MARKET ANCILLARY SERVICE SPECIFICATION

ISSUES PAPER

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

EXECUTIVE SUMMARY

On 24 November 2016 the Australian Energy Market Commission (AEMC) issued the National Electricity Amendment (Demand Response Mechanism and Ancillary Services Unbundling) Rule 2016 (Ancillary Services Unbundling Rule Change).[1]

The Ancillary Services Unbundling Rule Change “unbundles”, that is, separates, the provision of *ancillary services* from the provision of energy.

This will open up the provision of ancillary services to a new class of participant (the *Market Ancillary Service Provider)*. This in turn would create more competitive opportunities for these participants to offer customer loads into the *ancillary services* markets, both at a single site and aggregated across a number of sites. The new *ancillary services* options will also help AEMO control the frequency on the electrical system. Deeper and more diverse Frequency Control Ancillary Services (FCAS) markets have the potential to lead to more efficient prices, minimising the cost of these services.

The provision of services by these new participants requires review and revision of the existing *Market Ancillary Service Specification* (MASS).

AEMO publishes this Issues Paper in accordance with clause 3.11.2 (d) of the National Electricity Rules (the Rules) to commence the first stage of the *Rules consultation process* to consider proposed amendments to the MASS[2].

AEMO has prepared this Issues Paper to facilitate informed debate and to seek feedback from stakeholders on amendments to the MASS to:

- Articulate the principles underlying the *market ancillary service specification*.
- Identify and where possible address any barriers to entry for new *Market Ancillary Service Providers*.
- Better define the services required in terms of what is needed for system security.
- Better describe the principles for verifying the performance of *plant.*
- Provide more flexibility in allocating of switching controller settings, particularly for aggregated units.

AEMO invites stakeholders to suggest alternative options where they do not agree that AEMO’s proposals would achieve the relevant objectives. AEMO also asks stakeholders to identify any unintended adverse consequences of the proposed changes.

The scope of this review is limited to application of the MASS within the existing *Rules* framework. In particular, this review is not intended to consider the broader framework of different or additional *ancillary services* that may be required due to the changing generation mix and nature of the power system. AEMO is currently scoping a larger work program to examine this *ancillary services* framework. That review will consider the technical issues around frequency control and whether or not the current markets are meeting the technical need as the energy market transitions. This work is also anticipated to feed into future AEMC reviews.

Stakeholders are invited to submit written responses on the issues and questions identified in this paper by 5.00 pm (Melbourne time) on 10 March 2017, in accordance with the Notice of First Stage of Consultation published with this paper.

[1] http://www.aemc.gov.au/News-Center/What-s-New/Announcements/Draft-determination-on-the-Demand-Response-Mec-(1)
[2] The existing MASS can be found on the AEMO webpage: http://www.aemo.com.au/-/media/Files/PDF/01600136pdf.pdf

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1. STAKEHOLDER CONSULTATION PROCESS

As required by the *Rules*, AEMO is consulting on proposed amendments to the *Market Ancillary Service* Specification (MASS) made under clause 3.11.2(c) of the *Rules*, in accordance with the *Rules consultation process* in rule 8.9.

A glossary of terms used in this Issues Paper is included in Appendix A.

AEMO's indicative timeline for this consultation is outlined below. Dates may be adjusted depending on the number and complexity of issues raised in submissions and any meetings with stakeholders.

Deliverable	Indicative date
Issues Paper published	25 January 2017
Submissions due on Issues Paper	10 March 2017
Draft Report published	26 April 2017
Submissions due on Draft Report	19 May 2017
Final Report published	30 June 2017

Prior to the submissions due date, or in a submission on this Issues Paper, stakeholders can request a meeting with AEMO to discuss the issues and proposed changes raised in this Issues Paper.

2. BACKGROUND

2.1 Rules requirements

Clause 3.11.2(b) of the *Rules* provides:

(b) *AEMO* must make and *publish* a *market ancillary service specification* containing:

(1) a detailed description of each kind of *market ancillary service*; and

(2) the performance parameters and requirements which must be satisfied in order for a service to qualify as the relevant *market ancillary service* and also when a *Market Participant* provides the relevant kind of *market ancillary service*.

The current version of the MASS was published on 20 March 2012. AEMO may amend the MASS from time to time under clause 3.11.2(c) of the Rules.

Clauses 3.11.2(f) defines the additional monitoring required to provide *market ancillary services* while Clause 3.11.2(g) provides for AEMO to develop standards that must be met in installing and maintaining the required equipment.

At present the requirements of both Clause 3.11.2(b) and 3.11.2(g) are contained in the current version of the MASS.

When amending the MASS, AEMO must comply with the *Rules consultation procedures*.

The release of this Issues Paper commences the first stage of that process.

2.2 Context for this consultation

This review was prompted by:

- The need to update the MASS to reflect the Ancillary Services Unbundling Rule Change which is due to take effect on 1 July 2017.
- Technological developments which are increasing the range of participants that can provide *market ancillary services* in the *National Electricity Market* (NEM).

As a consequence, this document is focussed on the application of the MASS within the existing *Rules* framework and does not consider potential future changes to the *Rules*. The scope of this review is discussed further in section 4.2.

2.2.1 Growth in new technologies

Australia's electricity industry is undergoing transformational change with fossil-fuelled generation being displaced at both the utility scale and the residential level with renewable generation, as customers become more actively involved in determining how their energy demand is met.

This change is projected to continue with a shift from large-scale, centrally-dispatched *generation*, towards distributed, *intermittent generation*, provided by wind and photovoltaic (PV) systems. This distributed generation is connected to the power system through solid state inverter systems, and includes a growing proportion of non-dispatched distributed generation such as rooftop PV.

This change in generation mix challenges the designs built into the power system and the regulatory framework within which it operates.

The MASS was drafted at a time when *market ancillary services* were provided by large coal, gas and hydro powered *generating units*.

While it is intended to be technology neutral and the last revision did specifically address issues around the provision of *market ancillary services* from generation or loads aggregated to form single dispatchable units, AEMO must ensure the MASS is regularly updated to keep pace with is the changes in generation happening in the NEM.

Against this backdrop, AEMO is assessing whether the current MASS presents any technical barriers to participation by new entrants to the *market ancillary services* markets.

2.2.2 Ancillary Services Unbundling Rule change

On 24 November 2016, the Australian Energy Market Commission (AEMC) issued the Ancillary Services Unbundling Rule Change.

While the final rule does not implement the demand response mechanism, it does allow for a new class of participant, the *Market Ancillary Service Provider*, to register with AEMO and unbundle the provision of *ancillary services* from the provision of energy. This will open up competitive opportunities to offer *ancillary services* from customer loads, both at a single site and aggregated across a number of sites by allowing the new *Market Participant* to offer these *market ancillary services* into the market. The delivery of these services will need to be in accordance with the MASS.

In its consultation, the AEMC identified perceived issues with provision of *regulation services* from aggregated loads and has recommended that AEMO review the relevant sections of the current MASS, and consider whether these technical limitations can be overcome or removed to allow broad competition in the provision of *market ancillary services*.

3. ISSUES UNDER CONSIDERATION

3.1 Barriers for new entrants

AEMO has been approached by a number of proponents of potential new supplies of *market ancillary services* using technologies such as wind, PV, batteries and loads currently not registered to provide these services.

These potential new entrants do not come with the background of existing *Market Participants* and have highlighted the complexity of the MASS and have expressed some difficulty in understanding the requirements.

These proponents have also identified a number of other potential barriers to their participation in the *market ancillary services* markets that may be able to be overcome without compromising the integrity of the power system.

3.1.1 Provision of regulation services

AEMO *enables generating units* to provide *regulation services* (*regulating raise* and *regulating lower services*) to ensure that all normal load and generation variations do not result in frequency deviations outside the *normal operating frequency band*, except for brief excursions.

On a real time basis, AEMO uses the *Automatic Generation Control* (*AGC*) system to instruct plant *enabled* to provide *regulating raise* and *regulating lower* services at the time to adjust their dispatch levels. The *AGC* system sends signals every four seconds (or eight seconds in Tasmania) through the Supervisory Control and Data Acquisition (SCADA) system to *enabled plant* that are required to respond to the signals to maintain frequency within the *normal operating frequency band*.

While it may be possible to read clause 1.3 of the current MASS as placing a barrier on aggregated units providing *regulation services*, it is AEMO's opinion that the clause does not read this way, rather it indicates that AEMO's systems can support aggregated units, but do not manage the individual *generating units* or *loads* within an aggregated unit. The AGC systems would send a single signal to the aggregated *generating unit* or *load* for the required target. The *Market Participant* would then be required to use their own *control systems* to provide the required response, in total, from their aggregated *generating units* or aggregated *loads*.

For *Market Participants* to be able to offer *regulation services*, they are required to install and maintain communication and control equipment to transmit information and receive raise and lower signals sent from AEMO's *AGC* system through the SCADA system.

The *AGC* signals received will apply to the whole of the aggregated *generating unit* or aggregated *load* and the *Market Participant* must have systems in place to ensure that individual units within the aggregated unit respond such that, in total, the aggregated unit provides the required *regulation services*. To ensure the integrity of the AGC system, the operating characteristics of each *market ancillary service* may need to be modelled in AEMO's *AGC* prior to registration.

3.1.2 Aggregation of loads across regions

Clause 3.8.3(b1) of the *Rules* (as amended by the Ancillary Services Unbundling Rule Change) mandates that Aggregation of loads must be in a single *region*:

3.8.3

(b1) *AEMO* must approve applications for aggregation made under paragraph (a1) if the following conditions are fulfilled:

(1) aggregated *ancillary service loads* must be *connected* within a single *region* and be operated by a single person (whether in its capacity as a *Market Customer*, *Market Ancillary Service Provider* or both);

As this requirement is set in the *Rules*, AEMO does not intend to re-visit this requirement as part of this review of the MASS.

3.1.3 Variable generation

The *generation* from *intermittent generating units* such as, PV generators, wave turbine generators, wind turbine generators and hydro-generators without any material storage capability varies as the fuel source varies. Unless AEMO approves otherwise, *intermittent generating units* with a nameplate of 30 MW or greater must be classified as *semi-scheduled generating units*.

In order to determine the performance and availability of *semi-scheduled generating units*, AEMO will need to estimate the output that would be expected from the *generating units* had they not been *enabled* to provide the *ancillary services*.

For each *dispatch interval*, the NEM dispatch engine (NEMDE) calculates dispatch target for each *semi-scheduled generating unit.* The calculation considers an estimate of generation calculated by the Australian Wind Energy Forecasting System (AWEFS) of the Australian Solar Energy Forecasting System (ASEFS). The recent review of the energy conversion models (ECM) for wind and PV *generating units*[3] included a provision for generators to improve this forecast through provision of an "Estimated Power" figure by the generator to AEMO.

The default method of calculating the anticipated generation of the period is to use a straight line interpolation between the actual generation at the start of the period and the *dispatch* target, as is currently used for synchronous *generating units* supplying these services. AEMO is interested in stakeholders' views on the appropriateness of this approach to measure variable generation performance and welcomes other suggestions for how this measure could be achieved.

3.1.4 Measurement of response across aggregated sites

For all *market ancillary services* the current MASS requires that:

> "The power flow representing the generation amount or load amount must be measured at or close to the relevant connection point or, if otherwise agreed with AEMO, sufficient measurements may be provided to calculate the generation amount or load amount."

Further for the six contingency *market ancillary services* the current MASS requires that:

> "The local frequency must be measured at or close to the relevant connection point or, if otherwise agreed with AEMO, an alternative measurement may be provided that closely represents the frequency at the connection point."

The current drafting of the MASS thus allows for aggregation. However, when the aggregated unit from which the service is to be provided is *enabled*, it needs to respond in the timeframe required and to the level required. Sufficient information also needs to be provided to AEMO to compare the local frequency and power flow data in a common time scale. In determining the change in power flow over the aggregated sites, AEMO will need to estimate how the load or generation may have varied had the aggregated unit not been *enabled* for the ancillary service.

As discussed in section3.2.2, AEMO believes that the key principle underlying the MASS is that it be related to power system frequency control and not just the delivery of a megawatt (MW) response.

AEMO is interested in hearing stakeholders' views on options for accurately determining the total change in power flow from the aggregated unit with time intervals appropriate to the service. With regard to switching controllers where blocks of load or generation can be controlled very quickly, the *Market Participant* may find it easy to provide the information required by AEMO about the operation of these controllers and the load or generation they control. However, for switching controllers with more varied controls, stakeholders may find the provision of the information more complex, but may have

[3] http://www.aemo.com.au/Stakeholder-Consultation/Consultations/Energy-Conversion-Model-Guidelines-Consultation---Wind-and-Solar-Farms

views that AEMO would welcome on workable options for measurement and verification in this situation.

3.1.5 High Speed Metering

For the fast raise and fast lower services, the current MASS requires that measurements of power flow and local frequency must be made at intervals of 50 millisecond or less. Where a switching controller is used, AEMO may agree that the power flow measurement representing the generation amount or load amount may be made at intervals of up to 4 seconds. This is provided another measurement of power flow at an interval of 50 milliseconds or less is provided that is sufficient to determine the timing of the *market ancillary service* provision relative to local frequency.

For *slow* and *delayed raise* and *lower services*, unless otherwise agreed by AEMO, the measurements of power flow and local frequency must be made at intervals of four seconds or less.

For all contingency services, the current MASS requires that the equipment must record the power and frequency measurements from a defined period before the frequency disturbance until a defined period after the frequency disturbance. The recordings must be made digitally and provided to AEMO on request.

AEMO currently requires data at these resolutions to be able to verify the performance of the units. However to facilitate the extension of the MASS, AEMO invites submissions outlining alternatives which could be used.

3.1.6 Other barriers

AEMO is interested to hear stakeholder views on other potential barriers to entry contained in the current version of the MASS that have not been identified in this issues paper and options available to overcome them without impacting on the integrity of the services.

Questions

- What barriers to entry for new Market Participants and new technologies are contained in the current MASS and what options are available to overcome the barriers while maintaining the integrity of the markets?
- What options exist for determining the total change in power flow from aggregated loads?
- Do you agree with the approach to determining the performance of variable generation and if not, how should it be determined?
- Other than high speed recorders, what options exist for verifying the performance of the plant while maintaining the integrity of the services?

3.2 Definition of services

3.2.1 Context

Market ancillary services are *ancillary services* acquired by AEMO as part of the spot market to manage power system frequency in accordance with the requirements of the Frequency Operating Standard (FOS) set by the Reliability Panel[4].

Clause 3.11.2(a) identifies the *market ancillary services* as:

(1) the *fast raise service*;

[4] The Frequency Operating Standards can be found on the AEMC webpage: http://www.aemc.gov.au/Australias-Energy-Market/Market-Legislation/Electricity-Guidelines-and-Standards?type=2&publisher=2

(2) the *fast lower service*;

(3) the *slow raise service*;

(4) the *slow lower service*;

(5) the *regulating raise service*;

(6) the *regulating lower service*;

(7) the *delayed raise service*; and

(8) the *delayed lower service*.

Power system frequency varies continually as customer load changes and the output of *generating units* varies. AEMO rebalances supply and demand in the power system each five minute dispatch interval with dispatch instructions to *scheduled generating units*, *semi-scheduled generating units* and *scheduled loads*.

Between these dispatch instructions, AEMO manages the variations of supply and demand through use of *regulation services*, that is the *regulating raise service* and *regulating lower service*. These services require the *enabled* plant to vary its generation or load in response to AGC signals received from AEMO through the SCADA system[5].

In the event of a major event from the loss of large blocks of generation or load, the contingency services are used. The contingency services are:

- the *fast raise service*;
- the *fast lower service*;
- the *slow raise service*;
- the *slow lower service*;
- the *delayed raise service*; and
- the *delayed lower service*.

Market Participants enable these services in response to instructions received from AEMO, and respond to deviations in local frequency automatically to correct material frequency deviations that might arise from larger supply-demand imbalances.

The fast services are valued by their ability to arrest a rapid change in system frequency within the first six seconds of a frequency disturbance, and then provide an orderly transition to *slow raise service* or *slow lower service*.

The slow services are valued by their ability to stabilise system frequency within the first sixty seconds of a frequency disturbance, and then provide an orderly transition to delayed raise service or delayed lower service.

The delayed services are valued by their ability to restore system frequency to 50 Hz within the first five minutes of a frequency disturbance, and to sustain their response until *central dispatch* can take the generation requirement into account and frequency can be managed through the *regulation services*.

Under Clause 3.11.2(b)(1), AEMO is required to include in the MASS a detailed description of each kind of *market ancillary service*.

AEMO proposes to more explicitly define responses required to manage the power system frequency through the use of the eight *market ancillary services* and to define the interaction between the various services

[5] The AGC cycle is 4 seconds on the mainland and eight seconds in Tasmania.

3.2.2 Principles

As defined in Clause 3.11.1, *ancillary services* are services essential to power system security management, and that facilitate orderly trading in electricity as well as ensuring that electricity supplies are of acceptable quality. Specifically, the FCAS requirements are acquired by AEMO as *market ancillary services* on the spot market in accordance with Chapter 3 in order to maintain the power system frequency within the operating limits specified in the FOS.

Consequently a key principles underlying the MASS is that it should be related to the control of power system frequency, and not just the delivery of an amount of energy.

AEMO is interested to hear stakeholder views on how this or other principles that should be applied in the MASS.

3.2.3 Definition of the regulation services

The current description of *regulation services* was developed in relation to the performance of existing AGC systems of synchronous *generating units*. AEMO is seeking to extend the definition to more accurately reflect the different types of technology participating in the NEM such as wind, PV and loads. This extended definition will also consider performance of plant as control of system frequency transitions to and from contingency and *regulation services*.

The current description of *regulation services* does not include a definition of specific response expected from *Market Participants* providing these services. Clauses 5.4(c) talks about “automatically deliver a regulating raise/lower response corresponding to the raise/lower signal”, but does not define a timeframe for the response, or an expected accuracy.

The verification clauses only consider the performance over a five minute period in response to physical test signals and, in effect, calculates the maximum quantity of energy that can be offered into the market. They do nothing to verify the real time response to signals from the AGC system.

AEMO is considering the developing a complete definition of the *regulation service*. This could take the form of a definition of both the power performance required and the time frame for response. This could be in the form of either a hard performance figure or a performance index based on the energy performance required and the timeframe for response.

3.2.4 Definition of contingency services

Figure 1 shows the assumed interaction of the three contingency raise services. The ramp down of one service matches the ramp up of the next service providing a clean hand over and a controlled response without gaps or over delivery. This is based on an assumption that the generation or load can ramp in a linear fashion from one response point to the next. The MASS defines the quantities of the services as follows:

- Fast response is the lesser of:
  - Twice the time average of the response between zero and six seconds from the frequency disturbance time, excluding any inertial response.
  - Twice the time average of the response between six and sixty seconds from the frequency disturbance time, excluding any inertial response.
- Slow response is the lesser of:
  - Twice the time average of the response between six and sixty seconds from the frequency disturbance time, excluding any inertial response.
  - Twice the time average of the response between sixty seconds and five minutes from the frequency disturbance time,
- Delayed service is the lesser of:

- Twice the time average of the response between one and five minutes from the frequency disturbance time.
- The time average of the response between five and ten minutes from the frequency disturbance time,

While this, in a simple linear way, simulates the performance of synchronous *generating units* that have historically provided the services, it does not take into account some of specific issues associated with some technologies. For instance, hydro *generating units* providing fast raise service will typically reduce generation briefly as the supply valve opens before ramping rapidly in response to the frequency deviation or *loads* that may be switched off to provide the response. This response shows the assumed smooth transition from one service to the next and does not show any rapid changes in response that could cause additional frequency shocks to the system.

Figure 1 Expected response for plant with a linear ramp response

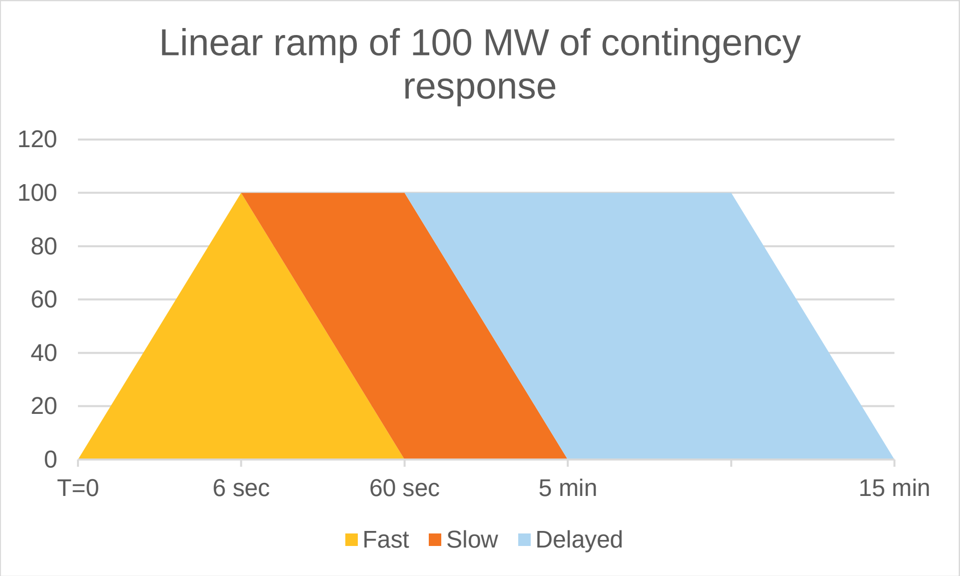
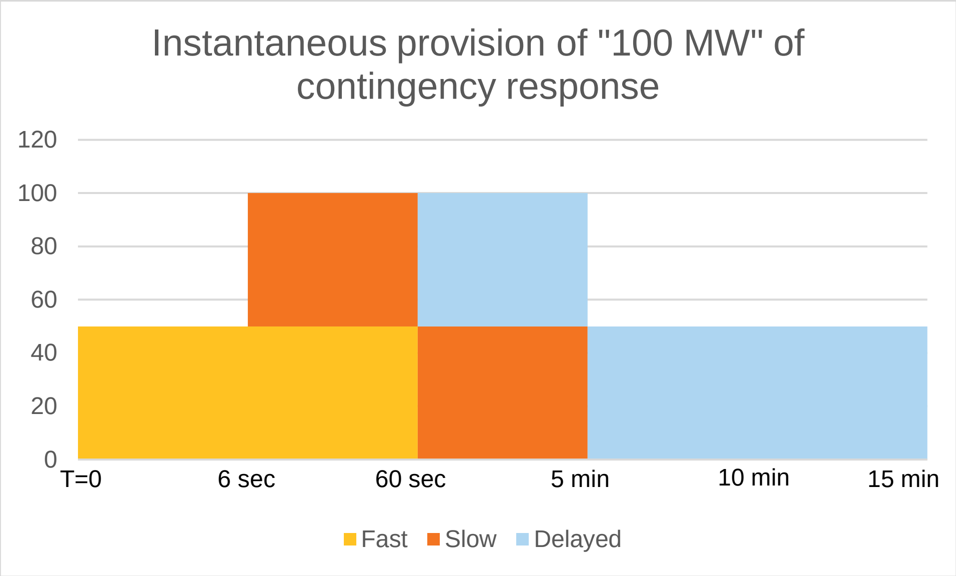


Figure 2 shows the potential response of very fast responding providers. These does not show an orderly transition to the next service as defined in the current MASS.

A sharp rise in response could lead to over-delivery of response as the services overlap while the sharp cut-off of service does not provide an orderly transition to next service and could trigger to a further rapid change in frequency. This could lead to oscillating under-and–over-frequency events and impinge on AEMO's ability to manage power system security.

Figure 2 Potential response from the "instantaneous" providers



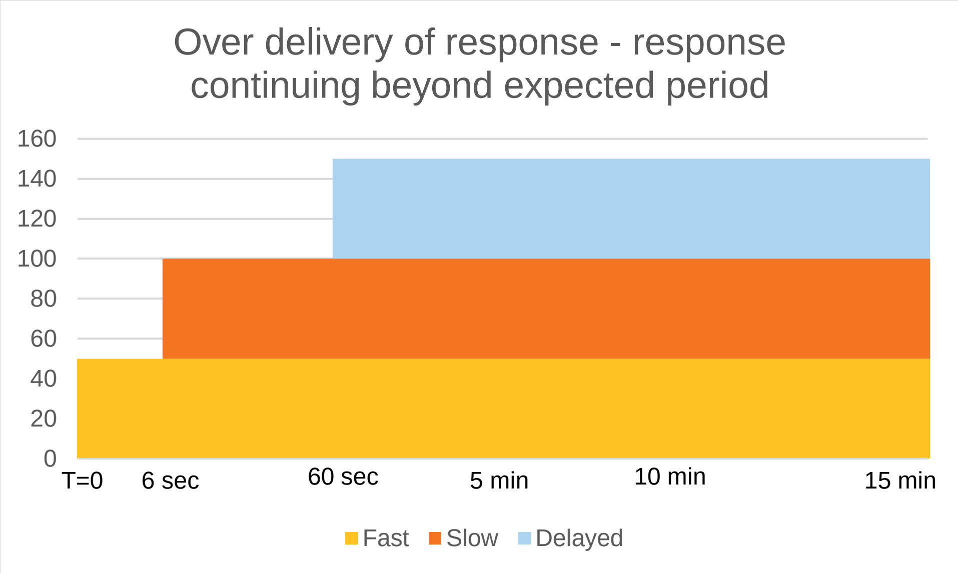
The current MASS requires providers to "provide an orderly transition" to the next service, but does not define what is meant by this phrase. It is implied in the verification clauses that the transition is a linear raise and linear reduction in service response, but this is not actually spelt out. AEMO proposes to include a description of the expected transition response.

Figure 3 shows a further example of over-delivery of the required services. In this example three different *ancillary service generation units* or *ancillary service loads* are enabled to provide the different contingency services. The fast response service has responded quickly to the event and helped arrest the change in frequency, but has not handed over to the slow service after 60 seconds as anticipated by AEMO's systems. The slow service has responded as required and has resulted in over-delivery of the contingency services. Equally over-delivery may be the result of a unit that delivers more than it is enabled to provide.

Over-delivery of services is a concern for power system security and may lead to further undesirable *frequency disturbances*.

In the detailed definitions of the contingency services, AEMO will be looking to avoid the potential for this over-delivery of services by including include a more detailed description of the expected transition requirements.

Figure 3 Over delivery of services



3.2.5 Interaction of Regulation and Contingency Services

In providing contingency services, in particular the delayed services, it is imperative for system security that the market does not over deliver on the services and that in the hand over from the delayed raise or delayed lower (whatever the case may be) to the AEMO AGC system progresses smoothly and does not lead to a further frequency disturbance.

As part of the performance parameters and requirements, the MASS should describe the performance AEMO is expecting from *market ancillary service providers* as frequency returns the *normal operating frequency band* following a contingency event.

AEMO proposes to amend the MASS require that, during a frequency excursion that triggers a contingency response, a *market ancillary service provider* is to give preference to the contingency service over responding to AGC instructions. However once the frequency has returned to the *normal operating frequency band*, the *market ancillary services provider* would be required to ramp back its ancillary services unit to its energy or AGC target, for a *scheduled generating unit*, *semi-scheduled generating unit* or *scheduled load*, or to its pre-contingency state for a *non-scheduled generating unit* or *non-scheduled load*. Should the frequency recover before t=6 seconds, there would be no "*slow raise*" or "*delayed raise*" action and a *generating unit* or *load* providing *regulation services* through the AGC system would be free to respond to those signals after t=6 seconds. If the frequency recovers to the *normal operating frequency band* before t=60 seconds, there would be no "delayed raise" action and a generating unit or *load* providing *regulation services* through the AGC system would be free to respond to those signals after t=60 seconds.

This preferential response from contingency and *regulation services* supports the principle that *market ancillary services* are to manage power system frequency.

Questions

- Do you agree that the principle underlying the MASS should be related to the control of power system frequency, and not just the delivery of defined an amount of energy? What other principles do you believe are required?

- Given these principles, what is the most appropriate performance measure for *regulation services*?
- What limitations exist to inhibit plant enabled to provide one of the contingency services from handing-over smoothly to other services following an event and how can these limitations be addressed?
- What should AEMO consider when drafting of a detailed description of the transition requirements from one contingency service to the next?
- What limitations exist to inhibit the ability of plant to resume standard operations in a timely manner following the recovery of local frequency?

3.3 Performance parameters and verification requirements

Working from the principle that *market ancillary services* are needed to maintain power system frequency within the limits set in the FOS, it is important that the market has confidence that the services *enabled* will actually deliver their response both accurately and in a timely manner. Such confidence should lead to a regime where the power system is managed effectively in the long term interest of consumers.

The ability to verify the performance of units *enabled* to provide *market ancillary services* is a key element of the *market ancillary service specification*.

The current verification clause for regulation services prescribes a simple test procedure that uses the response from test signals to calculate the amount of each of the services that the unit can deliver within a five minute period and hence the amount it can offer into the market. It does not consider the accuracy of the delivery within that period.

The current contingency services verification clauses are complicated and prescriptive. AEMO is proposing to revise these clauses greater emphasis the principles behind of the verification process.

AEMO has a role in monitoring *market ancillary service* performance. AEMO prepares reports on *market ancillary service provider* performance based on verification requirements using the data collected from AEMO's systems and participants. The Australian Energy Regulator (AER) polices whether *market ancillary service providers* are rule compliant.

3.3.1 Regulation services

The current MASS requires an *ancillary service generating unit* or *ancillary service load* to have controls to automatically deliver a regulating raise response or a regulating lower response corresponding to those raise signals or lower signals, but places no requirement on the time by which AEMO is expecting the response.

The current MASS verification clause 5.6 (Verification of Regulating Raise Service and Regulating Lower Service) is drafted around continuous performance over a five minute interval, and determines the maximum regulating raise or regulating lower response that can be provided over that period. This clause does indicate that AEMO only considers the period from after the unit starts to respond until the end of the five minute period, but does not consider the length of time before the initial response or the response to individual AGC signals. The verification is undertaken in a test environment with the units responding to physical test signals, rather than considering continuous performance in response to real time dispatch signals.

As the AEMO AGC system works to maintain frequency within the *normal operating frequency band* for 99% of the time and sends signals to *enabled ancillary service generating units* or *ancillary service loads* at periods of four seconds (or eight seconds in Tasmania), AEMO believes the performance requirements for regulating raise service and regulating lower service should be determined on real time data and include consideration of how rapidly and accurately these units and loads respond to AGC signals.

AEMO recognises that there are delays in the SCADA system that mean that some time will pass between the time AEMO's AGC system issues an instruction and when that instruction is received by the *Market Participant's* systems.

AEMO further recognises that there could be a legitimate time delay between the *ancillary service generating units* or *ancillary service loads* receiving an AGC signal to changing output to meet the target value. This time delay depends on the characteristics of the *ancillary service generating unit* or *ancillary service load*. There will be delays within the local *control systems*, particularly for aggregated systems such as wind farms or loads, and other delays depending on the technical characteristics of the units.

The response time also depends on how the *generating unit* is performing at the time and where it is in its operating range. Issues that could delay response include:

- A hydro unit operating close to its rough running band;
- Thermal units operating on poor quality coal; or
- An aggregated *generating unit* where the *regulation service* response requires an additional *generating unit* to be synchronised and run up.

These time delays are different for each unit and are not specifically known.

Accuracy Limitations options

AEMO needs to be confident that the AGC system is operating as intended and that *market ancillary service providers* of *regulating raise* and *regulating lower services* are actually delivering their response accurately and in a timely manner. A number of options exist for measuring the accuracy of the response of *generating unit* or *load* providing *regulation services*.

One option could be to simply include a requirement that *enabled market ancillary service providers* respond to within a set percentage of their target within a set period of time either after when the AEMO AGC system issues the instruction, or when the unit receives the instruction.

In determining the detailed requirement for this option, AEMO would need to consider both the requirements of the power system and the operating characteristics of generation and load units registered to provide the services.

A second option could be to place a requirement on *Market Participants* based on a combination of their response time and energy target performance.

Such an option could be measured using a simple frequency *regulation service* tool to detect material issues with the delivery of *regulation services*. The verification process would be performed for each unit registered to provide *regulation services* using, for example, a one minute granularity covering a calendar month. To avoid the smoothing out of *regulation service* delivery issues, the analysis could be based on instantaneous values, rather than averaged over the sample period.

The detailed analysis could be filtered to avoid potential noise in the results from smaller instances of non-compliance. For example, this could involve:

- Only assessing delivery of *regulation service* if the *enabled* amount of *regulation service* is above a threshold and frequency is within a tolerance around the normal 50 Hz.
- Only considering a response to be non-compliant if the energy value is on the wrong side of the AGC target by more than a set value of energy tolerance of the *enabled* amount of *regulation service*.

Such an approach would be similar to that used by PJM in the United States of America. PJM calculate a Performance Score[6] based on regulation signal data collected every 10 seconds. Before a resource can be approved to provide regulation services, it must pass a series of tests.

PJM uses statistical analysis to calculate a Correlation Score of the shape of the required response and a Delay Score to quantify the delay in response between the regulation signal and the resource change in output. It also calculates Precision Score as a function of the difference in the energy provided versus the energy requested by the regulation signal while scaling for the number of samples.

These three scores are combined to give the Performance Score for the regulation service provider. PJM Performance Compliance will certify a resource after three consecutive successful tests above a threshold.

Regulating resources that have not met performance thresholds over a specified time period will be disqualified and must re-qualify to offer into the regulating market. The disqualification threshold is based on the historic performance score.

In New Zealand, Transpower requires regulation service providers to comply with regulating service instructions issued to them; and ensure that the relevant site provides a response rate of at least 0.4 MW per minute per MW in the dispatched price band.

AEMO is interested to hear stakeholder views on the most practical and efficient method of measuring the performance of *generating units* or *loads* registered to provide *regulating raise* or *regulating lower* services.

3.3.2 Contingency

Current verification clauses are complicated and prescriptive detailing a particular methodology for verifying performance and, as such, assume some elements of the typical plant performance. The clauses provide no flexibility for *Market Participants* with different *control systems* to demonstrate their performance.

In New Zealand the Transpower requirements are more flexible and require that providers of instantaneous reserve[7] additional supply into the grid equal to or exceeding the dispatched quantity of instantaneous reserve automatically when there is an under-frequency event; or reduced demand from the grid be equal to or exceeding the dispatched quantity of instantaneous reserve automatically when the frequency of the grid falls to or below the trip frequency.

AEMO proposes re-drafting the verification clauses into a plainer English version with a greater emphasis the principles behind of the verification calculations.

These principles would include:

- Removal of the impacts of inertia.
- Determination of the reference trajectory for the generator excluding would have followed excluding any frequency disturbance; and
- Compensation for the differences between the actual frequency disturbance and the reference frequency trace.

In verifying performance of plant, AEMO will be considering the both under and under delivery. Plant with a performance outside a tolerance limit may be considered as non-conforming.

Market Participants would need to demonstrate how their plant performed against these principles. This would include accurate response to the local frequency, the required change on generation or consumption, and the interaction or transition to other services. The *market ancillary service provider* would need to demonstrate that, if the frequency recovered to the *normal operating frequency* band before the delayed service was due to respond, the *Market Participant* did not provide any delayed

[6] http://www.pjm.com/markets-and-operations/ancillary-services.aspx
[7] http://www.ea.govt.nz/dmsdocument/21484

service. Further, when the frequency returned to the *normal operating frequency* band, any unit away from its anticipated energy dispatch point (because it is responding to the contingency event) must verify that it has ramped gently and in a linear fashion back to its energy target or, if it is providing regulation services through the AGC system, has resumed responding to those signals.

AEMO uses the FCAS verification tool (FCASVT) to analyse the performance of *ancillary service generation* units and *ancillary service loads* following a power system *frequency disturbance*. The FCAS is an Excel spreadsheet that has been made available to *Market Participants* to calculate the contingency *market ancillary services* delivered by their plant. This would continue to be available as a means of verifying ancillary service unit performance.

Inverters

The introduction of *AS/NZS 4777.2–2015 Grid connection of energy systems via inverters Part 2: Inverter requirements* on 9 October 2015, sets requirements for all inverters less than 200 kilovolt amps (kVA) installed from 9 October 2016 and results in the standardisation of frequency responses for PV inverters (including battery storage) compliant with the revised standard. This will mean that new compliant inverters will not disconnect for frequency disturbances in the range of 47 Hz – 52 Hz and requires a droop-like performance in response to frequency deviations.

AS/NZS 4777.2–2015 covers all inverters used in small scale domestic installations. Multiple inverters of 200 kVA rating or lower can be aggregated to build systems with much higher overall power ratings, so AS/NZ 4777.2–2015 will often determine the response of PV and battery systems 200 kVA. Inverters used in utility scale installations would need to meet the performance requirements for generators under the *Rules*.

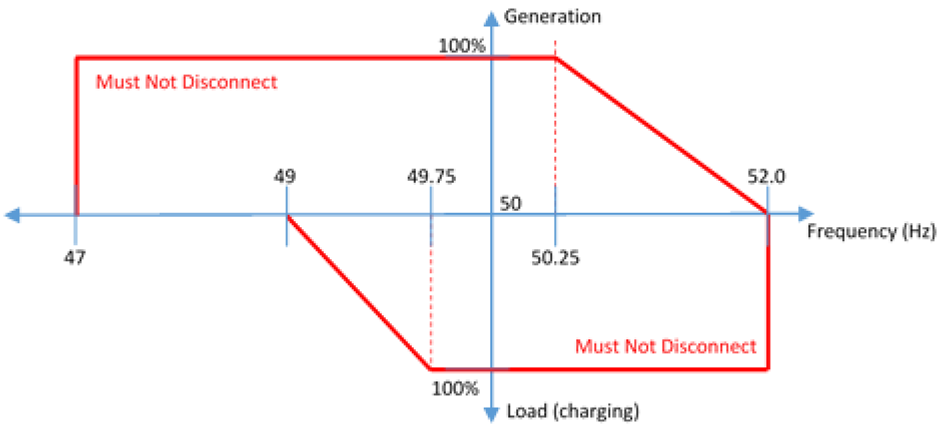
AS/NZS 4777.2–2015 includes new key requirements for the response to frequency disturbances. Full details are specified in Section 7.5 of AS/NZS 4777.2–2015.19.

A summary is given below and in Figure 4.

- Inverters must not disconnect due to frequency disturbances within the range 47 Hz – 52 Hz.
- Inverters should not disconnect, change power output, or change battery charge rate in response to frequency disturbances in the range 49.75 Hz – 50.25 Hz.
- As frequency rises from 50.25 Hz towards 52 Hz, generation output (provided by PV and battery storage) should linearly reduce from the pre-disturbance output at 50.25 Hz, reaching zero at 52 Hz. Generation output should be held at the lowest output reached, until frequency has returned to the range 49.85 Hz – 50.15 Hz for at least six minutes.
- As frequency falls from 49.75 Hz to 49 Hz, battery charge rate should linearly reduce from the pre-disturbance charge rate at 49.75 Hz, reaching zero at 49 Hz. Battery charge rate should be held at the lowest rate reached, until frequency has returned to the range 49.85 Hz – 50.15 Hz for at least six minutes.
- These responses must be provided as rapidly as possible, with no deliberate delay.
- Once frequency has returned to the normal range 49.85 Hz – 50.15 Hz for at least six minutes, normal PV generation or battery charging can be ramped back to normal, with a minimum ramp time of six minutes required to return to normal operation.

AS/NZS 4777.2–2015 only requires battery energy storage systems to cease charging, and does not require them to commence generating in low frequency conditions. Likewise, it does not require PV systems with battery storage capacity to go beyond ceasing generation, and to start charging, in high-frequency conditions.

Figure 4 Response of inverters to frequency variation required by AS/NZS 4777.2–2015



In total, the number of small installations with these inverters will grow with the growth in new installations and replacement of existing inverters. This, in effect, mandates that these inverters provide a form of contingency service and, as a mandated requirement it is not be appropriate for these be aggregated and offered into the market.

It may be possible for *Market Participants* to aggregate systems and offer services above those mandated in the standard. An example is a system that initiates controls for battery energy storage systems to start generating in low frequency conditions. Another is provision of PV systems with battery storage capacity that, in high frequency conditions, can start charging after generation stops. If this change in operation could be verified, it may be possible to offer the service into the market.

Questions

- In your opinion, what is the most practical and efficient method of measuring the performance of generating units or loads registered to provide regulating raise or regulating lower services?
- What are the limitations to your plant's ability to perform accurately and in a timely manner to AGC signals for regulation services? And if so how can these be overcome?
- Do you agree with the principles for contingency verification and if not what principles should apply?
- What amendments are required to the FCASVT to better represent the performance of your plant?
- How could the response of a large number of small scale installations, such as batteries at households, be verified in response to a local *frequency disturbance*?

3.4 Allocation of switching controller settings

Clause 6.2 of the current MASS provides a very detailed description of the procedure that AEMO must apply to allocate frequency settings to the switching controllers in *ancillary service generating units* and *ancillary service loads* for each *market ancillary service* (other than *regulating raise service* and *regulating lower service*).

The procedure defines five raise and five lower frequency settings used for the Tasmanian *region* and five raise and five lower frequency settings used for all other *regions* combined. The procedure also recognises that some units have combined controllers that respond to a combination of the local frequency and the rate of change of the local frequency for fast raise and lower services.

For raise services, the switching controllers work to switch the full *enabled* increase in generation or decrease in load in response to decreases in local frequency beyond the frequency setting. For lower services, the switching controllers work to switch the full *enabled* decrease in generation or increase in load in response to increases in local frequency beyond the frequency setting.

Variable controllers provide a response that increases as the frequency deviation increases. As such, variable controllers meet the principle of driving frequency control, while with switching controllers potential exists for the over-delivery of more response than is needed to recover frequency.

The current procedures for allocation of the switching controller frequency setting does provides a fair process where each *Market Participant* is treated equally based on the relative availability of the unit and the amount of service being offered. However, it provides little flexibility to change the settings in line with good technical practice relating to the units offered. It also does not anticipate a significant growth in the use of switching controllers.

Following the Ancillary Services Unbundling Rule Change, AEMO predicts an increase in the number of *ancillary service loads* with switching controllers being registered and the current procedure may no longer be appropriate.

AEMO is concerned that the presence of large numbers of load and generation sites with a limited number of frequency settings using switching controllers could lead to significant over-delivery of the services

A more flexible arrangement could be for the procedures to allow the settings on the different sites within the aggregated unit to be set at different frequencies such that the aggregated unit's response varies depending on how large the frequency deviation is. In effect this would allow an aggregated unit to simulate the performance of variable controllers to better meet the principle that *market ancillary services* should be enabled to maintain power system frequency rather than to just register an energy response. Within this process there may be a possibility for the aggregated unit to have its switching controllers set at finer frequency sets than the current steps of 0.05 Hz for the mainland and 0.1875 Hz for Tasmania.

In offering such an aggregated service, it will be important to be able to verify the performance of the *enabled* units. The current FCASVT is designed to verify the performance of variable controllers and individual switching controllers, and may need to be modified to handle units with multiple switching controllers set at different frequencies.

In the evolving marketplace, AEMO believes it needs a flexible process based on sound principles around the frequency recovery results required rather, than a highly prescriptive procedure.

This process should encode principles of

- *Market ancillary services* designed to maintain frequency as required by the FOS.
- Fairness: *generating units* and *loads* with the same performance will be treated equally.
- Certainty, AEMO must not request a change to an existing frequency setting unreasonably, and must allow the *Market Participant* a reasonable amount of time to change a frequency setting, during which time the relevant service is not disqualified if the relevant *control system* continues to use the previous corresponding frequency setting.

Questions

- What barriers exist to aggregated generation or loads with switching controllers being configured to provide a staggered response rather than have all units with the same settings and how can these be overcome?
- What limits exist in switching controllers on potential range of frequency settings and can this be adjusted?

- Do you agree with the proposed principles for the allocation of switching controller frequency settings? If not what principles should apply?

4. OTHER MATTERS

4.1 Minor corrections

As appropriate in the redrafting of the MASS, AEMO will also be correcting a number of minor errors including:

- Amending incorrect *Rules* clause references; in a number of places the current MASS refers to clause 3.11.7(a) rather than clause 3.11.2(f).
- The removal of unused terms from the Glossary

4.2 Matters not being considered in this review

This review is also not considering any fundamental changes to the current design of contingency markets. It is not be considering the appropriateness of the time frames for the current *fast*, *slow* and *delayed services*.

This is a review of the MASS under the current *Rules* (Version 88, with the amendments from Rule 2016 No. 10 (Demand Response Mechanism and Ancillary Services Unbundling). As a consequence, this review of the MASS is not considering any changes to the *market ancillary services* regime that would require an amendment to the *Rules*.

AEMO notes that there are a number of rule change applications before the AEMC and number of market reviews in progress considering the potential for additional *market ancillary services* (for instance, the inertia ancillary service market Rule change consultation[8]). These may result in amendments in the *Rules* that may also need to be addressed in the MASS. However, until such time as these rule changes have been made, AEMO is unable to consider the options as part of the MASS.

4.2.1 Broader review of ancillary services

While this consultation is narrow in its scope, AEMO is also scoping a broader project to examine the technical issues around frequency control and whether or not the current markets are meeting the technical needs in light of the ongoing energy market transition. AEMO's project will consider whether changes are required, for instance to support power system needs with respect to fast frequency response and/or system strength. That technical review is expected to feed into future AEMC reviews.

AEMO is preparing a work program that will include stakeholder consultation.

[8] http://www.aemc.gov.au/Rule-Changes/Inertia-Ancillary-Service-Market

5. SUMMARY OF MATTERS FOR CONSULTATION

In summary, AEMO seeks comment and feedback on amendments to the MASS to:

1. Articulate the principles underlying the *market ancillary service specification*.
2. Identify and where possible address any barriers to entry for Market Ancillary Service Providers.
3. Better define the services required in terms of what is needed for system security.
4. Better describe the principles for verifying the performance of *plant*.
5. Provide more flexibility in allocating switching controller settings, particularly for aggregated units

Submissions on these and any other matter relating to the proposals discussed in this Issues Paper must be made in accordance with the Notice of First Stage of Consultation published with this paper by 5.00 pm (Melbourne time) on 10 March 2017.

APPENDIX A - GLOSSARY

Words in italics have the same meaning as under the *Rules*. Capitalised terms are as defined below

Term or acronym	Meaning
ASEFS	Australian solar energy forecasting system
AWEFS	Australian wind energy forecasting system
FCAS	frequency control *ancillary services*
FCASVT	FCAS verification tool
frequency disturbance	means an occasion when the *power system frequency* moves outside the *normal operating frequency band*
frequency disturbance time	means the time at which the *local frequency* fall or rises outside the *normal operating frequency band* during a *frequency disturbance* referenced to Australian Eastern Standard Time
frequency operating standards	has the meaning given in the *Rules*, as applicable to the *region* in which the relevant *ancillary service generating unit* or ancillary service *load* is located
frequency recovery	[the following amended definition is proposed in this consultation] means the first change in *local frequency* from outside the *normal operating frequency band* to inside the *normal operating frequency band* to occur after a *frequency disturbance*
frequency setting	means a level of *frequency* determined by *AEMO* in accordance with the procedure set out in section 6.2 of the *MASS* and notified in writing to the *Market Participant* for use by a *switching controller* or a *combined switching controller* for a particular *ancillary service generating unit* or *ancillary service load* when providing a particular *market ancillary service*
generation amount	means the amount of power flow through the *connection point* of an *ancillary service generating unit*, measured in MW, flow from the *ancillary service generating* unit being positive
inertial response	means the change in *generation* amount or *load* amount due to the effect of the inertia of the *ancillary service generating unit* or ancillary service *load*
load amount	means the amount of power flow through the *connection point* of an *ancillary service load*, measured in MW, flow towards the *ancillary service load* being negative
local frequency	means the *frequency* of the electricity delivered by an *ancillary service generating unit* or consumed by an *ancillary service load*, measured in Hz
lower response	means the decrease in *generation* amount or increase in *load* amount with respect to the corresponding *initial value*
MASS	*Market Ancillary Service* Specification as contemplated by clause 3.11.2(b) of the *Rules*
PJM	PJM Interconnection: a regional transmission organization (RTO) in the United States of America.
PV	Photovoltaic
raise response	means the increase in *generation* amount or decrease in *load* amount with respect to the corresponding *initial value*
SCADA	Supervisory control and data acquisition

switching controller	means a *control system* that delivers a specific amount of service when one or more specified conditions are met
system frequency	means a *frequency* measured by or for AEMO that represents the *frequency* of the power system to which the *ancillary service generating unit* or *ancillary service load* is connected
time average	means, in respect of a *raise response* or *lower response* and a *time interval*, the average value of that *raise response* or *lower response*
variable controller	means a *control system* that delivers a variable amount of *market ancillary service* commensurate with the size of the *frequency disturbance*