binary control variables, so forecast system service prices would have to be calculated in another way, eg, pay-as-bid.

Looking forward, both the linear and binary methods could be used to procure unbundled system services as engineering and operational knowledge increases.

5.2.2 Interaction with market scheduler ecosystem

Setting aside potential drawbacks with the formulation of constraints that are described within the previous section, the modified pre-dispatch engine under this approach would select resources that meet not only the energy and FCAS requirements of the system, but also system security requirements.

The modified pre-dispatch engine would produce a dispatch schedule and forecast spot prices, including prices for the provision of system security support services from resources. Accounting for these forecasts, resources could adjust their bids, including bids for providing system security support services, which would then iterate through the next round of the pre-dispatch engine's solve.

Just like for energy and existing MAS services, the pre-dispatch engine would solve one interval at a time, but resources' bids would reflect private scheduling and profit maximising strategies over time.

As now, bids would become binding when resources are provided dispatch instructions, including with regard to the new system security support services. The value of providing system security support services would be settled based on the prevailing spot prices.

Resources would be able to indicate their preference to provide various services through their bids, just as they can now for energy and FCAS. That said, those resources that have entered into contracts with TNSPs (for example, for the provision of system strength services) could be required to submit bids for each dispatch interval in accordance with the terms and conditions of their contract.

For this, the Commission expects that the resource might receive availability payments from the counterparty to the contract (eg TNSP). In addition, there may be regulatory or contractual arrangements that allow them to modify the way they price their bids, reflecting their own information on costs and their expectations of the market conditions. Importantly, it would be necessary to ensure that there are appropriate incentives or regulatory requirements for contracted resources to bid in accordance with the physical needs of the system.

Overall, this MAS approach could be used to provide efficient price signals for both operational decisions for resources, as well as long-term investment, by including the value of providing these system security support services. Resources would respond to these signals to meet system requirements. This approach would significantly improve the transparency of price signals when compared with the current arrangements, in which the only valuation of these services exists through the directions process. That is, the explicit valuation of system security support services could enable market participants to make efficient investments and better manage risk resulting in more efficient market outcomes in the long term.

AEMO notes that as the power system is operated closer to its limits (for example, with fewer synchronous machines) a high degree of confidence is required before accepting those new conditions as the new norm.[72] However, concerns have also been raised that the iterative process between market participants re-bidding, and the pre-dispatch engine determining forecasts, may not converge on an efficient (or even secure) solution, nor provide the market operator sufficient confidence to avoid the need to direct.

As such, for this reason or if the set of constraints remains incomplete, relative to the true physical requirements of the power system, this approach may still not result in forecasting secure dispatch.

It is important to note that under this approach AEMO would maintain their ability to schedule resources through NMAS and make directions in order to ensure the power system remains secure. Of course, the intent of the MAS approach is that the market scheduler

72 AEMO, Maintaining Power System Security with High Penetrations of Wind and Solar Generation, p.4, October 2019.

ecosystem would converge sufficiently rapidly to a secure solution that AEMO would not need to schedule resources through NMAS or make directions.

The Hydro Tasmania proposed solution that was raised in their rule change request is consistent with this overarching approach as it would implement the scheduling of system security support services through the pre-dispatch engine itself through a continuous, linear formulation. However, the Hydro Tasmania solution did not propose to include all system requirements within the pre-dispatch engine, focusing on constraints currently implemented, and so would not allow for scheduling to meet transitional system configuration requirements.

QUESTION 3: QUESTIONS ON THE MAS APPROACH

- What are your views on the trade-offs identified between the linear and binary formulation of constraints?
- Would the transparency of the market improve under this MAS approach, and how important of a consideration is this?

5.3 The NMAS approach

Under the NMAS approach, the procurement of system security support services would be undertaken through an optimisation approach outside of the spot market to:

- procure and schedule system security support services through structured contracts in the operational timeframe instead of directions
- facilitate the optimal scheduling resources with TNSP-procured contracts (eg, those for system strength), and
- implement an explicit optimisation approach to the scheduling of NMAS contracts entered into by AEMO, and called upon in the operational timeframe.

This would allow a resource that is able to provide system security support services an opportunity to enter a contract with AEMO to provide system security support services based on its offered price, in the operational timeframe.

These modifications would provide a formal multi-interval optimisation framework to procure these services. This would act to increase the efficiency of scheduling resources to provide system security support services, including TNSP-procured contracts, as well as providing investment signals for these services.

These contracts could be scheduled to commit resource over multiple, consecutive intervals. That is, and in contrast to the MAS option discussed above, this optimisation engine would itself be an inter-temporal optimiser that produces schedules based on the self-declared availability costs included in the bids submitted by resources to AEMO.

The use of structured procurement through the optimisation engine allows the optimiser to determine the cost of committing contracted resources to provide system security support services that are difficult to define, measure and include in linear constraints, eg, transitional system configuration requirements. As such, under the NMAS approach, the scheduler could optimise and schedule:

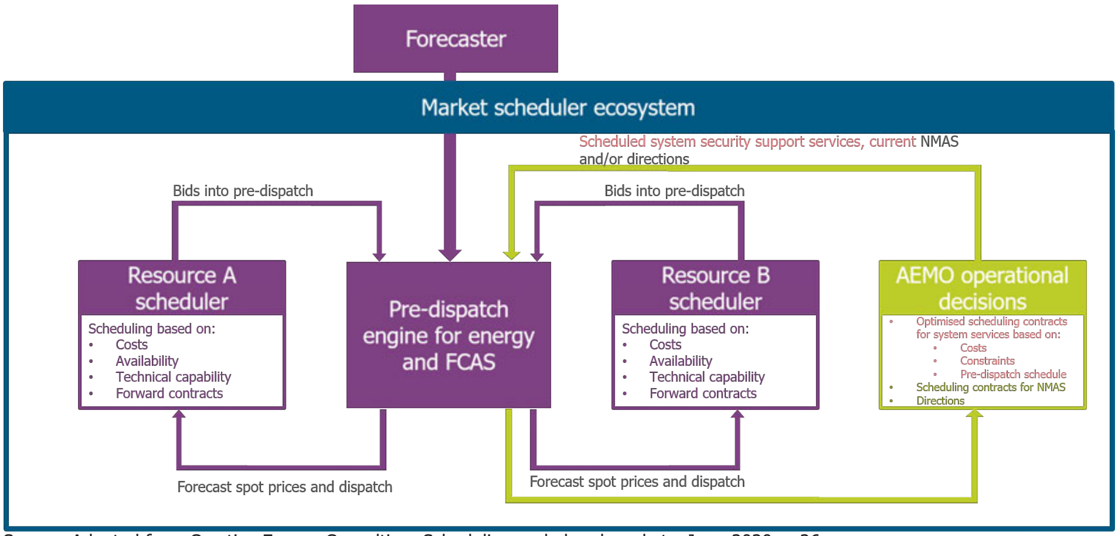
- known system security support services (for example, system strength or inertia), and
- bundled services (for example, as provided through system configurations).

Each of these could be procured via contracts entered into in by TNSPs or contracts entered into by AEMO.

While this approach would not make changes to the pre-dispatch engine, resources procured and scheduled for system security support services through the NMAS scheduler would update the broader market through re-bids, allowing the broader market scheduler to converge to a solution.

The structure of this approach is added and highlighted within the market scheduler ecosystem in the figure below.

Figure 5.3: Market scheduler under the NMAS approach



Source: Adapted from Creative Energy Consulting, Scheduling and ahead markets, June 2020, p 26.

5.3.1 Details of the optimisation engine

The implementation of this approach would require the implementation of a new optimisation engine within the market scheduler ecosystem. The optimisation mechanism would capture all system security requirements and would be able to optimise over multiple forward-looking intervals.

Objective function

The objective function for the new NMAS optimisation engine would be to maximise gains from trade from the procurement and scheduling of contracts for resources to provide system security support services. That is, maximising the benefits that these contracts could provide to the market less the cost of procuring them.

Under this optimisation approach of procurement, this engine could indicate both the minimum (eg, secure system configuration) and the efficient level of system security support services, recognising the trade-off between the cost of procuring more system security support services and the benefit of potentially relaxing constraints on the dispatch of lower-cost generation.

Controllable variables

The optimiser would select the system service status of resources (including those with TNSP contracts) that are capable of providing system security support services.

The scheduling of system security support services would span multiple dispatch intervals, taking in all forward-looking information provided in pre-dispatch, to optimise the provision of system security support services and commitment according to operating constraints reflected in the contract terms.

Coefficients

Resources could submit bids for their system service status, ahead of time.

Unlike the MAS approach, that relies on convergence to an efficient outcome through the iterative pre-dispatch process, the structured procurement nature of this approach does not dynamically determine prices that reflect scarcity. As such, the Commission expects that a resource would submit a bid value ahead of time, but be unable to rebid past a certain gate closure before the pre-dispatch process.

The bids would represent the price to the market for that resource to be online and providing system security support services during over a particular period and could provide more information into the NMAS inter-temporal optimisation engine relative to the MAS, including:

- start-up cost as well as a $ per hour figure to remain online
- the time it takes for the resource to come online, and
- the level of its minimum generation energy output.

As the optimiser is optimising over multiple time periods, these various inputs can be taken into account.

Formulation of constraints

The NMAS approach would adopt the binary formulation of constraints. As such, it would procure contracts according to the nature of the commitment of resources that provide system security support services, ie, with discrete on/off choices and the procurement to meet secure transitional system configuration requirements.

While the binary formulation has a number of drawbacks under the MAS approach, there are some advantages to having a completely separate optimisation engine to the pre-dispatch engine in this approach:

- while the binary formulation may increase computational times, the optimisation engine could be run on a different timeframe to the pre-dispatch and dispatch engines (eg, hourly, every two hours, etc) so it is more likely to find a solution in the required timeframe (whereas the dispatch engine needs to be run in moments prior to dispatch), and
- while it is unable to produce marginal prices for energy and FCAS, as it is separate to the pre-dispatch engine, it is not required to produce prices for these services. Contract prices could be used instead.

However, similar to the binary MAS approach, the optimisation of system security support services would still not be co-optimised with energy and FCAS, relying on convergence in the broader market scheduler to reach an efficient solution, and so may not always converge to a solution that is the most efficient option due to the separations between the NMAS and pre-dispatch optimisation engines. Also, the more time there is between solves, the more chance the last solution is sub-optimal.

As knowledge of the system progresses and AEMO is able to define specific services that are unbundled from secure system configurations, this NMAS approach could continue to be used to deliver system security support services in an optimised manner by including the new understanding of requirements within the optimiser.

5.3.2 Interaction with market scheduler ecosystem

The pre-dispatch process would operate as it does now, aiming to converge to an efficient dispatch schedule.

The new NMAS optimisation engine would run multiple times per day. When it runs, it would take in the information from the latest demand forecasts and dispatch schedules produced by the pre-dispatch engine and bids for system service provision. Taking this information, the NMAS optimisation engine would produce a system service contract schedule of resources required to be online to meet system requirements (system security support services and minimum system configurations).

The schedule of contracts could be non-binding until activated by AEMO at a time after the optimisation run and would be specified in the contract terms. This could potentially at the latest possible time for the resource to meet the obligations of its contracts (for example, just prior to the start up time for a resource that is needed).

While this approach would not directly affect the pre-dispatch engine, once activated by AEMO, resources that are shown on the system service contract schedule would be required to bid into the pre-dispatch engine in a manner consistent with their contractual obligations. This would allow the pre-dispatch engine, and the broader market scheduler ecosystem, to converge to a dispatch schedule that would be expected to be both secure and more efficient.

However, as the NMAS optimisation engine might run less often than the pre-dispatch engine and would create binding obligations ahead of actual dispatch, it may not be able to reflect the dynamic nature of the power system and may result in the under or over procurement of resources compared to the MAS approach that continues to converge up until dispatch itself.

The Commission expects this option would reduce the need for AEMO directions for system security, meaning that system security would be provided in a lower-cost and more transparent way. However, AEMO would retain their directions power in case of outages and other unforeseen events.

The Delta rule change proposed solution is broadly consistent with the overarching NMAS approach, which proposed to schedule resources that provide system security support services over multiple periods.

In addition, the ESB recommended approach to procuring and scheduling resources to meet system requirements is also consistent with the NMAS approach. The ESB recommended introducing a:[73]

- unit commitment for security (UCS) mechanism that could schedule contracts procured the planning timeframe (eg, those for system strength), and
- a system security mechanism (SSM) that would procure additional resources through contracts in the operational timeframe to ensure system requirements are met, and that would also be scheduled through the UCS.

Both of these mechanisms are broadly consistent with elements of the NMAS approach to procuring and scheduling resources for system security requirements.

The ESB propose a pathway of progression that commences with the establishment of structured procurement arrangements for system services (eg, a UCS and/or SSM (as above), with subsequent opportunity to explore spot-market arrangements as technology evolves and confidence grows in operating the system at very high levels of inverter-based resource penetration (and very low levels of synchronous generation).[74]

QUESTION 4: QUESTION ON THE NMAS APPROACH

Would the transparency of the market improve under this approach, and how important of a consideration is this?

5.4 Analysis, recommendation and next steps

The Commission has presented two approaches for the scheduling and procurement of system security support services. Each of these approaches have costs and benefits that the Commission will examine when considering which approach or approaches to continue to develop. These options, and the current status quo approach, are summarised in Table 5.1.

73 Energy Security Board, Post-2025 Market design final advice to Energy Ministers - Part B, July 2021, pp 60-62.

74 ESB, Post 2025 Market Design Options – A paper for consultation Part A, p.52, April 2020

Table 5.1: **Characteristics of the current, MAS and NMAS approaches**

	CURRENT APPROACHES	MAS	NMAS
Optimisation engine			
Single interval or inter-temporal optimisation	Single interval but does not solve for system service requirements	Single interval solve with little regard to neighbouring intervals	Inter-temporal solve to schedule over multiple intervals
Objective function	Does not consider value or costs of system service provision	To maximise the value of energy, FCAS and system security support services traded in the market for a given interval	To maximise the benefits that contracts could provide to the market less the cost of procuring them over multiple intervals
Controllable variables	Cannot control variables for the provision of system security support services	The system service status of resources	The system service status of resources
Coefficients	No bids for providing system security support services	Bids that reflect the market cost of the resource being online for one interval	Contract terms that potentially include information on start up cost, running cost and start up times
Formulation of constraints	Current constraints in the pre-dispatch engine do not fully include all system requirements	• Linear approximations of system requirements with continuous variables, that may not reflect system configurations, or • System requirements included in constraints with binary variables, including system	System requirements included in constraints with binary variables, including system configurations

	CURRENT APPROACHES	MAS	NMAS
		configurations	
Potential optimisation run time	NA	• Linear method would like have short run time, could be accomplished in current pre-dispatch timeframes • Binary method may have higher run times, increasing with complexity, may not be able to be run in pre-dispatch time	Potentially long run time, increasing with complexity of binary constraints, but run separate to the pre-dispatch engine
Interaction with broader market scheduler ecosystem			
Required optimisation engine changes	NA	Modifications to the pre-dispatch engine to incorporate controllable variables and constraints for scheduling resources for system security support services	Implementation of a new optimisation engine to schedule resources for system security support services via NMAS contracts
Re-bidding	Rebidding only for energy and FCAS	Resources could re-bid for energy, FCAS and system security support services up until moments before real time, subject to re-bidding rules	• Resources could re-bid for energy and FCAS up until moments before real time, subject to re-bidding rules • Resources cannot re-bid for system security support services past a certain gate closure
Binding instructions	Instructions only for energy and FCAS	As now for energy and FCAS, binding	Binding instructions, ie, calling the NMAS contracts,

	CURRENT APPROACHES	MAS	NMAS
		dispatch instructions for system security support services would be given moments before dispatch itself	would be provided ahead of time, likely at the latest possible moment to allow the resource to physically come online
Transparency and confidence			
Transparency to allow investment	Does not allow transparent price signals that facilitate investment decisions	Provides transparent price signals that may facilitate investment decisions	Provides transparent price signals that may facilitate investment decisions
Operating confidence	Directions used to AEMO to ensure secure dispatch	Iterative bidding may not improve AEMO's confidence that resulting dispatch would be secure, although directions would still be available	Provides AEMO with greater confident that resulting dispatch would be secure. Directions would also continue to be available.

5.4.1 Analysis of the current approach and two proposed approaches

Section 5.1 of this chapter described the current approach and tools at AEMO's disposal that it can use to ensure that dispatch is secure. This section described that, while the current arrangements do provide AEMO the tools to ensure that power system requirements are met, there are a number of drawbacks to these tools:

- no formal optimisation engine to aid in it optimising its operational decisions
- in the case of directions, a lack of transparency for market participants in the way in which AEMO makes its decisions, reducing market confidence, and
- in the case of directions, payment for market participants which may be insufficient to cover long-term costs, and so encourage inefficient investment and disinvestment decisions.

Each of these drawbacks may lead to inefficient operational and investment outcomes, increasing costs for consumers in the long term.

Due to these drawbacks, the Commission considers that the regulatory arrangements need to adopt mechanisms to more explicitly value, procure and schedule essential system services to minimise long-term costs for consumers and also have more transparent outcomes to promote innovation and efficient investment and operational decisions in relation to essential system services. The Commission has outlined two broad approaches to explicitly value and schedule system security services in a manner that may better contribute to the achievement of the NEO, addressing the problems outlined in chapter 2.

In addition, the Commission, consistent with the ESB, considers that progressing these measures will provide additional support for operations through the transition. These mechanisms will allow for evolving system configurations as experience and confidence builds with operating the system securely with increasingly higher instantaneous penetrations of inverter-connected generation.[75]

The Commission's analysis of the MAS and NMAS approaches is set out below, which considers the approaches against four criteria, ie:

- efficient and secure dispatch
- market transparency and efficient long-term decision making
- transitional considerations, and
- implementation costs and timelines.

Given the analysis set out in the rest of this section, section 5.4.2 sets out the Commission's current preference of the NMAS approach to confidently support efficient scheduling and dispatch by AEMO. At this stage, the Commission considers this structured procurement approach is more likely to result in a more efficient scheduling and dispatch of generators, and provide AEMO with greater confidence that the system will be secure, ultimately lowering costs to consumers.

Efficient and secure dispatch

A key criterion for deciding between the MAS and NMAS approaches is the extent to which they result in a secure dispatch that is more efficient that the status quo arrangements.

The Commission considers that both approaches could facilitate more efficient operational decisions relative to the status quo. In addition, the Commission considers that both approaches could have formulations that could reflect the underlying system needs but to varying degree's of accuracy. As such, the Commission considers that each of these approaches could feasibly contribute to the long-term vision to maintain a secure and efficient power system.

The MAS approach relies on dynamic scarcity of providing system security support services, as well as allowing resources to manage risk and trade-offs in the co-optimised energy and FCAS markets. In principle, this approach, if workable, may be expected to result in more efficient outcomes, when compared with the NMAS approach. This is because it would align the financial incentives of market participants to maximise their own profits with the efficient outcomes for the system as a whole.

The linear approach to constraint formulation within the MAS appears to have significant drawbacks, in that it may not accurately reflect the underlying physical requirements of the

75 ESB, Post 2025 Market Design Options – A paper for consultation Part A, p48, April 2020

system and so may not ensure that the pre-dispatch engine would produce dispatch schedules that are secure. Depending on how common this problem is in practice, the issues with the existing arrangements would remain and directions would continue to be used. In addition, the pre-dispatch engine may determine that the optimal selection of resources is to partially turn on a resource, even if the physical online status of a resource is a discrete on/off decision - calling into question to efficiency of the schedule in practice.

The Commission considers that it may be possible to allay these drawbacks by encoding the system service requirements in the MAS approach as binary constraints, which would allow all system requirements to be represented in the constraints (including secure system configurations) as well as making scheduling resources for system security support services as discrete on/off decisions.

Of key concern is that the binary formulation could grow increasingly difficult for computational algorithms to select the best resources as the number of binary controllable variables grows. As such, it may not be possible to run a binary optimisation in the same timeframe as the current linear pre-dispatch engine. This could potentially hamper convergence in the timeframes needed to derive an efficient and secure outcome.

Concerns have also been raised that, even if the issues with the computational timeframes were not problematic, the market-based scheduling ecosystem may not converge on a secure or efficient outcome, or may do so too slowly to provide AEMO with the confidence that the pre-dispatch process will result in a secure outcome. In either case, this may mean that the MAS option does not substantially reduce the need for AEMO to take operational decisions, such as issuing directions, to guarantee the security of the power system.

The NMAS approach also involves a binary constraint formulation, but because its optimisation engine would remain separate from the pre-dispatch engine, the same time strictures do not apply. In turn, this means that it could be run less frequently, and further in advance of dispatch. A key downside of this approach is that it would not reflect all dynamic changes in scarcity of system service provision, which could result relatively inefficient scheduling.

The NMAS approach would likely provide AEMO with greater confidence that dispatch would be secure, as the NMAS optimiser would be able to schedule resources ahead of time, rather than relying on convergence through the market scheduler ecosystem.

Under either approach using binary constraints (ie, the NMAS approach or the binary version of the MAS approach), the optimiser would not be co-optimising with the energy and FCAS schedule, and so a degree of inefficiency may be introduced as a result.

Furthermore, neither approach would produce marginal prices, and in both cases an alternative pricing system would be required. In the case of NMAS, the price would be specified in the contract; in the case of MAS, a pricing system such as pay-as-bid may be appropriate.

In both cases, market participants may be able to exercise a degree of market power in their bids to provide system security support services, in turn increasing costs for consumers. Arguably, the exercise of market power in contracting may be more difficult than through bids to the pre-dispatch engine, when shortages of essential services could result in near immediate security issues.

Market transparency and efficient long-term decision making

Both the MAS and NMAS approaches should improve transparency, compared to AEMO's existing directions process. By formally implementing an optimisation methodology to the valuing and procurement of essential system services, both MAS and NMAS approaches should provide market participants with greater information on system requirements, and would produce prices signals that could improve long-term investment and disinvestment decisions.

Both approaches should, in principle, be able to provide more efficient price signals than those sent through the directions process - which, at worst, only compensates directed participants their variable costs and does not support long-term investment decisions and ultimately increases long-term costs for consumers.

In the case of NMAS, the prices would be determined through the contracting process between market participants and their counterparty - be it the TNSP for the provision of system strength, or AEMO for any outstanding shortfalls in essential system systems. Prices struck through contracts may provide market participants improved incentives to make efficient investment and disinvestment decisions compared to the status quo.

Care would need to be taken that AEMO, in entering into contracts, did not undermine TNSPs' efforts to enter into contracts for certain system services (for example, system strength). This might be achieved, for example, by requiring that AEMO do not provide availability payments in contracts, and instead payments to market participants only occurred when the contracts are called and the market participant is scheduled.

In the case of MAS, the specific pricing methodology will be examined in future work by the Commission and so has yet to be determined. This design feature will clearly be of great importance in achieving efficiency in both operating and investment timescales.

Transitional considerations

Both MAS and NMAS approaches would involve including constraints into the optimisation engine that reflect secure system configurations. This may be necessary given the current state of engineering knowledge, and be an improvement on the status quo arrangements, which also relies on directing units to reflect secure system configurations. Nevertheless, a clear drawback of this formulation of these transitional system configuration constraints, as discussed in chapter 2, is that more efficient, innovative means to contributing to a secure system may not be recognised or rewarded. In turn, this may stifle the development of these innovations, increasing overall system costs over the long term.

It is not clear to the Commission whether either of the MAS or NMAS approaches better contribute to an improved engineering knowledge, and it welcomes feedback in this regard.

Initial analysis also suggests that the MAS and NMAS approaches would be broadly similarly suited to evolve to accommodate the unbundling of system services, as engineering knowledge improves. Again, the Commission welcomes stakeholder views on this topic.

Implementation costs and timelines

Acknowledging the difficulties in providing detailed feedback given the high-level MAS and NMAS approaches outlined above, the Commission is interested in stakeholder views on the likely implementation costs and timelines for each approach, for both market participants and AEMO.

The NMAS approach appears to limit major IT system changes to AEMO, which would be required to develop an optimisation engine for the purpose of scheduling contracts. AEMO and market participants would also be required to enter into contracts, and market participants would need to adjust their bids both in response to their own contract being called, but also in response to another contract being called, and the resulting flow-on changes within the pre-dispatch ecosystem.

Under the MAS approach, in addition to changes to the pre-dispatch engine for AEMO, market participants, would need to update their own scheduling systems to accommodate the new services being provided, and the new information flowing from the pre-dispatch engine.

QUESTION 5: QUESTIONS ON THE COMMISSION'S RECOMMENDATIONS

- Do you think that either option would be result in more a more efficient, secure dispatch? Weighing up the inherent limitations of both approaches, which is likely to be more efficient, and why?
- Which option might better address concerns relating to the exercise of market power by service providers?
- Do you think that either option would be result in greater market transparency? Which option would be more transparent?
- Which option might provide more efficient long-term signals to market participants, better influencing their investment and disinvestment decisions?
- Which option might better promote the evolution of our knowledge of the power system?
- 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?
- 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?
- Do stakeholders consider there are additional merits or drawbacks to either approach that are not explored in this paper?

5.4.2 Recommended approach

Overall, the Commission considers both the MAS and NMAS approaches have a number of merits and drawbacks and that it must make a number of trade-offs based on the characteristics of the two approaches.

At this stage, and consistent with the ESB's final advice, the Commission considers that the NMAS approach is its preferred approach as, despite not reflecting the value of system security support services in a dynamic way as in the MAS approach, it would allow scheduling system security support services to reflect the true physical system requirements and while allowing the optimisation engine enough time to find an optimal schedule.

The Commission considers that the NMAS approach would provide AEMO with greater confidence that the system will be secure, relative to the MAS approach, reducing the need for directions and so ultimately lowering costs to consumers. In addition, the Commission understands that the implementation cost of the NMAS approach would be largely confined to AEMO, potentially lowering the implementation cost to the broader market, relative to the MAS approach, particularly on implementation costs for participants and AEMO.

However, the Commission will continue its evaluation of both the MAS and NMAS approaches, taking into account stakeholder feedback provided to this directions paper. As such, the Commission particularly welcomes views on the merits and costs associated with each approach.

The NMAS approach is consistent with the UCS and SSM mechanisms proposed by the ESB in its final advice. The UCS mechanism would schedule resources providing services under structured procurement arrangements to support efficient scheduling of system services. Over and above this, the SSM would be a short-term procurement option, which could provide an adaptable operational tool to complement planning-based solutions to provide the system configuration needed to maintain security.

> QUESTION 6: QUESTIONS ON THE COMMISSION'S RECOMMENDATIONS
>
> What are stakeholders views on the Commission's recommendation of the NMAS approach?

5.4.3 Future work and next steps

For the purpose of this directions paper, the Commission has not examined in detail particular issues that it considers would be critical in informing specific policy design choices, which would be examined in its ongoing work. These issues include:

- Whether either or both approaches could lead to potential market power issues in the provision of system security support services.
- Whether there exist price distortions, such as those arising from disorderly bidding, in the energy market which may cause the scheduling to maximise the value of energy and FCAS traded in the market to lead to potentially inefficient outcomes.

- The structure of prices, settlement and cost-recovery mechanisms for providing system security support services.
- The nature of governance or regulatory arrangements that may underpin the market mechanisms, formulation of constraints and procurement of resources to meet system configurations.
- The relative merits and drawbacks of either approach when as sufficient engineering knowledge allows services to be unbundled and procured separately, and/or further reforms underway are introduced.

Notwithstanding, the Commission considers that potential issues of this nature are important considerations and will be the focus of its future work program.

In addition, there are a number of practical matters regarding the implementation of any mechanism that will need to be fulsomely evaluating in coming work, including:

- The implementation costs for AEMO associated with the implementation of any resulting mechanisms.
- The implementation costs that market participants would require in order to implement updated bidding systems/etc.
- Timeliness for any particular mechanism to be implemented.

The Commission will continue its evaluation of the approaches in order to develop a mechanism that best meets the long-term vision of the power system, taking into account stakeholder feedback provided to this directions paper as well as from future meetings with its technical working group. As such, the Commission welcomes stakeholder feedback on these outstanding issues that will inform its ongoing evaluation of the approaches in its future analysis.

QUESTION 7: QUESTIONS ON THE COMMISSION'S FUTURE WORK

- What are stakeholders views on the issues that need to be examined further to inform this analysis?
- Do stakeholders consider that there are additional issues that need to be examined in future analysis?