Issues paper - Semi scheduled generator rule change(s)

June 2020

AUSTRALIAN ENERGY REGULATOR

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Amendment Record

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1 Invitation for submissions

The Australian Energy Regulator invites interested parties to make written submissions on the semi scheduled generator rule change(s) by close of business, 24 July 2020.

We prefer that all submissions sent in an electronic format are in Microsoft Word or other text readable document form. Submissions should be sent electronically to wholesaleperformance@aer.gov.au.

Alternatively, submissions can be sent to:

Mr Peter Adams
General Manager, Market Performance
Australian Energy Regulator
GPO Box 520 Melbourne Vic 3001

We prefer that all submissions be publicly available to facilitate an informed and transparent consultative process. Submissions will be treated as public documents unless otherwise requested. Parties wishing to submit confidential information are requested to:

- Clearly identify the information that is the subject of the confidentiality claim.
- Provide a non-confidential version of the submission in a form suitable for publication.

We will place all non-confidential submissions on our website. For further information regarding our use and disclosure of information provided to us, see the ACCC/AER Information Policy (June 2014), which is available on our website.

Please direct enquiries about this paper, or about lodging submissions to wholesaleperformance@aer.gov.au.

2 Glossary

AEMO	Australian Energy Market Operation
AER	Australian Energy Regulator
AEMC	Australian Energy Market Commission
ASEFS	Australian Solar Energy Forecasting System
AWEFS	Australian Wind Energy Forecasting System
DI	Dispatch Interval - a 5 minute interval
FCAS	Frequency Control Ancillary Services
ISP	Integrated System Plan - AEMO's forecast of the likely development of the national electricity market over the next 20 years
NFOB	Normal Frequency Operating Band
MW	Megawatt - a unit of energy equivalent to 1 000 000 Watts
NEM	National Electricity Market
LREG/RREG	Regulation FCAS Services
L6/R6	fast services, which arrest a frequency deviation within the first six seconds of a contingent event
L60/R60	slow services, which stabilise frequency deviations within sixty seconds of the event
L5/R5	delayed services, which stabilise frequency deviations within five minutes of the event
RIS	Renewable Integration Study - AEMO's study of the challenges facing the NEM to integrated high levels of renewable energy into the NEM
TI	Trading Interval - 30 minutes comprising 6 dispatch intervals
UIGF	Unconstrained Intermittent Generation Forecast - the forecast output for the renewable energy generator by ASEFS/AWEFS
VRE	Variable Renewable Energy covers both solar and wind generators that are dependent on Intermittent Renewable Energy Resources.

3 Executive summary

3.1 Background

Currently the National Electricity Rules (NER) impose different obligations on semi scheduled generators when compared to scheduled generators. Semi scheduled generators are intermittent renewable energy generators such as grid scale wind and solar farms.

Renewable energy development in Australia on a grid scale started with small scale wind farms in around 2000. By 2005, thirteen wind farms were operating totalling around 550 megawatts. Developments in South Australia dominated the fleet and regional concerns triggered the first of a number of reviews into further development. By 2008 a new semi scheduled registration category was introduced with specific rules governing their participation in the National Electricity Market (NEM).

The environment in which these generators now operate is significantly different and is forecast to continue to change. The technical performance of renewable generation has increased markedly while their costs have fallen. Their financial viability is now less dependent on subsidies and there are financial incentives for some semi scheduled generators to rapidly respond to price.

Market operational requirements are increasingly critical as is the market operators' dependence on generators meeting dispatch expectations to balance customer demand. The central dispatch process assumes that generators will respond to dispatch targets. If participant’s rebid their intentions, the market operator can adjust the dispatch instructions for all participants appropriately. However, some semi scheduled generators have been observed to deviate materially from forecast production levels in their dispatch instructions output without rebidding, or prior to a rebid being received, during negative price dispatch intervals.

The rules for following dispatch instructions state that Registered Participants must comply with dispatch instructions unless to do so would, in their reasonable opinion, be a hazard to public safety or materially risk damaging equipment or they are providing other system services.

For scheduled generators, this is a strict obligation. However, the rules further define different obligations for semi scheduled generators that are less stringent - only imposing a cap on their output when advised by the Australian Energy Market Operator (AEMO) that a dispatch interval is a ‘semi-dispatch’ interval. At other times, an instruction to a semi scheduled generator is an expectation driven by AEMOs forecasting systems as an input to the dispatch engine that determine instructions to all market participants for the dispatch of energy and ancillary services.

The amount of semi scheduled generation has grown significantly and now comprises around 8,700 MW, over 16% of the 53 000 MW of installed generating capacity in the NEM.[1]

1 AEMO, 2020, Generator Information page, www.aemo.com.au//forecasting-and-planning-data/generation-information

This form of generation is forecast to grow to around 30 000 MW or 50% of the installed capacity in the NEM by 2035, dominating the future energy mix.[2]

The market design ensures alignment between market price and dispatch targets. Market participants have broad scope to amend their bids and offers (relative to many other markets) but once a 5 minute dispatch target and associated price has been calculated the market design expects that scheduled and semi scheduled generators (and demand) will follow those targets. AEMO manages system security on the basis that instructions are followed, including for example dispatch of ancillary services and management of operating constraints.

Recent behaviour by some semi scheduled generators moving significantly from their expected output without rebidding and receiving a new dispatch instruction is eroding reserves held for frequency management and contingency disturbances.

This behaviour brings into stark contrast the difference in the obligations between semi scheduled generators and their scheduled counterparts. Now, and into the future, the management of the power system will depend on AEMO being able to rely on participants providing energy as forecast and on which the total market dispatch solution and price has been predicated. To be clear, a semi scheduled generator deviating from its target may not currently contravene the rules, but incidence of deviations of this kind is growing and likely to grow further with increased renewable penetration. Furthermore the impact of these deviations is also likely to increase, particularly if automated dispatch software, that adjusts the output of the facility without an instruction from AEMO, is more widely adopted. These un-forecast changes in output are also reducing the accuracy of pre-dispatch price forecasts, contributing to poorer power system frequency performance and consuming a significant percentage of the regulation FCAS needed to manage 'normal' variations in demand and generation.

The key issue this rule change is seeking to address is the potential for semi scheduled generators moving from their anticipated level of output without informing the market operator of that intention through a rebid, and waiting to receive a revised dispatch target.

3.2 The rule change request(s)

System security and reliability have been the focus of considerable attention by the market institutions and State and Federal governments for some time. The COAG Energy Council (Energy Council) was aware of the current and potential future challenges to security and reliability that the different dispatch obligations on participants have for the market as a whole.

The Energy Council asked the Australian Energy Regulator (AER) to prepare two rule changes to submit to the Australian Energy Market Commission (AEMC) relating to the operation of semi scheduled generation. This request was one part of the Energy Council's interim security measures work program. As it applies to semi scheduled generators there are two work parcels:

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2 AEMO 2019, Draft 2020 Integrated System Plan, Draft 2020 ISP Generation outlooks, Central scenario, www.aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp

- That semi scheduled generators be obligated to follow their dispatch targets in a similar manner to scheduled generators; and
- Semi scheduled generators being required to continually inform AEMO of any restrictions on their available capacity due to physical factors, ambient weather conditions and their market intentions.

3.3 Rule change 1: Semi scheduled generators following dispatch targets

This request from the Energy Council requires consideration of how semi scheduled generators could be obligated to follow their dispatch targets in a similar manner to scheduled generators.

3.3.1 Options

The AER has developed four potential approaches to the issue for consideration by stakeholders. Crucially, in all cases, the intermittency of the fuel resource on which these generators depend is a fundamental consideration. The following options were postulated:

- **Amend causer pays factors for ancillary services to increase economic incentives for semi scheduled generation to follow dispatch instructions.** The AER's assessment of the causer pays factors is that the current arrangement does not create a material incentive to follow an instruction as if it were a target. While a new causer pays approach could be designed to provide sufficient incentives for semi scheduled generators to follow their targets it would require a major overhaul of the calculation and application of these factors and may have other unintended consequences. This is not considered practicable in the context of this problem.
- **Remove the semi scheduled classification.** All semi scheduled generators would become scheduled and be required to follow dispatch instructions for a megawatt target for the end of each 5-minute interval at a defined rate. There would be numerous legacy and transition issues to be dealt with under this approach including recognition of the intermittency of the resource. The requirements for scheduled generators inherently need accurate information to be provided to AEMO. Special arrangements would be needed to facilitate these generators continuing to use Australian Wind Energy Forecasting System (AWEFS) or Australian Solar Energy Forecasting System (ASEFS) calculations to determine their dispatch, creating further complications.
- **Amend existing arrangements for semi scheduled generation.** Three sub-options are considered. In all cases, dispatch instructions to semi scheduled generators are targets but they differ in how information is assembled and the form of the target.
    - Amend the rules such that semi scheduled generator dispatch instructions are to be followed by the participants subject to the availability of their dependent resource. These dispatch instructions would be of the same form as for scheduled generators - a megawatt target for the end of the dispatch interval and a ramp rate.
    - An energy target may better accommodate variations in resource within 5-minute intervals. The energy target could be produced by AEMO from the AWEFS and

ASEFS megawatt target or, where the participant has an approved self-forecast methodology a nominated volume in their offer. While this option may allow some variation in output from the semi scheduled generator during the interval, the determination of their Frequency Control Ancillary Services (FCAS) causer pays factors would be problematic.

  - Operate as an inflexible generator and advise AEMO of a fixed megawatt level for the dispatch interval and, subject to system security requirements, this will be the generator's target.

- **Amend registration requirements and approvals for semi scheduled generators to prevent the installation or use of either systems or procedures that allow for, or automate, a reaction to price that does not match their target.** That would be an additional requirement on semi scheduled generators to preclude equipment, systems or procedures that would automatically change the generators output away from their dispatch target, unless there was a change in their resource or the semi scheduled generator was providing other power system services. This approach was also considered impractical in the circumstances and does not alleviate the potential for a manual intervention by an operator during a dispatch interval to deviate from a dispatch target.

Each option needs to recognise the "fuel" resources upon which semi scheduled generator depends over a dispatch interval, as well as their potential to participate in the provision of wider system services. Semi scheduled generators should be expected to follow their dispatch instructions linearly across a dispatch interval, subject to the availability of the resource, unless there is a demonstrable hazard to their physical generation or personnel or as part of providing a system service.

The AER's analysis highlights the advantages and challenges of each option and considers the most appropriate solution is the adaptation of the existing semi scheduled rules. Participants in this category should be required to follow dispatch targets in the form of a megawatt target, subject to the availability of the resource.

3.4 Rule change 2: Better information provision

This request from the Energy Council requires consideration of how semi scheduled generators could be required to continually inform AEMO of any restrictions on their available capacity due to physical factors, ambient weather conditions and their market intentions.

Current information provision requirements from participants to AEMO, as set out in the rules for both scheduled and semi scheduled generators, are comprehensive. However, in some cases, information from semi scheduled generators may be replaced by information determined by AEMO and information may be used which is from other communication protocols.

3.4.1 Options

Unlike the options for rule change 1, the AER has not developed specific options to address this proposed rule change.

The preferred option for the first rule change will affect what is needed for a second rule change to address the provision of better information. For example, if the semi scheduled classification were to be removed, participants may then be solely responsible for forecasting their output and representing their full capability through their offers to AEMO. As their targets would be determined on the basis of their offers the participant would need to account for partial plant outages and the performance of their machines with respect to temperature, local conditions and all other aspects that would affect their performance.

Alternatively issues relating to information provision might be addressed by changes to AEMO operational and forecasting procedures.

Depending on the final approach taken to address rule change 1 the details of what information and procedures that may need to be changed or improved will not be known. Compliance requirements and penalties for any rule or procedural changes with respect to information provided by semi scheduled generators will need to be considered in line with any change to their responsibilities. While training is always available to industry participants regarding their responsibilities and obligations with respect to the rules and dispatch processes, additional opportunities should be provided and regularly updated to match the rapidly increasing number of participants.

3.5 Questions for stakeholders

The AER is seeking feedback on this issues paper, and the following questions are provided to guide submissions in response to the issues raised.

1. Is a rule change required to address the issues described in the paper?
2. Are there other impacts on the market that are not presented in the paper?
3. Are there other impacts not considered from the difference in the requirements for scheduled and semi scheduled generators to follow dispatch instructions?
4. Has the semi scheduled category done its job?
5. Are the four options presented in the paper the most efficient way to achieve the desired outcomes?
6. Are there other options that haven't been considered?
7. Are there any differences in how the four options would apply to wind or solar?
8. Do stakeholders have views on the potential costs and benefits of each of the options presented in this paper?
9. What are the potential impacts of each of the options presented in this paper on participants that are likely to be affected?
10. How can the flow of data and information to AEMO be improved?

11. Only two options appear to satisfy the Energy Council's intention for semi scheduled generators to follow dispatch instructions. Should further consideration be given to the options that were noted as not practicable (sharper causer pays factors and amendments to registration of semi scheduled generators)?

3.6 Next steps

AER will hold a webinar to discuss the proposed rule change, the issues and proposed solutions raised in this paper.

The AER invites submissions to be sent to the AER by 24 July 2020 to the General Manager, Market Performance at wholesaleperformance@aer.gov.au.

This paper, and the feedback provided by participants at the webinar and via submissions will then be used to form the basis for the rule change request to the Australian Energy Market Commission. Due to the level of consultation undertaken prior to submitting the rule change request for rule change 1, it is proposed that this request will also see that the rule change be considered under the fast-tracked rule change option.

As discussed in this paper, the outcome of rule change 1 will inform any decision on the second potential rule change. The AER considers that a rule change request arising from this would not seek to be fast tracked.

4 Introduction

The Energy Council has asked the AER to prepare two rule changes to submit to the AEMC relating to the operation of semi scheduled generators. They are to achieve the following:

- Semi scheduled generators to be obligated to follow their dispatch targets, in a similar manner to scheduled generators; and
- Semi scheduled generators being required to continually inform AEMO of any restrictions on their available capacity due to physical factors, ambient weather conditions and their market intentions.

The request from the Energy Council arose from AEMO concerns about system security and reliability challenges facing the evolving electricity industry. This request comes as part of a suite of actions that comprise the interim security measures.[3]

The first major grid connected wind farms in Australia were built in the early 2000's and the equipment chosen by the developers at that time was, compared to current technology, unsophisticated. All of the approximately 550 MW of wind farms connected in the NEM by 2005 were non-scheduled and of that total 386 MW was operating in South Australia. From 2005, the Essential Services Commission of South Australia imposed jurisdictionally specific requirements on new wind farms in the State that mandated, amongst other things, registration as scheduled generators, increased technical performance requirements and involvement in forecasting. These requirements were designed to minimise the impact on the market and network of the significant number of projects that were being proposed at that time. The South Australian local requirements also recommended the development of a NEM wide semi scheduled registration category that would facilitate the development of this form of generation on the basis that it could continue to develop and participate more fully across the NEM. In 2008, the wider NEM review resulted in the creation of the semi scheduled generator category for intermittent generation, more stringent technical standards (that did not entirely replace the local South Australian requirements) and the commitment to create the AWEFS by the market operator. Semi scheduled generators were afforded flexibility to operate with few restrictions because of their intermittent resource.[4] At that time:

- intermittent renewable energy generation was in its infancy in terms of participation in energy markets and a softer regulatory approach was taken to facilitate their entry, evolution and to provide experience for participants and the market as a whole;
- customer demand was still forecast to be growing and this form of technology would not make up a substantial portion of the generating mix;
- intermittent renewable energy generation technologies were materially more expensive than conventional generation;

3 COAG EC, 2020, Interim Security Measures, www.coagenergycouncil.gov.au/interim-security-measures

4 AEMC, 2008, Central Dispatch and Integration of Wind and Other Intermittent Generation, www.aemc.gov.au/sites/default/files/content/f5714de5-ecf9-46c8-9e85-4ad87ebc444a/Final-Rule-Determination.pdf, page 12

- intermittent renewable energy generation was considered unlikely to be dominant in the long-term;
- the operators of intermittent renewable energy generators were likely to be under-resourced and would not have access to forecasting technology or market systems;
- out of market financial incentives were essential for the viability of the technology in the NEM; and
- renewable energy generators were not expected to be price sensitive and would operate to the full extent of the resource in their location.

AWEFS and, later, ASEFS were integrated in the dispatch process by the market operator. Semi scheduled generators would still offer their capacity into the market in the same way as a scheduled generator in 10 price-volume bands but AEMO took their maximum available capacity to be the AWEFS/ASEFS forecasts prepared by AEMO under rule 3.7B(a). While these systems were state of the art for the time, improvements may still be able to be made by utilising existing additional information[5].

The situation has now changed and the rules that were created in 2008 no longer allow AEMO to adequately manage the power system.

- the cost of intermittent renewable generating technologies are now significantly cheaper and have evolved significantly, supported by precise control system software facilitating both very fast ramping and close control of output;
- the volume of semi scheduled generation has grown from around 550 MW in 2008 to around 8,700 MW operating currently. Furthermore AEMO's Integrated System Plan (ISP) forecasts that intermittent renewable generation will dominate the future energy mix with levels approaching 30,000 MW before the end of the 20 year forecast horizon;
- grid demand is static or falling and conventional generation is retiring and not being replaced by generators of equivalent capability. There is now enough intermittent renewable generation to meet all of a region's demand in some periods;
- negative prices are occurring more frequently and more recent contracts are likely to require these generators to take some exposure in negative price periods; and
- automated dispatch software is now available and being used by some generators – in some cases this may be occurring without integrating with dispatch offers or without allowing for appropriate ramping across a dispatch interval.

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5 In the interests of improved forecasting and transparency the forecast process must continue to include outages of wind turbines or panels and inverters. However additional information on balance of plant limitations that affect output should be reported for all semi scheduled generators.
Some additional relevant factors could be included that may improve the output forecast accuracy. For wind farms additional information that AWEFS could include:

- Temperature information: warning regarding high temperature shut down;
- Wind direction: recognises the configuration of the wind farms generating units on the site.

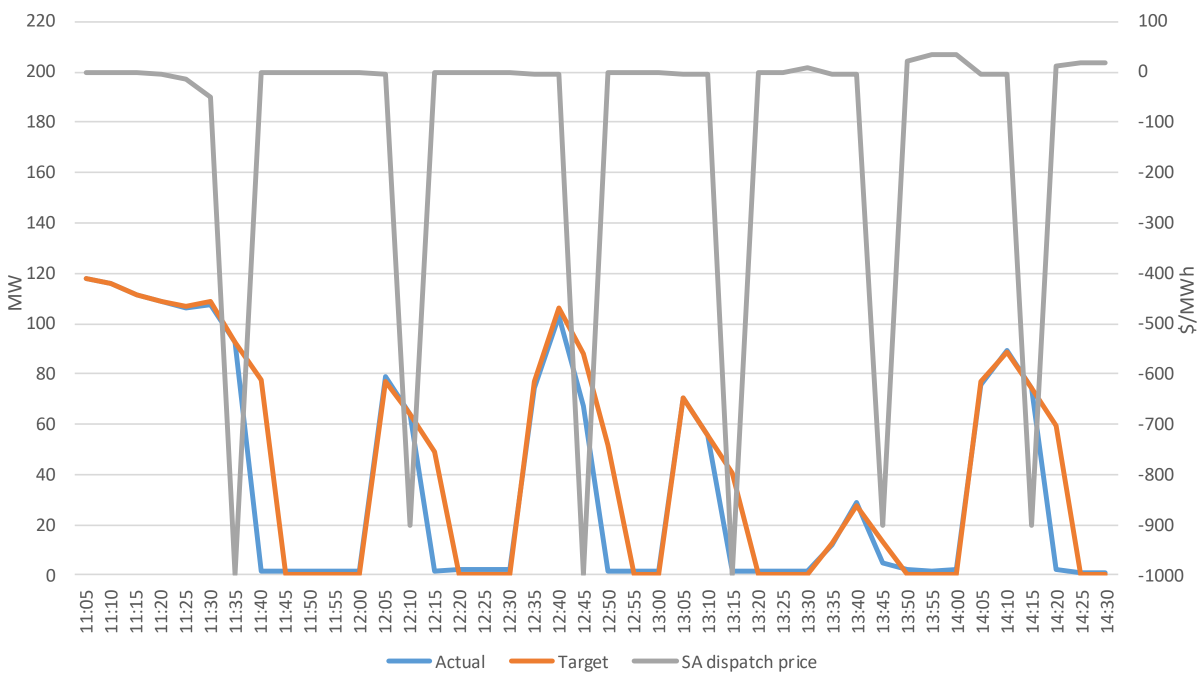
For solar farms this information could include:

- Panel dirt: will reduce performance;
- Wind strength may be a trigger for some sun tracking units to move to a park position.

Wind and solar forecasting have improved markedly due to generators' experience and the increased capabilities of computers and learning software. However local constraints and future complications from battery renewable hybrid systems are making and will make forecasting increasingly problematic. While AEMO prefers to register batteries separately this may not always be possible or feasible from a developer's perspective.

There has also been a significant increase in the ability of, and financial incentives for, some semi scheduled generators to rapidly respond to price. The central dispatch process matches participant bids and offers to meet customer demand. If the market operator is informed of a change to a participant's intention to operate at a particular price through a rebid, AEMO can re-dispatch the market setting new targets for all participants. The central dispatch process assumes that generators will respond to dispatch targets. However, some semi scheduled generators have been observed to rapidly reduce their output without rebidding, or prior to a rebid being received, away from their estimated production levels, in response to receiving dispatch instructions during negative price dispatch intervals.

Figure 1: An example from a wind farm, actual output compared to target



Source: AEMO, AER analysis

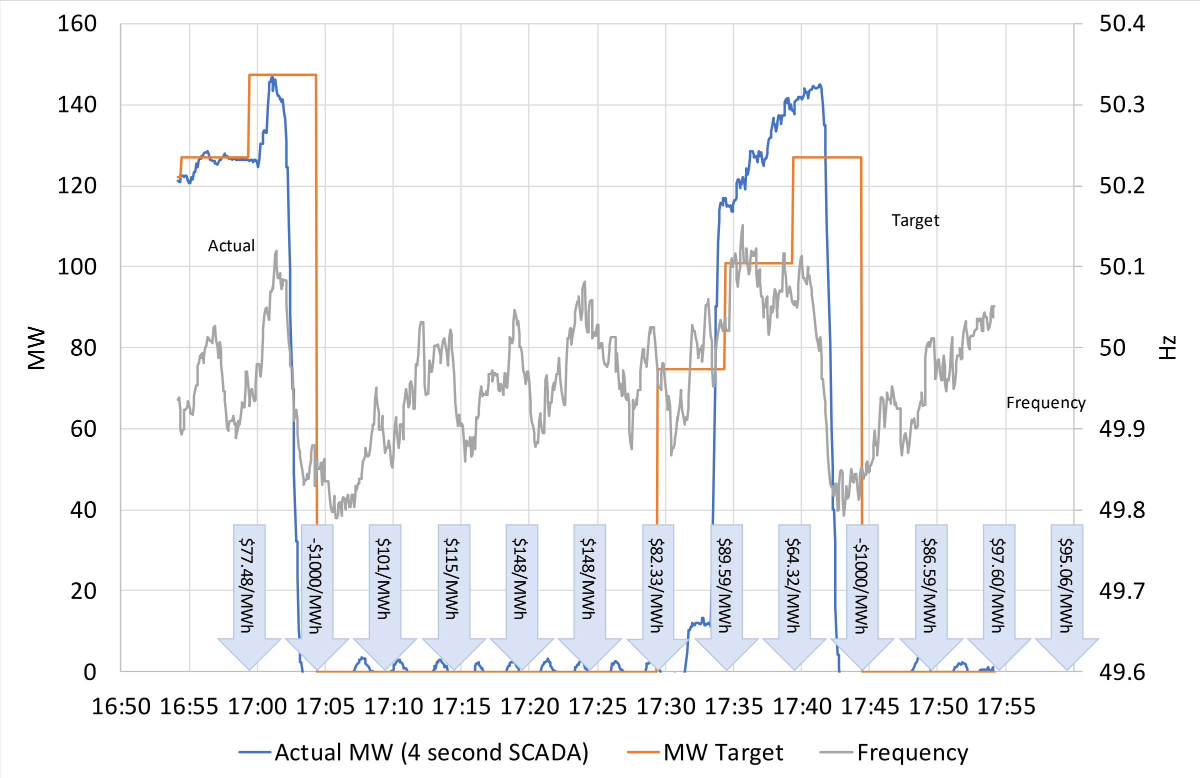
Figure 1 shows the output from a wind farm with respect to its forecast and market price[6]. During this period the dispatch price in the region ranged from around $36/MWh to -$1000/MWh. In this case the participant changed their output more rapidly than was represented in the ramp rate in their offer. Supporting wind data indicates that the observed reductions were unrelated to fluctuations in the wind resource.

Figure 2 shows an example of a wind farm ceasing production during a dispatch interval in which there was an actual negative dispatch price. In the figure, light blue arrows show the

6 Data in this figure has been time shifted so that targets align with initial MW for the next dispatch interval.

regional dispatch price and when it was published for the subsequent dispatch interval. The orange line shows the AWEFS target for the unit or the offer from the participant. The blue line shows unit output. The grey line shows the power system frequency during that time (referenced against the right hand axis).

Figure 2: Negative price response



Source: AEMO, AER analysis

From 17.00hrs the output from the unit initially climbs towards the higher dispatch target based on wind forecasts and the generator's offer. From 17.02 the output starts to sharply reduce, reaching zero well before the end of the dispatch interval at 17.05. The reduction appears to have been prompted by the -$1,000/MWh price for the dispatch interval. The participant also submitted a rebid at 17.02, moving all its capacity from -$1,000/MWh to more than $12 500/MWh, however it only became effective for the 17.10 dispatch interval.

In this example, the early rapid reduction to 0 MW, before a corresponding dispatch instruction was issued with a 0 MW target, appears unrelated to resource availability or technical limitations. SCADA[7] data indicates the number of turbines available remained relatively constant and the wind speed fell only slightly.

7 SCADA is an acronym for Supervisory Control And Data Acquisition, a computer system for gathering and analysing real time data. In this case it forms part of AEMO's supervisory systems in the NEM which monitor a large range of measurement points across the power system and returns the values to an AEMO database.

As a result of the negative priced dispatch interval, the spot price for the trading interval[8] ending 17.30 hrs was -$67.61/MWh.

The participant's rebid made at 17.02 was only for the 17.30 trading interval, so all of its available capacity reverted back to its original offer of -$1000/MWh for the 18.00 trading interval.

During the 17.45 dispatch interval, for which the dispatch target was in excess of 120 MW, at 17.42 the participant again started to rapidly reduce output. Again, at the same time, the participant also submitted a rebid for the remainder of the trading interval, moving all their capacity from -$1000/MWh to more than $12 500/MWh. However, this rebid did not become effective until the 17.50 dispatch interval. The spot price for the 18.00 trading interval was -$94.47/MWh.

Figure 2 also shows the power system frequency in grey. Power system frequency can be seen as a measure of the supply demand balance. As the generator reduced its capacity and deviated from AEMO's forecast target, the power system frequency fell and moved outside the normal frequency operating bands.[9] The impact on frequency would be more substantial if a number of semi scheduled generators operated in this way concurrently. Appendix B provides more detail about the current dispatch process.

Question 1: Is a rule change required to address the issues described in the paper?

4.1 The problem to be addressed

Unexpected outcomes, like those shown in Figure 1 and Figure 2, where a generator moves materially away from its expected level of output reduces the available supply to meet customer demand in that interval, and this adversely impacts system frequency. However, the increasing frequency of negative prices is not the issue the proposed rule change is trying to address – the key issue is semi scheduled generators moving from their anticipated output levels without informing the market operator of that intention through a rebid, and waiting to receive a revised dispatch target. The request from the Energy Council specifically relates to whether dispatch instructions are complied with, that is, whether the target dispatch level at the end of each 5-minute dispatch interval has been met.

Changes in output that are unrelated to fluctuations in the wind or solar resource are increasing in size and frequency. At times, a significant percentage of the regulation FCAS needed to manage 'normal' variations in demand and generation are being consumed by deviations from dispatch targets by semi scheduled generators. This has reduced pre-dispatch forecast accuracy and contributed to poorer power system frequency performance by consuming more FCAS to maintain power system security. Over the longer term, this might result in an increase in the required regulation services. All of these potential consequences can have adverse impacts on system security and on the accuracy of prices to the market.

8 The spot price for the 30 minute trading interval is determined by the average of the six dispatch interval prices in that trading interval.

9 The normal frequency operating bands (NOFB) are 0.15Hz on either side of 50Hz. When the frequency moves beyond these limits contingency FCAS is triggered to return the NOFB of 49.85Hz to 50.15Hz.

At this stage, most of these variations are not exceeding the capabilities of the system. However, if a number of semi scheduled generators were to reduce their output, during a dispatch interval (which could be equivalent to, or more than, the magnitude of a credible contingency event), this would place the power system at a greater level of risk than for credible contingency events that are currently considered. This concern is compounded by the forecast growth in the volume of semi scheduled generation in the future.

In recent years, almost all investment in new capacity in the NEM has been in intermittent wind and solar renewable generation. This, together with rapidly growing rooftop PV in some regions, has at times resulted in significantly more capacity being available than needed to meet customer demand. This oversupply situation has resulted in negative prices as generators compete to continue to generate. Since 2019 the frequency of negatively priced dispatch intervals has increased[10] and is likely to continue to increase. See appendix C for a discussion of negative pricing.

While the number of occasions where semi scheduled generators shut down during negative priced periods is currently relatively low, it has grown and could continue to increase while their dispatch obligations remain less stringent compared to scheduled generators.

4.2 System security impacts

Analysis by AEMO highlights that the level of dispatch within each interval and the rate of change of output is of concern.

Regulation FCAS is acquired by AEMO to continually manage the balance between supply and demand and support power system frequency. It was designed to cover relatively small uncertainties rather than significant contingencies. A more extensive description of FCAS is provided in Appendix A.

Contingency FCAS is designed to correct and support the market when more significant variations occur. Typically this would be the failure of a major generator or transmission element.

Key drivers of the variability are:

- the inherent uncertainty in forecasts of the net customer demand comprising consumers and small generation;
- the variations in output from unavoidable events that effect semi scheduled and scheduled generators, such as a modest change in the available renewable resource or a partial forced outage in a thermal plant; and
- the output of non-scheduled generators.

While regulation FCAS is designed to accommodate these variations it also provides the first response to deviations from expected generator output, and this is the central issue in the Energy Council's request.[11]

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10 AER, 2020, Wholesale markets quarterly report - Q4 2019, www.aer.gov.au/system/files/Wholesale%20markets%20quarterly%20Q4%202019.pdf, page 8

11 Governor and invertor controls also contribute to frequency control.

When a scheduled generator fails to achieve its expected dispatch levels in dispatch instructions, the rules provide enforcement options. The rules for semi scheduled generators provide for enforcement when the cap is exceeded during a semi dispatch interval, reflecting their more limited obligation to follow dispatch instructions. While deviations from expected output, including moving below a cap if one is applied, will incur FCAS causer pays costs, it also consumes available FCAS, and is currently allowed under the rules. AEMO currently enables in the order of 200 – 250 MW of regulation FCAS to cater for current levels of uncertainty.

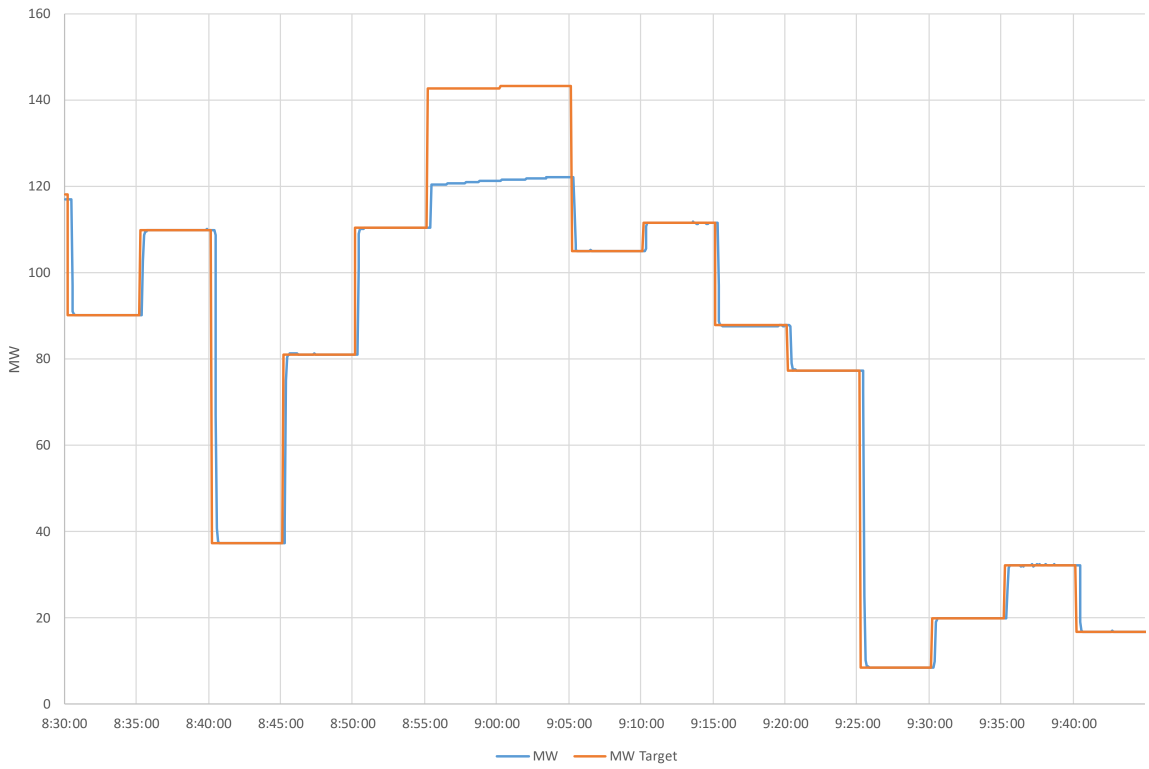
Rapid un-forecast withdrawal of capacity by a semi scheduled generator or the trip of a thermal generator will consume a significant proportion of the available regulation FCAS and may potentially trigger FCAS contingency services. If multiple wind farms in a region behave in a similar way in response to negative pricing, this will naturally present higher system security risks.

Figure 3 below uses 4 second SCADA and shows how quickly this solar farm's output can change. In this case, with the exception of 2 dispatch intervals, the participant followed the dispatch instructions and was not in contravention of the rules.

From a system perspective, this behaviour would have adversely affected the frequency. From the participant's perspective, while it followed its targets, the step changes in output would have increased its FCAS causer pays factor, an outcome that could have been avoided if the participant had moved linearly to its end of dispatch interval target.

Contingency FCAS arrangements particularly presume that there will only be occasional step output change events and in the case of a major disturbance, up to 30 minutes is allowed to fully restore reserves on the assumption that a second disturbance is unlikely during the recovery period. When rapid changes like those shown in Figure 3 occur multiple times a day, and over time grow in size as more participants start to act in this way, regulation FCAS, and possibly even contingency FCAS, are at risk of being fully utilised to manage credible contingency events. Operating margins and the level of FCAS procured may also need to be increased to avoid materially degrading system security.

Figure 3: High ramp rate output changes



Source: AEMO, AER analysis

Examination of historical records show that there has been an upward trend, particularly in South Australia, of individual events at extreme ramp rates which have resulted in falls in power system frequency approaching or exceeding the limits of the normal frequency operating band.

The impacts on system security has contributed to the proposed options set out in section 6, which include defining a ramp rate within a dispatch instruction.

4.3 Emerging impact of storage

As the costs of battery storage are predicted to fall materially into the future, a number of participants are preparing their sites for the installation of battery storage to create hybrid systems.

The energy supplied to the grid at any time from a hybrid storage / wind or solar facility will be dependent on the participant's intentions regarding charging and discharging the battery as well as the availability of the wind or solar resource and market price. As a result, the forecasts from AWEFS or ASEFS used in the NEM Dispatch Engine (NEMDE) are unlikely to be accurate, making AEMO's forecasting function problematic.

This effectively means that despite AWEFS and ASEFS being able to learn the behaviour of the generators they are not able to forecast net capability and dispatch of the hybrid-intermittent renewables or indeed any hybrid system. Hybrid systems would therefore be expected to self-forecast their output and inform AEMO through their offers, but they may still be able to utilise AWEFS or ASEFS as a starting point.

Hybrid development may also allow the participant to operate at higher rates of change of output than from the natural variations that would occur from changes to the intermittent resource itself. Rather than being a negative, this could effectively be used to smooth its output and should ensure that the participant reaches its target and facilitates participation in the provision of FCAS services.

Importantly, if these hybrid systems intend to operate differently to that based on the availability of the renewable resource, then perhaps they are more suited to being classified as scheduled as their output is not then directly linked to the availability of an intermittent resource and they can predict and inform AEMO of their output capabilities with greater certainty.

Currently, during the registration process for new generators, AEMO prefers to register battery systems separately to the generation component of the facility. While the addition of a battery behind the existing connection point will trigger a review of the generators' Schedule 5 registered performance standards, it may not necessarily result in a change in their registration category. AEMO has submitted a rule change request to the AEMC which proposes amendments to the rules to recognise and define energy storage systems and provide a framework that supports their participation and business models where there are a mix of technology types connecting behind a connection point.[12]

The registration process for a semi scheduled generator is defined in clause 2.2.7 of the rules. The rule requires AEMO accept an application for registration as a semi scheduled generator if the matters listed in the clause are satisfied. A change to the registration category of a participant is currently only able to be triggered by a request from that participant to AEMO.

The levels of both storage and renewable energy forecast in the ISP support a conclusion that together these technologies will operate increasingly commercially. This changing dynamic within the market has informed the creation of options presented later in this paper.

Question 2: Are there other impacts on the market that are not presented in the paper?

Question 3: Are there other impacts not considered from the difference in the requirements for scheduled and semi scheduled generators to follow dispatch instructions?

12 For more information, see AEMC 2019, Rule change request from AEMO 'Integrating Energy Storage Systems into the NEM', www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem.

5 How material is the problem?

While AEMO has reported individual examples of the generators turning off during negative price dispatch intervals without a target in submissions to the AER and AEMC[13,14], it is important to consider whether this is a material or persistent issue. Future circumstances should also be considered to see if this issue may become more challenging for the power system.

5.1 Observed instances of behaviour

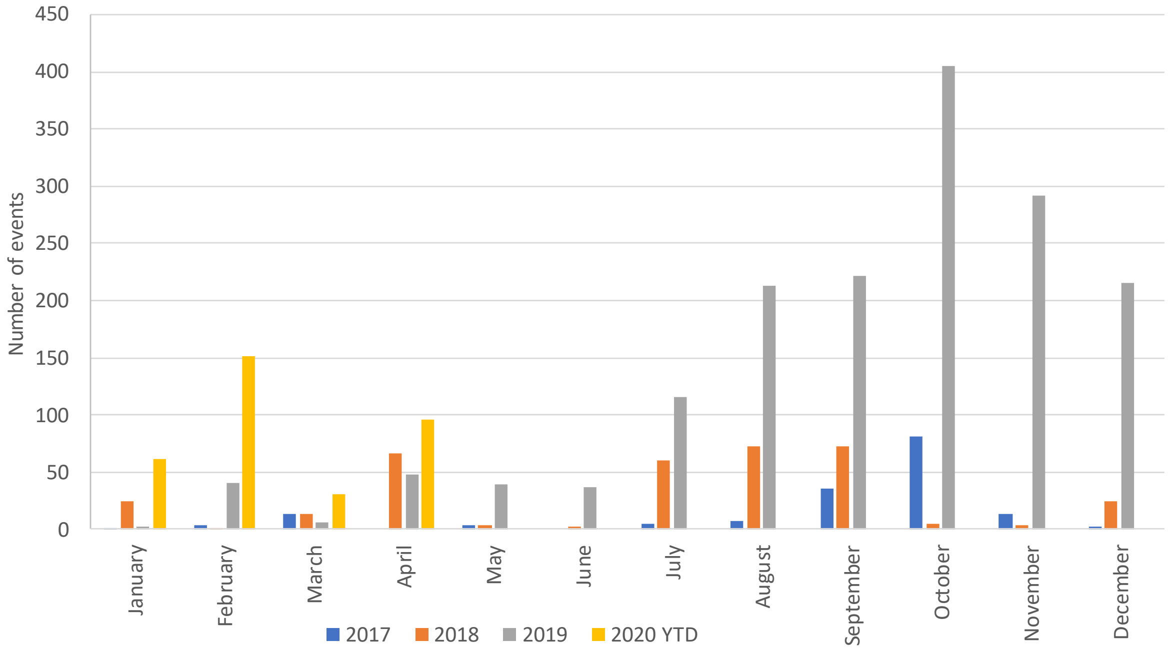
The South Australian region has the largest proportion of semi scheduled generation, compared to total capacity in the region, as well as largest number of negative dispatch prices historically. For these reasons we have chosen to focus on this region to analyse how material the problem is.

Figure 4 shows the number of events where semi scheduled generators deviated more than 20 MW below the dispatch target when the dispatch price was negative, in each month over the last three years in South Australia. The 20 MW threshold was chosen as it was considered a large enough deviation from target that it would not normally be explained by a sudden change in the fuel resource, beyond the change predicted in the forecasting systems.

13 AEMO, 2019, submission to AER, Rebidding and technical parameters guideline - Amendments for five minute settlement, www.aer.gov.au/system/files/DORIS%20-%20D19-162559%20AEMO%20submission%20-%20Draft%20rebidding%20and%20technical%20parameters%20guideline%20%282019%29%20%281%29.PDF, page 2

14 AEMO, 2019, submission to AEMC review of Black System Event in South Australia: Issues and approach paper, www.aemc.gov.au/sites/default/files/2019-05/Rule%20Change%20Submission%20EPR0057%20-%20AEMO%20-%2020190530.PDF, page 3

Figure 4: South Australian semi scheduled generation – events where output was more than 20 MW below the target during negative prices

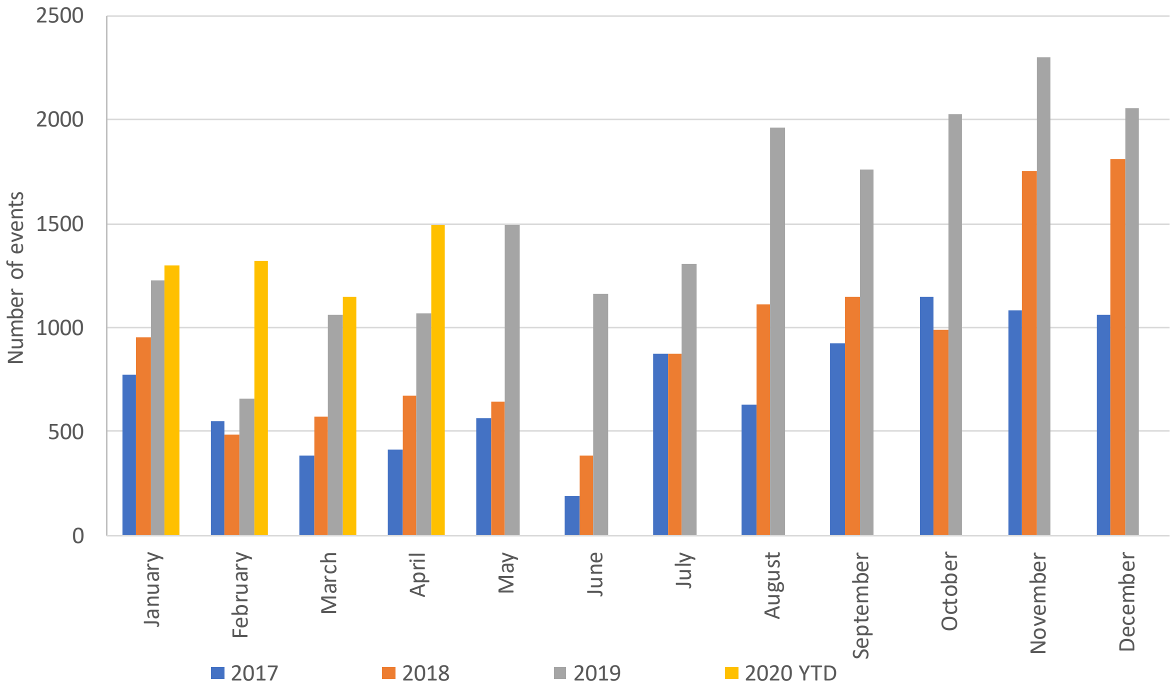


Source: AEMO, AER analysis.

The figure shows that while there was no clear trend across 2017 and 2018, from 2019 onwards the instances of the semi scheduled generators being at least 20 MW below their target during a negatively priced dispatch interval has increased.

It is also important to consider a deviation like this across all dispatch intervals and when a semi scheduled generator is either above or below its target. Figure 5 shows the total number of events where, independent of price, the South Australian semi scheduled generators are more than 20 MW from their dispatch target, in each month over the last three years. This chart excludes events where the semi scheduled generator exceeded a semi-dispatch cap as the existing rules already provide enforcement mechanisms for these events.

Figure 5: South Australian semi scheduled generators – events where output are more than 20 MW from the AWEFS/ASEFS forecast.



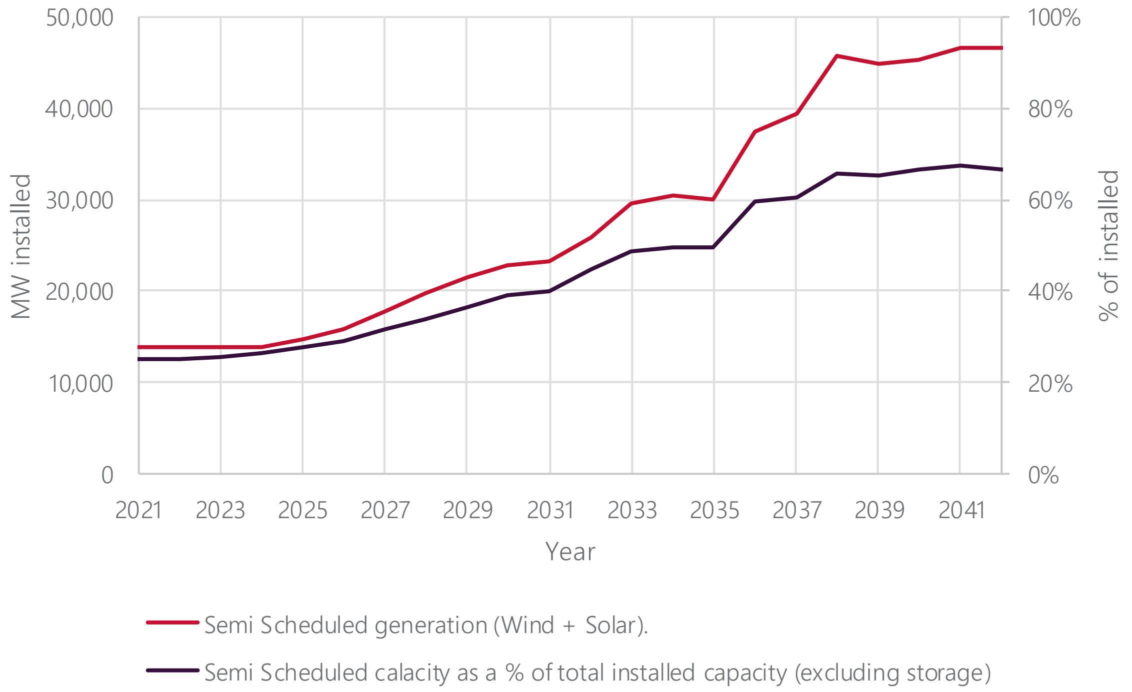
Source: AEMO, AER analysis.

Figure 5 shows a fairly consistent increase across each of the years for each month. While the increase could be attributed to an increase in the behaviour from a few select participants, or an increase in the number of semi scheduled generators adopting this behaviour, the conclusion is the same - there is an increasing number of dispatch intervals where semi scheduled generators are materially away from their target.

5.2 Forecast growth of semi scheduled generation

As shown in Figure 6, AEMO's integrated system plan is forecasting significant growth in the installed capacity of semi scheduled generation in the NEM. If the trend in Figure 5 continues as the capacity of semi scheduled generation grows, then the importance of changing the rules to ensure that semi scheduled generators are incentivised to meet dispatch targets increases. This is supported by AEMO's analysis in the recently published Renewable Integration Study (RIS).

Figure 6: Forecast growth in semi scheduled generation capacity



Source: AEMO 2020 draft ISP, AER analysis15

AEMO published the RIS at the end of April 2020. AEMO's analysis focused on system curtailment issues related to system security and shows that managing power system frequency will become increasingly difficult as the existing high inertia thermal generators retire.[16]

Figure 7, taken from the RIS, shows that in 2019 renewable generation was at times able to meet almost 50% of electricity demand in the NEM (grey scatter dots) and by 2025 this could increase to 75% and even 100%, under two different ISP future scenarios (red scatter dots shows the ISP central scenario, and yellow scatter dots show the even higher ISP step change scenario). Instantaneous penetration levels in this figure represent aggregated contributions from all wind and solar generation in the NEM in the half hour divided by the total underlying NEM demand.

A primary conclusion of the RIS report is that, by 2025, instantaneous intermittent renewable penetration levels in the NEM will be constrained to between 50%-60% unless a range of initiatives are implemented. It should be noted that the ISP assumes that market dispatch has perfect foresight, wind and solar generators are not price responsive and follow their simulated output unless constrained by the network.

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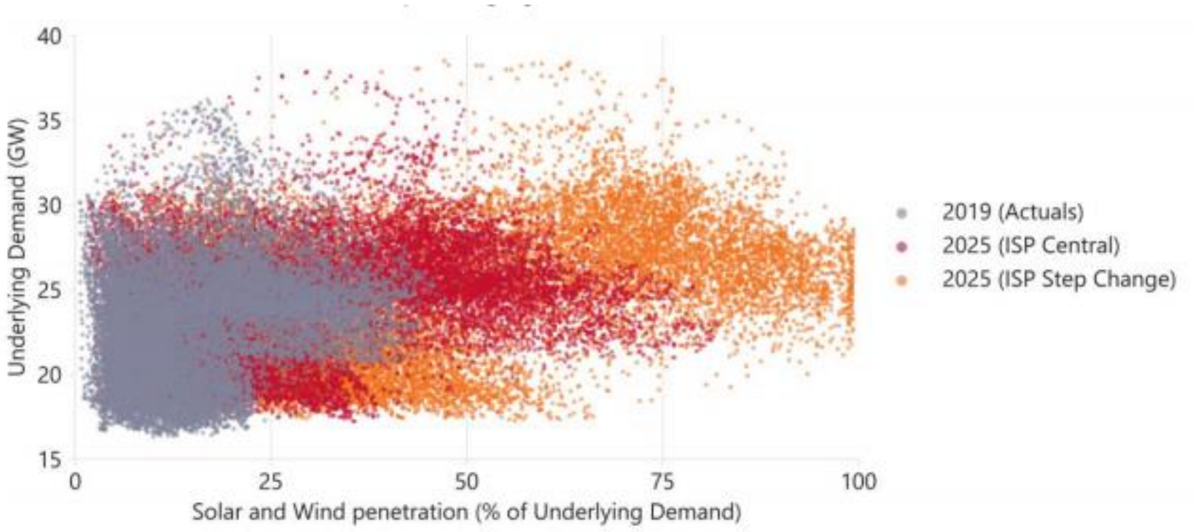
15 AEMO 2019, Draft 2020 Integrated System Plan, www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2019/draft-2020-integrated-system-plan.pdf?la=en. Figure is based on the optimal development path.

16 AEMO 2020, Renewable Integration Study, www.aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en, page 6

Figure 7: Instantaneous penetration of wind and solar generation, actual in 2019 and forecast for 2025 under ISP Central and Step Change generation builds



Source: AEMO Renewable Integration Study.

The report also highlights the challenges with managing increasing uncertainty and interventions with respect to system operability, frequency management and resource adequacy to ensure that a sufficient overall portfolio of energy resources is available to achieve real time balancing of supply and demand.

> *"...increasingly variable and uncertain supply and demand, and declines in system strength and inertia, have moved the system to its limits, reducing its resiliency and increasing the risk to the system for complex events. The knowledge and tools operators have used in the past to operate the system securely are now less effective and need to be adapted. For example, intervention by AEMO has always been a part of operating a secure NEM, but where it was used rarely in the past as a last resort to manage specific issues on the grid, it has now become commonplace, especially in regions with higher shares of renewable generation (South Australia, Tasmania, and Victoria). This RIS analysis projects that under the current market design the need for interventions to address system security requirements will grow across all NEM regions. Successfully managing the system's increased uncertainty and operational complexity will require different approaches and better co-ordination of all resources. The existing dispatch process for the NEM was not designed for these new conditions, and the current reliance on operators to balance factors and intervene is sub-optimal and unsustainable."*[17]

As highlighted, the existing arrangements that effectively only constrain a semi scheduled generator to remain below a cap during a semi scheduled dispatch interval are part of operating the power system down to its minimum physical limits.

17 AEMO 2020, Renewable Integration Study, www.aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en, page 25

5.3 Forecast growth of aggregated ramp rates

The RIS also examined 5-minute ramp events. A "ramp" being defined as the net change in output from all of the renewable energy generators (semi scheduled and non-scheduled) between the start and end of a 5-minute interval. The magnitude and frequency of large ramps by renewable energy generation in the NEM will increase as their combined capacity increases, and this means that there will be larger and more frequent fluctuations in generation to be managed to maintain the supply-demand balance.

Figure 8 shows how 5-minute ramps have changed between 2015 and 2019, and how they are projected to change by the year 2025.

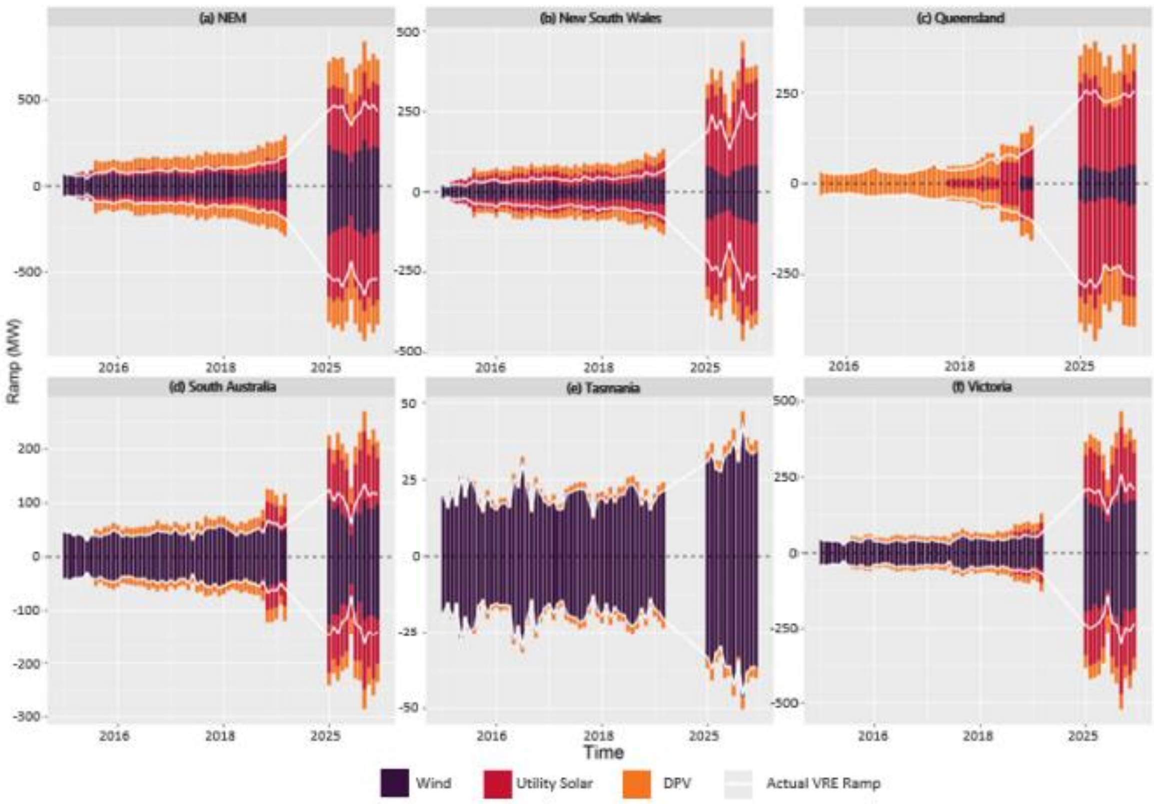
The white line indicates the aggregate ramp across all renewable generation, and the coloured bars represent the 99th percentile of ramps that occurred for each individual technology type (purple for wind, pink for utility scale solar, and yellow for distributed PV). There are approximately 105 000 5-minute dispatch intervals in 12 months, the 99th percentile averages approximately the top 1000 ramps of those 105 000 5-minute intervals. The white line is lower than the sum of the largest ramps as a result of timing. That is, the largest ramps from the different sources did not happen in the same 5-minute intervals.

AEMO's analysis shows that historically the 1% largest downward renewable energy generation ramp in the NEM in one hour was -1.4 GW. By 2025, the largest equivalent renewable energy generation ramp in the NEM is projected to be -4.5 GW and could be as high as -5.8 GW.

As the installed capacity of renewable energy generation grows, so does the magnitude of ramps and the potential for them to impact system operation.

Figure 8 also shows that although ramps are increasing in magnitude, these increases are smaller than the growth in installed capacity. This is most evident for regions with a greater diversity between renewable technologies (that is between wind, utility solar, and distributed PV) and greater geographic distribution of the same renewable generation technology

Figure 8: Butterfly plot - monthly top 99th percentile upward and downward 5-minute VRE ramps in the NEM[18]



Source: AEMO

Table 1 expands on this assessment of the 5 minute change in output both historical and forecast. This table shows by year the megawatt and percentage of change with respect to the capacity or renewable energy generation that was operating at the time. Across the NEM, the largest historical 5-minute downward variable renewable energy change was -814 MW. This is projected to increase to -1,416 MW by 2025.[19] Of interest too is that by 2025, the 99th percentile ramps are close to the maximum ramps recorded in 2018 and are approaching the size of the largest NEM units.

Table 1: VRE 5-minute ramp statistics in the NEM

Year	Average		Maximum				99th Percentile			
	MW	%	Up (MW)	%	Down MW	%	Up (MW)	%	Down MW	%
2016	26	0.61	772	17.87	-782	-18.11	98	2.27	-107	-2.48

18 It should be noted that this analysis considers both forecast and un-forecast changes in output and includes the output from semi scheduled and, where SCADA was available, non scheduled variable renewable energy generators.

19 AEMO 2020, Renewable Integration Study Appendix C, https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-c.pdf?la=en, page14

Year	Average		Maximum				99th Percentile			
	MW	%	Up (MW)	%	Down MW	%	Up (MW)	%	Down MW	%
2017	30	0.60	256	5.08	-300	-5.97	112	2.24	-123	-2.45
2018	37	0.61	897	14.73	-814	-13.36	136	2.23	-151	-2.49
2025	123	0.87	1008	7.10	-1416	-9.96	480	3.38	-685	-4.82

While these figures show that on average the result is not excessive, the maximum and 99th percentile figures are likely to challenge power system security.

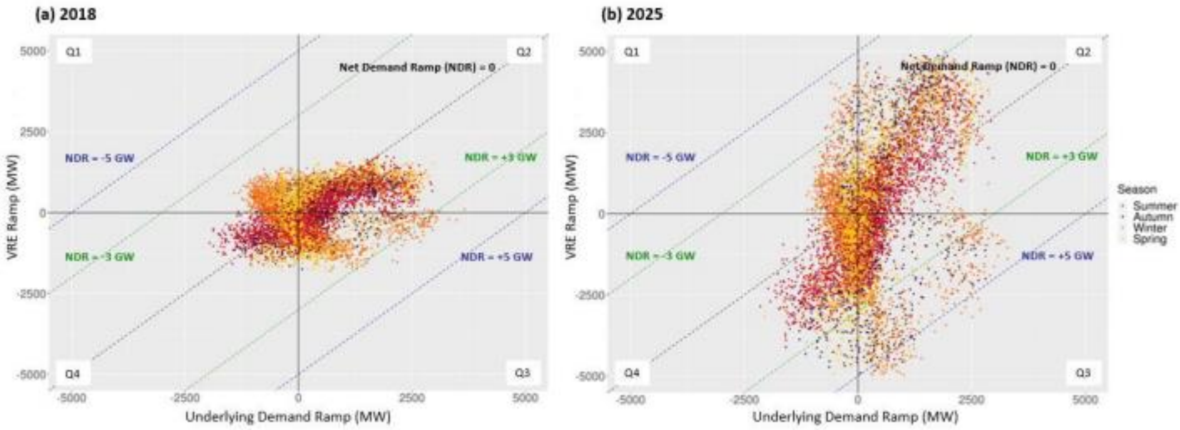
To put these actual and forecast ramp changes in perspective, AEMO compared renewable energy generation ramps to those of customer demand.

While existing demand forecasting techniques are relatively reliable in predicting demand ramps. The same cannot be said for predicting the large renewable energy generation ramps. This problem is compounded by semi scheduled generators not being obliged to follow dispatch targets.

Figure 9 is a scatterplot of underlying demand and renewable energy generation hourly ramps. The figure is read as follows:

- Demand ramps are on the horizontal axis and renewable energy generation ramps are measured against the vertical axis.
- Panel (a) presents 2018 actual while panel (b) shows data forecast for 2025.
- Different seasons are represented by different colours in the scatter (summer is red, autumn is purple, winter is orange and spring is yellow).
- From the top left Q1 is January to March, top right Q2 is April to June, bottom right Q3 is July to September and bottom left Q4 is October to December.
- Data points in Q2 and Q4 represent times when both underlying demand and net renewable energy generation move in the same direction. In these quadrants, renewable energy generation and underlying demand offset one another, reducing the requirements on the scheduled fleet to cover the net load variability.
- Data points in Q1 and Q3 represent times when underlying demand and aggregate renewable energy generation move in opposite directions.
- The dotted lines represent the locus of net demand ramps. The black line indicates a net demand ramp of zero. The green and blue lines show ±3 GW and ±5 GW changes in net demand, respectively.

Figure 9: Changes in 1-hour underlying demand and VRE



Source: AEMO 2020, Renewable Integration Study, appendix C page 28

The AEMO study concluded that renewable generation is projected to be a significant driver of ramps in net demand by 2025. The comparison between panel (a) and panel (b) shows this change; in 2018 52% of the time the renewable generation ramps are greater than underlying demand and by 2025 they are forecast to have grown to being larger than underlying demand 83% of the time.

Over time it is also projected that the top 1% of new demand ramps will change from being driven by changes in demand to being driven by changes in renewable generation (Panel (a) shows that in 2018 the top 1% of ramps (ramps greater than 3.4GW) were driven by changes in underlying demand, which is largely predictable. By 2025 the top 1% is now ramps greater than 5.1 GW and is driven mainly by changes in renewable generation which is typically much more uncertain.

Figure 7, Figure 8, Figure 9 and Table 1 show the materiality of the potential power system security management challenge. At levels of penetration predicted in these studies, semi scheduled generators are likely to be more frequently constrained by power system security and market conditions.

Supporting that power system management objective and to avoid more conservative management of dispatch of scheduled plant and interconnector flows AEMO will need to be assured that targets determined in the dispatch for semi scheduled generators will be followed as closely as possible by those generators.

6 Options to address the two proposed rule changes

The AER has identified a number of options that, in principle, could be the basis for amending the NER to achieve the desired outcomes. They are to:

- Remove the semi scheduled classification and make all semi scheduled generators scheduled.
- Amend the obligations on semi scheduled generators to facilitate closer compliance with forecast expectations.

Other options were also briefly examined that could reduce or ameliorate some of the behaviours that adversely affect market efficiency and power system security. These included the introduction of rate of change obligations or to preclude, via conditions attached to registration, the connection of equipment that would apply financial controls over output without notifying the market operator and consideration of providing sharper financial incentives such as changes to FCAS causer pays. These were assessed as not as effective as the two options set out above.

For the preferred options the potential benefits and costs to the market and generators are relatively similar.

The benefits of these options may include:

- Improvements in reliability and accuracy of pre-dispatch forecasts and actual prices for all participants and AEMO
- Increased ability for AEMO to manage reliability and security by having greater confidence in generation output
- Potentially lower FCAS costs
- Potentially a reduction in the curtailment of semi scheduled generators

There would also be some potential, although limited costs. These may include:

- Increased IT and control systems costs for some semi scheduled generators
- Increased staffing costs for some semi-scheduled generators

Overall there will be differing costs to semi scheduled generators across the NEM depending on their current levels of sophistication with bidding systems and plant operations. For participants who already actively manage their plants output in response to price (amongst other things), the overall cost should be relatively minor. These participants have already demonstrated they are able to adjust the output of their generating units when required and would have the systems and staffing in place to ensure dispatch instructions are followed subject to the availability of the resource.

For semi-scheduled generators that currently are not actively managing their generation output and simply outputting what is available subject to their fuel resource, there may be some costs to ensure varying dispatch instructions can be more closely followed. However offers at the market price floor should ensure that changes to dispatch instructions are limited.

The following sections set out further specific costs and benefits as well as describe each of the dispatch related options and assess the potential for each to achieve the outcomes sought by the Energy Council.

Question 4: Has the semi scheduled category done its job?

Question 5: Are the four options presented in the paper the most efficient way to achieve the desired outcomes?

Question 6: Are there other options that haven't been considered?

Question 7: Are there any differences in how the four options would apply to wind or solar?

Question 8: Do stakeholders have views on the potential costs and benefits of each of the options presented in this paper?

Question 9: What are the potential impacts of each of the options presented in this paper on participants that are likely to be affected?

Question 11: Only two options appear to satisfy the Energy Council's intention for semi scheduled generators to follow dispatch instructions. Should further consideration be given to the options that were noted as not practicable (sharper causer pays factors and amendments to registration of semi scheduled generators)?

6.1 Consider improved market incentives before changing regulatory settings

Before imposing regulatory changes, it is appropriate to consider the potential for market-based incentives, as these should be investigated and are preferred, if feasible. The key relevant incentive in the current rules comes from the regulation FCAS causer pays factor. FCAS cost recovery arrangements are designed to allocate cost to the causers of the need for a FCAS response

AEMO's causer pays procedure describes the mechanism by which regulation services costs are allocated to Market Generators and Loads. These factors reflect the degree to which the generators actual output or, in the case of a scheduled load, their actual demand, differ from the targets assigned by NEMDE.

AEMO determines the level of regulation FCAS required to meet the frequency operating standard.

Currently, unless AEMO determines that minimum levels of regulation FCAS must be procured within specific regions, those requirements are procured and funded across the NEM as a whole.

An introduction to FCAS arrangements is presented in Appendix A.

6.1.1 Current causer pays allocates accountability for FCAS at the time

Semi scheduled generators are subject to causer pays regulation FCAS costs allocation which seek to attribute some financial accountability for the variability of intermittent generator output on power system frequency. A semi scheduled generator that deviates materially from its dispatch instruction in a manner that does not support frequency control, will be assigned an increased causer pays factor. This factor relates to the FCAS that has been scheduled and does not allocate accountability for any additional FCAS that may be required. Furthermore if the response moves the frequency outside the normal frequency operating band (NFOB) then the event and behaviour are excluded from the causer pays calculation. The determination of this factor also includes significant averaging as it is calculated across a portfolio within a region over a 28-day period from the previous month. This effectively disconnects contextual coincidence – that is behaviour right now does not directly correlate to costs immediately incurred. Hence occasional exposure may not be commercially significant to participants, even though the circumstance creates a material short term security risk. If more semi scheduled generators deviate materially from their expected output then it is likely that the frequency will also deviate more often from the NFOB further undermining the causer pays approach.

Based on analysis provided by AEMO, the causer pays calculations would need significant adjustment to deter the identified behaviour, for example, to operate with a shorter averaging period or to be more proximal to the event. This may be addressed in the ongoing work on the mandating of primary frequency rule change.

AEMO provided the AER with a “what if” style analysis that determined the change in the causer pays factor if repeated dispatch intervals where the participant had withdrawn capacity during a negative priced interval without a dispatch instruction did not occur. This analysis, based on excluding four dispatch intervals where a semi scheduled generator reduced its output by an average of 73 MW in response to actual negative prices in a 28 day period, only changed their MPF by 0.028301. (see Table 2).

Table 2 Example calculation of actual MPF compared to the ‘what-if’ MPF

Market Participation Factor	What if Market Participation Factor	Difference
1.2387	1.2104	0.028301

The AER considers this change to be immaterial and unlikely to deter rapid reduction in output that leads to adverse system security outcomes. In reaching this conclusion the AER is aware that some semi scheduled generators are currently facing significant payments from the FCAS causer pays regime, however, we were concerned the likely change in factor is not sufficient incentive for these generators to follow their targets.

6.1.2 Rate of Change of Frequency (RoCoF) and interconnector limits – not accounted for in FCAS or other cost allocations

High Rate of Change of Frequency (RoCoF) in the power system can threaten system security, requiring AEMO to hold higher levels of regulation and contingency FCAS or impose operating constraints. Although no single semi scheduled wind or solar farm is currently of a size that can cause RoCoF to exceed safe limits, coincident reductions by a number of farms may result in the breaching of these limits. As the number of semi scheduled generators grows, the probability that new risks such as unsafe high RoCoF may occur. Currently there is no financial incentive in the NEM to signal RoCoF risk or the impact of additional costs.

Accordingly, ensuring semi scheduled generators follow dispatch instructions and do not ramp at high rates mitigates the potential for high RoCoF from this source.

Estimating the increase in FCAS requirements due to one participant or performance characteristic is complex. Given that the key disincentive of the impact on causer pays is low and unlikely to materially affect decisions to avoid negative payments for energy, this analysis has not been undertaken.

This conclusion is consistent with the AEMC's views in its recent review of the mandatory primary frequency final determination[20]. In this review the AEMC concluded that:

> *"The Commission considers this change to the NER is justified by the need to improve and maintain the security and resilience of the national electricity system to meet AEMO's concerns, but also recognises that the final rule will not adequately value or reward frequency response from capable generating units. For example, passing the cost of primary frequency response through the energy market does not reveal the extent of these costs to the market and places the costs directly on consumers rather than recovering the costs through the FCAS markets. Generators are therefore not exposed to the full costs of managing system frequency through causer pays and thereby have little incentive to minimise any adverse impacts on frequency."*

Short of a major overhaul of the causer pays regime, the 'changing causer pays approach' does not appear to create a meaningful incentive to address the problem at hand and is not considered further.

6.1.3 Existing arrangements only indirectly account for additional FCAS

If, as a consequence of more semi scheduled generators deviating from their targets, more FCAS is required, the overall cost of FCAS to the NEM as a whole would increase. While those participants not following their dispatch targets would see an increase in their causer

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20 AMEC, 2020, Final Determination Mandatory Primary Frequency Final Determination, www.aemc.gov.au/sites/default/files/2020-03/ERC0274%20-%20Mandatory%20PFR%20-%20Final%20Determination_PUBLISHED%2026MAR2020.pdf, page 81

pays factors from the intervals in which they have deviated from their targets, this is not guaranteed to balance the overall cost in the NEM. If additional FCAS were needed as a consequence of more semi scheduled generators not following their forecast dispatch targets, the cost base would rise but the direct impact on the causer pays factor of any party may not change markedly blunting the signal to participants. That is, due to the indirect nature of the contribution factors calculation process there is a risk that additional costs could be socialised or allocated inaccurately.

6.2 Removal of the semi scheduled classification

The most definitive way to make semi scheduled generators follow dispatch targets like scheduled generators is to completely remove the semi scheduled classification. While there would undoubtedly be a number of legacy and transition matters to address with this option, the discussion below focusses on the implications after removal of the semi scheduled classification.

The key characteristic of the scheduled generator classification is that dispatch instructions are targets that are based on information provided by participants in their offers, including their expected generator availability. Dispatch instructions effectively govern the response of the generator and are ideally implemented through continuous SCADA instructions from AEMO's automatic generation control (AGC) system[21].

Generators currently classified as semi scheduled are required to provide dispatch offers with price and quantity bands and ramp rates (see NER cl 3.8.6) and must comply with instructions to operate at less than or equal to a stated cap on output during semi dispatch intervals. AEMO calculates dispatch instructions based on the offer information supplied by generators, and its calculation of the available capacity using the Unconstrained Intermittent Generation Forecast (UIGF), from AWEFS/ASEFS, unless the offer from the generator includes an availability value that is lower than the UIGF.

AEMO developed AWEFS/ASEFS to determine the available capacity for participants, but has also developed an operating procedure where generators may self-forecast their capacity. Information from AEMO indicates that the learning algorithms in these forecasting systems are however also learning about network constraints that affect the dispatch of these generators. This situation is not ideal as the UIGF should represent the generators unconstrained output. Where lower values are determined the opportunity for the operators of these facilities to position themselves is compromised.

As scheduled generators, they would determine their maximum capacity and provide price volume pairs in their offers on which NEMDE would determine their dispatch target. This would normally operate under the control of AEMO's AGC. As a result, intermittent generation would be dispatched to no more than their target, subject to an allowance for any ramp needed to meet the target.

Removing the semi scheduled category would require the participant to provide a more technically comprehensive offer. This could use AEMO's AWEFS/ASEFS UIGF values and the corresponding 10 price volume pairs. Where their resource capability is less than

21 The AGC system sends SCADA dispatch targets to each generating unit with that capability

instructed by the AGC system, their output would fall below the AGC instruction. While this would in principle breach existing obligations for scheduled generators to follow the dispatch instruction, where there is evidence that not achieving the target was due to the resource the AER could exercise its discretion with respect to compliance in accordance with the existing practice under 4.9.8. The AWEFS and ASEFS could be used as the benchmark non-compliance to some degree. For example, if the AWEFS or ASEFS at the end of the interval indicated a fall in resource, the plant may not be considered to be non-compliant if its output fell by an equivalent amount.

Semi scheduled generators are already required to comply with dispatch instructions that require them to operate at less than or equal to a stated cap on output during semi dispatch intervals and if classified as scheduled would operate to instruction at all times. Anecdotally, we understand that many of these generators already have systems to monitor AEMO information systems for intervals when a semi dispatch cap is applied and to adjust their output accordingly. Therefore, the cost for operation as a scheduled generator would be little different to that currently, when classified as a semi scheduled generator.

While AWEFS and ASEFS and alternative self-forecasting arrangements have improved over time, some intermittency of resource on which semi scheduled generators depend will remain. The increasingly commercial behaviour of some semi scheduled generators, with adverse outcomes for system security and economic efficiency contradicts one of the original assumptions for the semi scheduled category that intermittent plant will always seek to operate to the full extent of the renewable resource. While the incentive to avoid negative prices is an obvious reason not to maximise dispatch, it is a significant change in conditions from the original assumptions when the semi scheduled category was established.

Removing the semi scheduled classification will not change the fact that the resource the generators rely on will remain intermittent. Unique compliance arrangements for intermittent generators could make broader enforcement actions problematic and would be inconsistent with the recent review of NER clause 4.9.8.

Hybrid facilities would be well suited to this approach because of their increased ability to control their output and would be ideally suited for dispatch as a scheduled generator.

Operation on AEMO's AGC system as described would prevent an intermittent plant from increasing output in the event its resource input increased within a 5-minute period. Any increase in resource input would require intermittent energy to be spilt. This outcome is a disadvantage, although understood to be not significant and will be impacted by forecasting techniques such as intensive wind gust and cloud monitoring – it is also is similar to a thermal generator where heat rate of fuel increases unexpectedly.

A significant benefit of this option is that rapid controllable increase or decrease that results in adverse system security outcomes will no longer be possible. However, the risk of rapid falls due to cut-out at high wind speed or temperature will not be directly affected and can only be addressed through better forecasting and pre-emptive offloading. Further work will be required in this area to determine how to balance costs and risks.

Currently, AEMO non-conformance reporting only applies to semi scheduled generators when a semi dispatch cap is in place. The removal of the category would mean that semi scheduled generators would be continuously included in AEMO non-conformance monitoring and notification. This will, at least, provide a delayed signal for these generators about deviating from their targets. While this is not a replacement for following dispatch instructions, it could provide a transition step for some period prior to the activation of an expectation of compliance with a dispatch target in a new rule.

Amendments to the rules would need to be relatively substantial but would broadly include the removal of definitions such as dispatch level, semi dispatch / non semi dispatch interval and all reference to semi scheduled generating units and systems. The removal of clause 4.9.5 (6) of the NER, which only applies to semi dispatch generation, and the amendment of clause 4.9.2 to remove the distinction between scheduled and semi scheduled generation would also be necessary. It would also require the removal of the chapter 2 semi scheduled registration arrangements and adjustments to chapter 3 with respect to AEMO dispatch procedures and bids/bidding. A non-exhaustive examination of rule changes is provided in Appendix D.

The benefits of this option would include better management of resources in order to better target reliability and security. However, there would be costs associated with semi-scheduled plant installing more IT systems and controls in order to meet these requirements.

Removal of the semi scheduled classification would contribute to the NEO by removing the opportunity for commercially driven changes to output from generators that creates adverse risks to system security, higher FCAS costs, and distortions to market price. This benefit would be achieved with little or no cost. The downside of preventing semi scheduled from exceeding the target even if its resource increases during the 5 minute period is understood to not be material.

6.3 Amendment to rules for operation of semi scheduled generation

This option (and associated sub options) is designed to create requirements for semi scheduled generation to respond to dispatch instructions in a manner more closely aligned with scheduled generation while retaining other features of the semi scheduled classification. The AER has assessed three potential sub options for change within the overarching principle of amending the rules for semi scheduled generation. Each of the sub options also aims to ensure that AEMO has accurate information about either availability for dispatch or explicit dispatch intentions.

While the AER recognises the original reasons for the creation of the semi scheduled classification and the light-handed regulatory obligations that were imposed at that time, it appears that many of the assumptions that supported that approach have not eventuated or have been rendered invalid over time.

Importantly, semi scheduled generation technologies can, as shown in Figure 3 change their output extremely rapidly. If a semi scheduled generator is to be expected to achieve a target by the end of a dispatch interval it would also be appropriate to define a ramp rate within an instruction. This would avoid the generator turning off and on again within an interval and also manage the rate at which that generator returns to service following a rapid fall in output due to high wind speed or temperature cut-out.

Each of the sub options seek to make only those changes needed to address the current issues and includes provisions that recognise the potential variability of the resource and the complexity of implementing systems for compliance for generators, the AER and AEMO. The three sub options examined are described below:

- Dispatch instructions for semi scheduled generators to be megawatt target for the 5-minute interval which would automatically incorporate the effect of a cap on output if necessary.
- Dispatch instructions for semi scheduled generators to be an energy target (megawatt hours) for the 5-minute interval which would automatically incorporate the effect of a cap on output if necessary.
- Semi scheduled participants to develop and advise AEMO of their preferred dispatch and subject to system security requirements these preferences will become their target via an instruction back to the generator.

6.3.1 Dispatch instructions to semi scheduled generators to be a megawatt target for the end of the 5-minute interval and a ramp rate

The intent of this sub-option is to require semi scheduled generators to comply with a target for the end of the 5-minute interval at a rate that accommodates both their dispatch instruction and intermittency of fuel resource. The target would be in the form of a megawatt level for the end of the 5-minute interval and is therefore very similar to the arrangements for scheduled generation. The concept of a semi dispatch interval and a semi dispatch cap would be removed.

The rules and AEMO's procedures would be amended to require that output moves linearly to the target; the same as currently applies to scheduled generators (other than when providing FCAS). This requirement would extend the arrangement to require semi scheduled generators to comply with targets at all times and would replace the current requirement to not exceed a cap during a semi dispatch interval.

As each target would be determined accounting for the total capacity of generating units available and wind speed determined either by AWEFS/ASEFS, or an AEMO approved self-forecast methodology, the targets should already incorporate some relevant known environmental conditions. However, improvements to the AWEFS/ASEFS calculations to ensure more complete consideration of risk of cut-out would be beneficial to price and dispatch information for participants. Dispatch targets developed by AEMO for the resumption of production would need to be governed by ramp rates in the generator's offer to avoid excessive ramp rates.

Since the semi scheduled generator would be required to follow its target, output above the target, for example if the wind or solar input increased above what was forecast, would not be allowed given the potential impact on FCAS and ultimately on system security. This would be reflected in subsequent dispatch targets once either the self-forecast of the higher output has come into effect with a rebid, or AWEFS/ASEFS has recognised the change in circumstance and adjusted the available capacity. Output below the target caused by reduced wind or solar resource would be accepted. Arrangements for the submission of PASA and offer data would remain as they are.

Generators seeking to dispatch other than in line with their wind or solar resource, for example where there is a storage embedded behind the meter will need to ensure their bids reflect their commercial interests or are based on self-forecasts. Where an existing semi scheduled generator is converted to a hybrid, their registration should be changed to scheduled.

The key amendments to the NER for semi scheduled generators under this option would be the inclusion of a new sub clause under 4.9.8 to allow a semi scheduled to deviate below its target depending on their resource, to remove the definition of dispatch level, semi dispatch interval and non semi dispatch interval in Chapter 10 of the NER cl 4.9.2 (3) and cl 4.9.5 (6) which relate only to semi scheduled generation, and to include semi scheduled generation in NER cl 4.9.2 (2). Chapter 3 processes such as non-conformance and causer pays determination for semi scheduled generators would also need minor adjustments.

For similar reasons to those discussed for removal of the semi scheduled classification, costs to individual semi scheduled generators are expected to be low given that any generator classified as semi scheduled is already required to provide dispatch related information to AEMO and must comply with instructions to operate at less than or equal to a stated cap on its output during semi dispatch intervals. Semi scheduled generator revenues are not expected to be materially affected. With more reliable pre dispatch forecasts, semi scheduled generators can rebid their capacity to higher prices for those intervals to avoid dispatch into a negative priced dispatch interval. Furthermore by moving linearly between targets their causer pays outcomes should be lower.

Similar to the option to remove semi scheduled classification, and other options to amend provisions for semi scheduled generators, a significant benefit of this option is that rapid controllable increase or decrease that results in adverse system security outcomes should not occur. However, the risk of rapid falls in output due to cut-out at high wind speed or temperature will not be directly affected and can only be addressed through better forecasting and pre-emptive offloading should the size of a potential drop become problematic. Pre-emptive offloading would clearly be of commercial concern to the generators and further work will be required in this area to determine how to balance costs and risks.

The amendments in this sub option would contribute to the NEO by removing the opportunity for commercially driven changes without a corresponding dispatch target by semi scheduled generators, which create adverse risks to system security, higher FCAS costs and distortions to market price. Restrictions on self-dispatch, especially by limiting rapid changes in output would closely align with the restrictions on scheduled generators.

6.3.2 Dispatch instructions to semi scheduled generators to be an energy target to be achieved during the 5-minute interval

The intent of this sub option is to require semi scheduled generators to comply with a target for the 5-minute interval at a rate that accommodates both their dispatch instruction and intermittency of resource. The target would be in the form of an energy target over the interval. It would be developed from NEMDE's calculation of megawatts at the end of the interval.

Expressing the target in terms of energy over the 5 minutes means there would be more flexibility to cater for inherent variability of the "fuel" resources during the interval and potentially lower the compliance monitoring burden needed. The definition of a dispatch instruction to a semi scheduled generator would be amended to state the energy target to be produced during the dispatch interval and, if appropriate, a maximum megawatt range to ensure that a network limit is not exceeded may need to be applied. Together the energy target, maximum ramp rate and a maximum megawatt range would describe an operational envelope. The concept of a semi-dispatch interval and the semi dispatch cap would both be removed because the generator is expected to perform in accordance with that envelope

An energy target over the interval would be based on expected wind or solar resources over the interval, as well as any commercial considerations in the bid from semi scheduled generators and derived from the outcome of NEMDE. The key advantage of an energy target is that minor fluctuations within the interval will be absorbed and the final megawatt output at the end of the interval will be of less concern. However, to comply with the target semi scheduled generators will need to follow the ramp rates of their resource and any commercial factors included in the bid that was used to form the instruction. In particular, there will be no scope to vary dispatch by any significant amount and still achieve the energy target. Defining an instruction to semi scheduled generation as an energy target would be consistent with the original expectation of the behaviour of intermittent generation at the time the semi scheduled category was created.

Similar to the option to remove semi scheduled classification and other options to amend provisions for semi scheduled generators a significant benefit of this option is that rapid controllable increase or decrease in output that results in adverse system security outcomes would be proscribed. However, the risk of rapid falls in output due to cut-out at high wind speed or temperature will not be directly affected and can only be addressed through better forecasting and pre-emptive offloading. Further work will be required in this area to determine how to balance costs and risks.

The key amendments to the NER to achieve this option would be to remove the definition of dispatch level, semi dispatch interval and non semi dispatch interval in Chapter 10 and NER cl 4.9.5 (6) of the NER, and amend NER cl 4.9.5 (3) to refer to an energy target in place of a maximum power level (or perhaps amend NER cl 4.9.2 (a)(2) with respect to the level of power to be supplied over the specified period).

For similar reasons to those discussed for the previous two options, costs to individual semi scheduled generators are expected to be low. Under this option there would be greater flexibility to allow output to move up or down where it could be demonstrated the variation related to varying resource availability.

However, determination of causer pays for this option may be problematic but could be resolved by reference to the original AWEFS/ASEFS end of dispatch interval target on which the energy in the period was calculated. This approach would avoid significant structural changes to the fundamental causer pays calculation. While using an energy target allows some variation during the dispatch interval, the calculation of causer pays factor against an end of dispatch interval target is somewhat of a contradiction. However, it should be noted the causer pays factor itself has major approximations– see Appendix A

This sub option will contribute to meeting the NEO for similar reasons to the previous option but provide greater flexibility for minor variations in output while aligning restrictions on the rate of change in output to those of scheduled generators. However, it has the disadvantage of compromising uniformity of approach to the structure of an offer by introducing the complexity of determining an energy target for semi scheduled generators, different to the megawatt target for scheduled generators.

6.3.3 Semi scheduled participants to develop and advise AEMO of their preferred megawatt dispatch level and subject to system security requirements this will be a target

Another option that allows participants to be responsible for their output would be to provide their preferred level of dispatch for each 5-minute interval. That is, all semi scheduled participants would behave as if they were inflexible. They would develop and nominate their preferred level of dispatch, as opposed to availability, for each 5-minute dispatch interval. AEMO would incorporate this as an inflexible input to NEMDE and, subject to any requirements for a different level to manage system security, and issue a target for the end of the interval. The rules currently give inflexible generators priority over some constraints, a situation which may need some consideration with respect to system security.

As each semi scheduled participant would determine its level of dispatch. That is they would be operating in a similar, but not identical, manner to inflexible generation. Like an inflexible scheduled generator, they would be price takers and not be involved in setting market price. Consequently, they would have no protection from adverse price outcomes, for example if market price was unexpectedly (to them) lower or higher than anticipated when submitting their dispatch profile.

Changes in plant availability due to variations in resource input (wind strength or solar irradiance) from start to the end of a dispatch interval would be used to assess compliance within the AWEFS and ASEFS. There would be enhanced representation of local conditions that are not currently included in the AWEFS and ASEFS algorithms. While currently wind turbine or inverter outages are included, depending on the future role of these systems, other conditions such as the condition of the balance of plant, wind direction and temperature for wind, and wind speed and panel dirt for solar could also be reflected.

The behaviour and intentions of hybrid systems with behind the meter storage would be easily accommodated, but are largely irrelevant, as the participant would be inflexible.

AWEFS and ASEFS will remain important for determining the allowances to be made for non-scheduled generation. While AWEFS/ASEFS could still be used for semi scheduled generation it would be desirable for all semi scheduled generation to submit self-forecast availability and price-quantity bids/offers. AWEFS and ASEFS would continue to be a back-up for failure to receive self-forecast information and for assessing output of non-scheduled generators to offset demand in NEMDE. Relevantly, AEMO and ARENA are currently undertaking a short-term forecasting trial involving approximately 35 per cent of semi-scheduled wind and solar capacity registered in the NEM (or around three gigawatts of installed capacity). The trial investigates the accuracy of the forecasting technologies used by the trial participants and the effect different weather, operational conditions and geographies have on the accuracy of forecasts across the NEM.

However, this option has a significant disadvantage for economic efficiency. Under this option, semi scheduled participants will have greater dependence on pre-dispatch to assess how to position their offers for dispatch.

Based on the ISP forecasts of future levels of semi scheduled generation, if this option were to be adopted a significant percentage of the generation fleet would effectively be self-dispatched.

This would likely lead to inefficient outcomes sacrificing the benefit of dispatch based on the prices submitted by participants and reducing economic efficiency overall of dispatch. This would occur as pre-dispatch would be a progressively less reliable guide to how to structure bids defeating the role of pre dispatch to assist in setting the level of dispatch.

For this reason this option is not considered practical and has been excluded from further consideration.

6.4 Semi scheduled registration conditions

In principle the conditions attached to the registration of semi scheduled generators could include restrictions to address generators dramatically changing their output without a corresponding dispatch instruction. When considering an application for registration of a generator as semi scheduled, AEMO must approve an application if amongst other requirements, AEMO is satisfied that the output of the generating unit is intermittent as defined in the rules.

While that registration may be subject to conditions imposed by AEMO[22] it is not clear that the current power to impose conditions would allow AEMO to prohibit the operation of control systems and manual procedures that allow for a rapid change in output, including the effect of behind the meter storage, in response to a change in price, without notifying AEMO (via a rebid for the applicable dispatch interval). A broadening of the scope of the power to impose conditions could potentially enable AEMO to do this. This would be similar to the treatment of a scheduled generator failing.

However, an amendment of the power to impose conditions would not apply to existing registrations/conditions. This would be problematic and consequently impractical as it will leave significant legacy conditions and result in a range of participants subject to different conditions. Also, it may not be appropriate to use registration conditions to affect operational behaviour and any such conditions would still be required to account for the effect of intermittent wind and solar resources.

Accordingly, amending the registration process is not a preferred means to respond to the underlying need for change and is not considered further.

22 See NER cl 2.2.7 (c), (e) (f)

7 Improving the quality of information to AEMO

Under current arrangements, AEMO receives bids and offer information and has knowledge of ramp rate capabilities on which, in conjunction with network information, it develops dispatch instructions. However, as noted, the rules allow semi scheduled generators very wide discretion on their level of dispatch and the rate at which they may change output. Furthermore the AEMO process to dispatch semi scheduled generators using AWEFS/ASEFS is dependent on the design of those algorithms rather than information provided by the participants. AEMO has introduced a self-forecast option using an approved forecasting methodology which is preferable notwithstanding AWEFS and ASEFS will still be the most pragmatic means to account for non-scheduled plant capacity in running NEMDE. To the extent that AWEFS/ASEFS are retained as the primary source of input for dispatch further work would be valuable to refine their operation to account for the risk of high speed and high temperature cut out and separation of plant and network capacity. However, these amendments would appear to be able to be undertaken within current rules. For example: AEMO prepares the forecast of available capacity for the semi schedule generator (NER cl 3.7B), this is their theoretical Unconstrained Intermittent Generation Forecast which is then used in NEMDE with the 10 price / volume pairs in the bid from the semi scheduled generator. For conventional generators, the available capacity for each unit is submitted by the generators.

AEMO's AWEFS guideline[23] indicates that, although Max Avail is mandatory field, for semi-scheduled generators the available capacity value is the output of the AWEFS calculation and the Max Avail field from the participants offer is effectively discarded. We also note that certain generator status values are telemetered to AEMO via SCADA and NEMDE uses the most constraining value in dispatch.[24]

The existing market rules require generators to continually update AEMO with information and forecasts of future capability, however processes that override information provided with other sources compromise the efficacy of that information provision and rules obligations.

All options identified as practical will involve a change to the way in which the rules provide for what a dispatch instruction for a semi scheduled generator involves/includes (or, to go further, to remove the semi scheduled classification). Until the final form of the rule to be implemented is known it is problematic to determine other changes that would be needed to ensure that AEMO is more fully informed.

Question 10: How can the flow of data and information to AEMO be improved?

23 AEMO, 2016, Australian Wind Energy Forecasting System (AWEFS), www.aemo.com.au/-/media/Files/PDF/Australian-Wind-Energy-Forecasting-System-AWEFS.ashx

24 AER, 2019 Rebidding and Technical Parameters Guideline, page 12

Appendix A – Explanation of FCAS

Frequency Control Ancillary Services

Frequency control ancillary services (FCAS) are required to maintain the frequency of the power system within the frequency operating standards. The two general categories of FCAS are:

- Regulation services, which continuously adjust to small changes in demand or supply (changes that cause the frequency to move by only a small amount away from 50 Hz). There are regulation services to increase the frequency (raise regulation or RREG) and services to decrease the frequency (lower regulation or LREG).
- Contingency services, which manage large changes in demand or supply that occur relatively rarely and move the frequency by a large amount. There are three contingency services to increase the frequency and three contingency services to decrease the frequency. Raise contingency FCAS are required to be available to correct frequency excursions that have arisen from a credible contingency event that leads to a decrease in frequency. As these contingency events usually involve step reductions in supply side, the Electricity Rules stipulate that generators pay for these services. Lower contingency FCAS are the services required to be available to correct the frequency excursions that arise from a credible contingency event that leads to an increase in frequency. As these contingency events usually involve step reductions in customer demand, the Electricity Rules stipulate that customers pay for these services.

Participants providing regulation services receive adjusted dispatch targets every 5 minutes via their automatic generation control (AGC) signals from AEMO. Participants are paid through the FCAS markets in accordance with their offered volumes. Their energy production, which may be higher or lower depending on the AGC signals they receive, are settled in accordance with energy market prices.

There are three lower and three raise contingency services:

- fast services, which arrest a frequency deviation within the first six seconds of a contingent event (L6 and R6);
- slow services, which stabilise frequency deviations within sixty seconds of the event (L60/R60); and
- delayed services, which stabilise frequency deviations within five minutes of the event (L5/R5).

Participants offering to provide contingency services are enabled in accordance with the “trapezium” supplied in their offers. While participants will not necessarily be supplying these services until a contingency occurs they are paid in accordance with their enablement.

Frequency Control Ancillary Service Settlement

AEMO settles the FCAS markets on a weekly basis, as follows[25].

- Regulation FCAS: Cost recovery on a "causer pays" basis using the Causer Pays Procedure[26] developed by AEMO in accordance with the appropriate NER procedures.
- Contingency FCAS: Generators pay for Raise Services and customers pay for Lower Services.

The 'Causer Pays' Procedure allocates regulation FCAS costs to those market generators, customers and small generation aggregators with facilities that have the metering capable of determining their contribution to frequency deviations at any time.

Every four weeks based on historical data AEMO calculates a causer pays contribution factor for each generator. Broadly, the contribution factor is determined from historical 4 second generator output and frequency information and is a measure of how each generator contributed to managing changes in the system frequency. If a generators' output changes such that it supports maintaining the system frequency its contribution factor is positive. Conversely, if a generator's output changes such that it exacerbates a frequency deviation, its contribution factor will be negative. The causer pays contribution factors for a portfolio of generators effectively represent the aggregation of the individual performance of the generators in that portfolio.

Settlement is determined by allocating the FCAS costs incurred in the current period in accordance with the causer pays contribution factor for that portfolio from the preceding period. Thus cost allocation to a participant is not dependent on the amount of energy purchased or consumed in that period but by the performance of that participant in managing system frequency in the previous period.

Consequently a portfolio of generators with a negative factor in a particular period will still pay a share of FCAS costs irrespective of how much it generates in the current period.

Since not all of the costs will be recovered from generators, the residual costs are recovered from market customers (including retailers) in the relevant region, based on the amount of energy each market customer is purchasing.

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25 For a full description go to https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Ancillary-Services/Ancillary-Services-Payments-and-Recovery

26 For a full description go to https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Ancillary-services-causer-pays-contribution-factors

Appendix B – Operation of dispatch instructions

Dispatch instructions are based on information provided by each generator and technical parameters specifying the current condition of the power system. In the case of wind and solar generation AEMO uses resources including the AWEFS and ASEFS respectively which use data transmitted from measuring points within the different wind and solar farms and converted to megawatt capability using Energy Conversion Models (ECMs). These models are required to be submitted at the time of registration. Participants' ECMs are verified by AEMO in a lengthy process over a number of weeks as part of their commissioning and trials processes and adjusted in light of experience. Alternatively, generators that can demonstrate to AEMO that they are capable of performing the function adequately, may calculate their own expected generation availability in self-forecasts.

The proposed rule changes are intended to address Energy Council concerns by making sure that semi scheduled generators follow dispatch instructions in the same way as scheduled generators, restricting the observed deviation from target and ensuring AEMO has the most accurate information about each semi scheduled generator for the forecast period.

The amendments are being developed in the context of the existing arrangements for generators and loads to interact with the NEM which are summarised below:

- **Scheduled generators and loads** receive dispatch instructions each 5 minutes and have clear obligations to comply with those instructions in respect of output (or consumption in the case of loads) at the end of the 5 minute dispatch interval and also the rate at which their output changes within the interval[27]. Scheduled generation is required to submit data to the projected assessment of system adequacy (PASA) and pre-dispatch processes in accordance with the deadlines prescribed in accordance with the rules.
- Although **semi scheduled generators** receive dispatch instructions for each 5-minute dispatch interval, these instructions are based on the participants' price/volume offer pairs and AWEFS and ASEFS calculations unless a participant uses an approved self-forecast. However, a dispatch instruction for semi-scheduled generation only represents a maximum level of power over the dispatch interval. They are only identified as non-conforming if they exceed an applicable semi-dispatch cap. Semi scheduled generators are therefore technically compliant with dispatch instructions if they self-dispatch to any level below the cap in a semi dispatch interval, and otherwise at any level up to the resource availability.

  An AEMO operating procedure[28] requires the semi scheduled generating units to ramp linearly to a cap if it is applied in the next dispatch interval.

27 see NER cl 4.9.2, 4.9.3, 4.9.4 and 4.9.5

28 AEMO System Operating Procedure 3705, Section 5.2

Semi scheduled generators are required to submit plant availability data from which AEMO will determine the facilities' availability capacity for PASA[29]. A dispatch instruction to a semi scheduled generator therefore has quite a different status to a dispatch instruction to a scheduled generator. However, in both cases the dispatch level specified in the instruction represents AEMO's expectation of the energy dispatch of all generators and ancillary service allocations to meet demand securely and determines market price.

- **Non-scheduled generators** do not receive dispatch instructions and are free to self-dispatch, but their expected outputs are determined on the basis of persistence (that is assuming that their forecast output at the end of the next 5 minute interval will be the same as it is at the start of that interval) and deducted from the forecast of customer demand by AEMO prior to determining instructions to scheduled and semi scheduled units. For this reason, other than a small number of grandfathered units, only small intermittent generators are permitted to be non-scheduled.
- The bulk of **consumer demand** is non-scheduled in that individual consumers can increase or decrease consumption as they wish. A key part of AEMO's short term dispatch process is to forecast the aggregated consumption of consumers. Behind the meter and small grid connected generation is also able to change output as they wish.

29 NER cl 3.7B(b)

Appendix C – Negative prices – part of a normally functioning market

Negative prices are part of the normal functioning of the market

The negative market price floor and the ability to lodge negative price offers were originally designed to provide financial incentives for participants to self-manage their commitment decisions. Thermal generators could indicate in their offers their minimum output level and willingness to continue operating or shut down. During negative wholesale market price periods all generators operating at that time pay not only their operating costs but also the market price for their energy. The price floor has been minus $1000 per MWh since the initial zero price floor was removed in 2000.

Broadly AEMO dispatches generators using the lowest priced offers first. This means that generators offered at the price floor are committed first, ensuring their dispatch. Negative priced offers form a large part of the capacity offered into the market. When there is sufficient negatively priced capacity available to meet demand the wholesale market price is negative as the price of the last dispatched megawatt to meet demand sets the wholesale price.

Why do generators offer at negative prices?

Intermittent generators that rely on renewable fuel sources, like solar and wind, have zero fuel costs and running costs around $5/MWh. These technologies can operate at virtually any level of output providing that their resource is available and incur virtually no additional costs to start or shut down. They also have access to out-of-market forms of incentives, such as the large-scale generation certificates created under the Renewable Energy Target, which provide an income for every megawatt hour produced regardless of the wholesale market electricity price. Where two or more semi scheduled generators are connected to the network in an area with limited capacity, a negative price offer may also be used to differentiate or compete with those other participants behind the constraint. Semi scheduled generators therefore may offer capacity in negative price bands to ensure that their energy is dispatched, although, depending on their contracts with retailers, they may be financially exposed if negative prices eventuate.

Thermal generators operate from more secure fuel supplies and have minimum stable operating levels – similar to the idling of an automotive engine. Different types of thermal generation have different minimum stable levels and may have significant variation in the cost to start and stop. Gas turbines can be started relatively quickly and cheaply compared to a baseload generator (e.g. a coal-fired generator) that incurs significant costs in conjunction with extended start up and shut down times. Gas turbines would typically operate on more expensive fuels than base load generators. A baseload generator operating continuously to avoid start and stop costs will reduce their output to its lowest possible level when prices fall below their fuel and operating costs. Hence, during short periods of negative price these generators are likely to continue to operate, paying the market to produce energy. Furthermore thermal generators have significant levels of financial market contracts. If their generation is off when a high price occurs they could be materially exposed in the financial markets. These generators therefore offer at negative prices to avoid being switched off, leaving their contract positions exposed, and incurring high start-up and shut-down costs.

Where congestion or network constraints may affect dispatch outcomes, scheduled and semi scheduled generators may also offer their capacity in negative priced bands to compete for dispatch with others behind the same network constraint.

Appendix D – Proposed solutions and applicable rule changes

Based on the analysis and discussion within the issues paper, we have concluded that the following options merit further consideration as options to achieve the objective, which is to ensure semi scheduled generators follow their dispatch instructions:

- Amend the definition of a dispatch instruction to semi scheduled to be a target in the form of a MW for the end of the dispatch interval and ramp rate. Retaining the semi scheduled classification and setting a clear megawatt dispatch target with a specified ramp rate would align arrangements for semi scheduled most closely with those for scheduled generation while recognising the inherent variability of intermittent generation.
- Delete the classification of semi scheduled generation and subject to legacy or transitional arrangements require all current semi scheduled generation to be classified as scheduled. Dispatch instructions to scheduled generation already impose ramp rate requirements so nothing further would be needed. Most generation that is currently classified as semi scheduled would not be able to operate on the AEMO AGC system to ensure it ramped progressively to its target in situations where the generation was operating to the limit of its resource.

The following sections set out the main proposed amendments to the Rules to achieve both of these options. Further administrative changes to the Rules would also be required for both options.

Option 1 - Dispatch instructions to semi scheduled generators to be a megawatt target for the end of the 5-minute interval and a ramp rate

Chapter 10 - Glossary

~~***dispatch level***~~

~~Means:~~

1. ~~for a semi-dispatch interval, the amount of electricity specified in a dispatch instruction as the semi-scheduled generating unit's maximum permissible active power at the end of the dispatch interval specified in the dispatch instruction; and~~
2. ~~for a non semi-dispatch interval, an estimate of the active power at the end of the dispatch interval specified in the dispatch instruction.~~

~~***semi-dispatch interval:***~~

~~For a *semi scheduled generating unit*, a *dispatch interval* for which either:~~

~~(a) a ***network constraint*** would be violated if the ***semi-scheduled generating unit's generation*** were to exceed the ***dispatch level*** specified in the related ***dispatch instruction*** at the end of the ***dispatch interval***; or~~

~~(b) the ***dispatch level*** specified in that ***dispatch instruction*** is less than the ***unconstrained intermittent generation forecast*** at the end of the ***dispatch interval***,~~

~~and which is notified by ***AEMO*** in that ***dispatch instruction*** to be a ***semi-dispatch interval***.~~

~~***Non semi-dispatch interval***~~

~~For a *semi scheduled generating unit*, a *dispatch interval* other than a *semi dispatch interval*~~

Chapter 3 – Market Rules

Clause 3.8.23 Failure to conform to dispatch instructions

(a) If a *scheduled generating unit*, *semi-scheduled generating unit*, *scheduled network service* or *scheduled load* fails to respond to a *dispatch instruction* within a tolerable time and accuracy (as determined in AEMO's reasonable opinion), then the *scheduled generating unit, semi-scheduled generating unit, scheduled network service* or *scheduled load* (as the case may be):

1. is to be declared and identified as non-conforming; and
2. cannot be used as the basis for setting *spot prices*.

~~(b) If a *semi-scheduled generating unit* fails to respond to a *dispatch instruction* within a tolerable time and accuracy (as determined in AEMO's reasonable opinion) in a *semi-dispatch interval* where the unit's actual *generation* is more than the *dispatch level*, the unit is to be declared and identified as nonconforming and cannot be used as the basis for setting *spot prices*.~~

Chapter 4 – Power System Security

4.9.2 Instructions to Scheduled Generators and Semi-Scheduled Generators

(a) To implement *central dispatch* or, where *AEMO* has the power to direct or to instruct a *Scheduled Generator* or *Semi-Scheduled Generator* either under Chapter 3 or this Chapter, then for the purpose of giving effect to that direction or instruction, *AEMO* may at any time give an instruction to the *Generator* in relation to any of its *generating units* (a *dispatch instruction*), in accordance with clause 4.9.5(b), nominating:

1) whether the facilities for *generation* remote control by *AEMO*, if available, must be in service;

2) in the case of a *scheduled generating unit* or *semi scheduled generating unit*, the level or schedule of power to be supplied by the *generating unit* or *semi scheduled generating* unit over the specified period;~~ and~~

~~3) in the case of a *semi-scheduled generating unit*, the maximum level of power to be supplied by the *generating unit* over the specified period.~~

4.9.5 Form of dispatch instructions

(a) a *dispatch instruction* for a *scheduled generating unit, semi-scheduled generating unit, scheduled network service* or *scheduled load* must include the following:

(3) in the case of a dispatch instruction under clause 4.9.2, the ramp rate (if applicable) which is to be followed by the generating unit, *semi scheduled generating unit* or a specific target time to reach the outcome specified in the dispatch instruction;

~~(6) in the case of a *dispatch instruction* for a *semi-scheduled generating unit*:~~

~~i. a notification as to whether the *dispatch interval* to which the *dispatch instruction* relates is a *semi-dispatch interval* or a *non semi-dispatch interval*; and~~

~~ii. the *dispatch level*~~

4.9.8 General responsibilities of Registered Participants

(a2) A *Semi-Scheduled Generator* does not fail to comply with a *dispatch instruction* for a *dispatch interval* because of a limitation in the availability of the resource (including energy storage).

Option 2 - Removal of semi scheduled classification

Chapter 10 - Glossary

~~***dispatch level***~~

~~Means:~~

1. ~~for a semi-dispatch interval, the amount of electricity specified in a dispatch instruction as the semi-scheduled generating unit's maximum permissible active power at the end of the dispatch interval specified in the dispatch instruction; and~~
2. ~~for a non semi-dispatch interval, an estimate of the active power at the end of the dispatch interval specified in the dispatch instruction.~~

~~***semi-dispatch interval:***~~

~~For a *semi-scheduled generating unit*, a *dispatch interval* for which either:~~

~~(c) a *network constraint* would be violated if the *semi-scheduled generating unit's generation* were to exceed the *dispatch level* specified in the related *dispatch instruction* at the end of the *dispatch interval*; or~~

~~(d) the *dispatch level* specified in that *dispatch instruction* is less than the *unconstrained intermittent generation forecast* at the end of the *dispatch interval*,~~

~~and which is notified by *AEMO* in that *dispatch instruction* to be a *semi-dispatch interval*.~~

~~***Non semi-dispatch interval***~~

~~For a *semi scheduled generating unit*, a *dispatch interval* other than a *semi-dispatch interval*~~

Chapter 2 – Registered Participants and Registration

2.2.1 Registration as a Generator

(e) To be eligible for registration as a Generator, a person must:

(1) obtain the approval of AEMO to classify each of the generating units that form part of the generating system that the person owns, operates or controls, or from which it otherwise sources electricity, as:

~~(ii) a semi-scheduled generating unit; or~~

(2A) if a generating unit is classified as a scheduled generating unit ~~or a semi-scheduled generating unit~~ in accordance with subparagraph (1):

2.2.2 Scheduled Generator

(a) A generating unit which has a nameplate rating of 30 MW or greater or is part of a group of generating units connected at a common connection point with a combined nameplate rating of 30 MW or greater must be classified as a scheduled generating unit unless AEMO approves its classification as:

~~(1) a semi-scheduled generating unit under clause 2.2.7(b); or~~

2.2.3 Non-Scheduled Generator

(a) A generating unit with a nameplate rating of less than 30 MW (not being part of a group of generating units described in clause 2.2.2(a)) must be classified as a non-scheduled generating unit unless AEMO approves its classification as:

~~(2) a semi-scheduled generating unit under clause 2.2.7(b).~~

~~**2.2.7 Semi-Scheduled Generator**~~

Chapter 3 – Market Rules

3.15.6A Ancillary service transactions

(k) *AEMO* must prepare a procedure for determining contribution factors for use in paragraph (j) and, where *AEMO* considers it appropriate, for use in paragraph (nb), taking into account the following principles:

~~7 a *Semi-Scheduled Generator* will not be assessed as contributing to the deviation in the *frequency* of the *power system* if within a *dispatch interval*, the *semi-scheduled generating unit:*~~

~~i. subject to the provision of *primary frequency response* by that *semi-scheduled generating unit* in accordance with the *Primary Frequency Response Requirements*, achieves its *dispatch level* at a uniform rate;~~

~~ii. is enabled to provide a market ancillary service and responds to a control signal from AEMO to AEMO's satisfaction; or~~

~~iii. is not enabled to provide a market ancillary service, but responds to a need for regulation services.~~

Chapter 4 – Power System Security

4.9.2 Instructions to Scheduled Generators and Semi-Scheduled Generators

(a) To implement *central dispatch* or, where *AEMO* has the power to direct or to instruct a *Scheduled Generator* ~~or *Semi-Scheduled Generator*~~ either under Chapter 3 or this Chapter, then for the purpose of giving effect to that direction or instruction, *AEMO* may at any time give an instruction to the *Generator* in relation to any of its *generating units* (a *dispatch instruction*), in accordance with clause 4.9.5(b), nominating:

1) whether the facilities for *generation* remote control by *AEMO*, if available, must be in service;

2) in the case of a *scheduled generating unit*, the level or schedule of power to be supplied by the *generating unit* over the specified period;~~ and~~

~~3) in the case of a *semi-scheduled generating unit*, the maximum level of power to be supplied by the *generating unit* over the specified period.~~

(d) A *Scheduled Generator* or ~~*Semi-Scheduled Generator*~~ must, with respect to its *generating units* that have an availability offer of greater than 0 MW (whether *synchronised* or not), ensure that appropriate personnel are available at all times to receive and immediately act upon *dispatch instructions* issued by *AEMO* to the relevant *Generator*.

4.9.5 Form of dispatch instructions

(a) A *dispatch instruction* for a *scheduled generating unit*, ~~*semi-scheduled generating unit*~~, *scheduled network service* or *scheduled load* must include the following:

(1) specific reference to the *generating unit* (including any aggregated *generating unit*), *scheduled network service* or *scheduled load* or other *facility* to which the *dispatch instruction* applies;

(2) the desired outcome of the *dispatch instruction* (if applicable) such as *active power, reactive power, transformer* tap or other outcome;

(3) in the case of a *dispatch instruction* under clause 4.9.2, the *ramp rate* (if applicable) which is to be followed by the *generating unit* or a specific target time to reach the outcome specified in the *dispatch instruction*;

(4) the time the *dispatch instruction* is issued;

(5) if the time at which the *dispatch instruction* is to take effect is different from the time the *dispatch instruction* is issued, the start time; and

~~(6) in the case of a dispatch instruction for a semi-scheduled generating unit:~~

~~(i) a notification as to whether the dispatch interval to which the dispatch instruction relates is a semi-dispatch interval or a non semi-dispatch interval; and~~

~~(ii) the dispatch level.~~