AEMC

REVIEW

Australian Energy Market Commission

PROGRESS UPDATE

Frequency control frameworks review

19 December 2017

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About the AEMC

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

Contents

1 Background

1.1 Context

In July 2017 the Australian Energy Market Commission (AEMC) self-initiated and published terms of reference for the *Frequency control frameworks review*.[1] The purpose of the review is to explore, and provide advice to the COAG Energy Council on, any changes required to the regulatory and market frameworks to meet the challenges in maintaining effective frequency control arising from, and harness the opportunities presented by, the changing generation mix in the national electricity market (NEM).

These challenges and opportunities have been noted by a number of organisations, including the Australian Energy Market Operator (AEMO) through its Future Power System Security work program, the Finkel Panel's *Independent review into the future security of the national electricity market* and the AEMC itself through the various projects in its system security work program. An overview of the AEMC's system security work program is provided in Appendix A.

The *Frequency control frameworks review* represents continued consideration of, and collaboration with stakeholders on, those aspects of the *System security market frameworks review* that relate to frequency control. The AEMC published its final report on the *System security market frameworks review* in June 2017.[2] The review made nine recommendations for changes to market and regulatory frameworks that enable the continued take-up of new generation technologies while maintaining power system security. A summary of progress against these recommendations is provided in Appendix B. The *Frequency control frameworks review* also provides the means by which to progress a recommendation made by the AEMC in the final report of the *Distribution market model* project regarding the participation of distributed energy resources in system security frameworks.[3]

The COAG Energy Council has made a commitment to ensure the implementation of 49 of the 50 recommendations made by the Finkel Panel in its *Independent review into the future security of the national electricity market* within the time frames put forward in that review.[4] The *Frequency control frameworks review* provides the means to progress a

1 See: http://www.aemc.gov.au/getattachment/900f37e2-efa4-4c7f-99ea-fa9c78b41993/Terms-of-reference.aspx

2 See: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

3 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Distribution-Market-Model

4 See: http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/12th%20COAG%20Energy%20Council%20Communique%20V2.pdf

number of the recommendations related to frequency control within those time frames, including:[5]

- requiring new generators to have fast frequency response capability (within 12 months)[6]
- moving towards a market-based mechanism for procuring fast frequency response if there is a demonstrated benefit (within three years)
- investigating and deciding on a requirement for all synchronous generators to change their governor settings to provide a more continuous control of frequency within a dead band (by mid-2018)
- reviewing the framework for power system security in respect of distributed energy resources participation (by mid-2019).

The scope of the review is set out in more detail in section 1.2 of the issues paper published on 7 November 2017.[7]

1.2 Purpose of the review

The frequency of the power system varies whenever the supply from generation does not precisely match customer demand. In the majority of situations, the changes in supply and demand are such that the corresponding variations in frequency are very small. However, large generating units, transmission lines or large loads may sometimes trip unexpectedly and stop producing, transmitting or consuming electricity. These events tend to result in larger changes in system frequency and more significant impacts on the safety and reliability of the power system. Controlling frequency is therefore critically important.

The National Electricity Rules (NER) set up market and regulatory frameworks by which AEMO, as the body responsible for maintaining power system security, can manage frequency levels. Effective control of power system frequency requires the coordination of power system inertia and the provision of a range of frequency control services. These services are intended to work together to maintain a steady power system frequency during normal operation, and to stabilise and restore the power system frequency by reacting quickly and smoothly to contingency events that cause frequency deviations, such as a generator tripping. The last resort for maintaining power system frequency following a large generator trip is to shed load using under frequency load shedding.[8]

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5 See recommendations 2.1, 2.2, 2.3 and 2.5 of the Finkel Panel review.

6 This issue is also the subject of a rule change request currently under the AEMC's consideration. See: http://www.aemc.gov.au/Rule-Changes/Generator-technical-performance-standards

7 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Frequency-control-frameworks-review

8 Under frequency load shedding is an emergency frequency control scheme. It is explained in section 2.4.4 of the issues paper.

A number of drivers are creating challenges for conventional forms of frequency control in the NEM and making it more challenging for AEMO to manage power system security.

The electricity industry in Australia is undergoing fundamental change as newer types of electricity generation, such as wind and solar PV, connect and conventional forms of synchronous electricity generation, such as coal, retire. An increasing amount of these new energy technologies is being connected to distribution networks by residential and small business consumers. The gradual shift toward more variable sources of electricity generation and consumption, and difficulties in predicting this variability, increases the potential for imbalances between supply and demand that can cause frequency disturbances.

As conventional generators retire, they reduce the inherent levels of inertia in the power system and lessen its ability to dampen rapid changes in frequency due to disturbances. The withdrawal of synchronous generation also contributes to a reduction in the availability of ancillary services in the NEM, including the provision of services that are used by AEMO to restore power system frequency to normal operating levels. In addition, investigations undertaken by AEMO reflect that, in recent years, system frequency performance has been deteriorating under normal operating conditions.

The *Frequency control frameworks review* is exploring whether the existing frequency control arrangements in the NEM remain fit for purpose in light of these changes and challenges, both in the short term and in the longer term. The changing generation mix also presents an opportunity to consider how newer technologies can be accommodated within market and regulatory frameworks to help address system security issues.

An overview of stakeholder views on the purpose and scope of the review, as set out in submissions to the issues paper, is provided in section 2 of this progress update.

1.3 The issues paper

The AEMC published an issues paper on the *Frequency control frameworks review* on 7 November 2017.[9] The issues paper:

- provides an overview of frequency control and the drivers for consideration of frequency control arrangements in the NEM
- sets out the AEMC's framework for assessing any changes to the existing regulatory or market arrangements for frequency control
- provides the AEMC's preliminary analysis of each of the issues set out in the terms of reference for the review, drawing on the work of other organisations, including AEMO

9 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Frequency-control-frameworks-review

- sought stakeholder views on the scope and materiality of each of the issues.

Written submissions on the paper closed on 5 December 2017 and are available on the AEMC website.[10]

1.4 Purpose of this progress update

The *Frequency control frameworks review* comprises three main streams of work: primary frequency control, frequency control ancillary service (FCAS) markets and the participation of distributed energy resources in system security frameworks.

This progress update provides an overview of:

- each of these issues, as expressed in the issues paper
- the AEMC's views on possible options to address the issues, as set out in the issues paper
- stakeholder views on the matter, as set out in their submissions to the issues paper
- the AEMC's proposed next steps for these work streams
- the AEMC's next steps for the review as a whole.

10 Ibid.

2 Overview of stakeholder views on the issues paper

This section provides a summary of stakeholder views on the purpose and scope of the review as expressed in written submissions to the issues paper. A summary of stakeholder views on the specific issues within the scope of the review are set out in sections 3 to 5 of this progress update.

Only those submissions that the AEMC had received by the date of this progress update (i.e. 19 December 2017) are summarised.

2.1 General comments

A number of stakeholders considered that the review provided a timely opportunity to examine the regulatory and market frameworks that underpin frequency control as the electricity system changes.[11]

Pacific Hydro considered that the review provided a worthwhile opportunity to revisit the assumptions that underpin the existing market-based arrangements for frequency control in the NEM and determine whether they are fit for purpose in a future whether there is greater diversity in generation technology, more distributed energy resources and a diminishing number of large, synchronous units.[12]

The South Australian Department of the Premier and Cabinet considered that the development of national frameworks has not kept pace with the changes taking place in South Australia, and that local initiatives have been, and may continue to be, necessary to maintain power system security in that state.[13]

TransGrid submitted that it may be premature to redesign the frequency control framework without first establishing clarity about the design of the Australian Government's proposed National Energy Guarantee, and whether this will be accompanied by a more fundamental redesign of the NEM, including ancillary services markets.[14]

2.2 Approach to the review

Several stakeholders noted the importance of the AEMC coordinating the analysis and findings of the review with relevant rule changes and reviews,[15] and collaborating with AEMO on any related processes and concurrent work.[16] The Australian Energy

11 Submissions to issues paper: AEMO, p. 1; Energy Networks Australia, p. 1; TasNetworks, p. 1; Tesla, p. 1.

12 Pacific Hydro, Submission to issues paper, p. 1.

13 Department of Premier and Cabinet, Government of South Australia, submission to issues paper, p. 1.

14 TransGrid, submission to issues paper, p. 1.

15 Submissions to issues paper: Australian Energy Council, p. 1; Energy Networks Australia, p. 2.

16 Energy Networks Australia, submission to issues paper, p. 2.

Council also considered it important for the AEMC to explore how the reliability guarantee under the Australian Government's proposed National Energy Guarantee would affect frequency control frameworks.[17]

Energy Networks Australia asked that the AEMC more clearly define the issues to ensure that the scope is proportionate and any proposed outcomes are manageable.[18]

AEMO put forward its views on how the AEMC should approach the review. It considered it important to first consider the needs of the system in terms of frequency control before specifying the services that match those needs and exploring procurement options for those services. It expressed concern that progressing too quickly to solutions or procurement options would not deliver a framework that meets the underlying objectives of the review and the NEO. It proposed an objective focused on ensuring that the NEM has a frequency control framework that is robust, efficient and cost effective in light of a rapidly evolving power system.[19]

2.3 Scope of the review

Energy Networks Australia submitted that the issues within scope of the review seemed to be most relevant to DNSPs. It recommended that the AEMC consider the role of TNSPs in more detail, for example in the design of future inertia markets, procurement functions and how distributed energy resources could be utilised to provide support services to both DNSPs and TNSPs. It also proposed that the AEMC consider and advance the findings of the Electricity Network Transformation Roadmap to ensure a holistic review of issues as they relate to distributed energy resources.[20]

Tesla considered that the scope of the review was a good first step in addressing some of the structural issues in the NEM that currently make it less suitable for emerging technologies, such as battery storage.[21] It also suggested that the AEMC consider whether a change to Chapter 2 or Chapter 5 of the NER to classify battery storage as a separate class of registered participant, or introduce specific energy storage connection requirements, would be beneficial.[22] While relevant, the AEMC is of the view that these considerations are not directly within the scope of the *Frequency control frameworks review*. These issues are instead being considered through the AEMC's *Coordination of generation and transmission investment review*.[23]

17 Australian Energy Council, submission to issues paper, p. 1.

18 Energy Networks Australia, submission to issues paper, p. 2.

19 AEMO, submission to issues paper, pp. 3-4.

20 Energy Networks Australia, submission to issues paper, pp. 1-2.

21 Tesla, submission to issues paper, p. 1.

22 Ibid., p. 2.

23 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Reporting-on-drivers-of-change-that-impact-transmi

S&C Electric Company considered that the scope of the review was well framed,[24] but submitted that the issues paper focused on generation and did not assess the impact of demand. It questioned whether demand forecasting and the challenges associated with responsive demand were within the scope of the review.[25]

Pacific Hydro submitted that the scope should include consideration of whether the control philosophy adopted by the FCAS market is suitable to the operation of a long, weakly interconnected alternating current (AC) power system. It considered that the review should determine whether a market that aims to minimise services and costs delivers the reliability and security requirements necessary to have energy dispatch conform to security constraints. Pacific Hydro was strongly of the view that the current degradation of frequency control in the NEM was no longer a market or policy problem, but rather a deep seated control engineering issue, and that this should be recognised in the way that the AEMC approaches the review.[26]

AEMO considered that the scope of the review (as set out in the terms of reference) was too limited and too "solution focused". In line with its views on the how the AEMC should approach the review, AEMO proposed that the scope instead target the technical needs of the power system through a staged approach that first considers the needs of the power system.[27] This staged approach is described in pages 5-8 of AEMO's submission to the issues paper.

Snowy Hydro considered that AEMO's forecasting errors and its role in determining the amount of regulating FCAS in the normal operating frequency band were not properly explored in the issues paper, and should be considered in more detail through the review.[28]

The TasNetworks submission focused on issues that have particular relevance in Tasmania. It expressed concern that an approach that excludes regulatory measures that deal with issues in a specific region only could exclude solutions that can be implemented in Tasmania and are not relevant in other parts of the NEM.[29]

2.4 Assessment framework and principles

Several stakeholders expressed support for the AEMC's assessment approach and principles, as set out in chapter 4 of the issues paper.[30]

Tesla considered that the AEMC's current approach to amending the NER (1. Define the issues, 2. Determine the options available, 3. Assess the range of options against the

24 S&C Electric Company, submission to issues paper, p. 3.

25 Ibid., pp. 1-5.

26 Pacific Hydro, submission to issues paper, p. 5.

27 AEMO, submission to issues paper, p. 5.

28 Snowy Hydro, submission to issues paper, p. 5.

29 TasNetworks, submission to issues paper, pp. 1-2.

30 Submissions to issues paper: Energy Queensland, p. 6; Hydro Tasmania, p. 6; Snowy Hydro, p. 6.

NEO and the guiding principles) works best for dealing with non-structural regulatory changes, or introducing new technologies that have long project development lead time. It suggested that the AEMC instead consider a 'regulatory sandboxing' approach to provide empirical evidence of how some of the new services should operate in the market, and whether they are suitable for the needs of the system. Tesla was of the view that such an assessment approach would be an important step in fundamentally redesigning the NEM to adapt to non-synchronous generation technologies.[31]

Pacific Hydro was of the view that the AEMC's assessment framework should be broadened to explore the performance criteria of all units and find a way to value the control actions that are necessary to manage the power system.[32]

Several stakeholders suggested that the AEMC have consideration of a number of other principles, including:

- All connecting parties should be treated fairly and equitably.[33]
- Any changes to the existing frequency control framework must ensure that existing generation does not suffer additional costs that were not anticipated at the time of commissioning of the plant, or forced to retired prematurely by the imposition of a mandatory framework that physically cannot be met.[34]
- Market-based approaches are preferable to mandated services,[35] but regulatory interventions may still be needed, for example where there are technical constraints or specific network requirements.[36]
- Technology neutrality is important, but should recognise that all technologies have their own technical characteristics that must work within the limits of their control boundaries.[37]
- Efficient frequency control is provided when all units act to support the power system.[38]
- Ensure regulatory and commercial outcomes are aligned with good engineering practice.[39]

Pacific Hydro submitted that the AEMC should further consider elevating the role of power system control philosophy and its role in the delivery of security. It considered

31 Tesla, submission to issues paper, pp. 3-4.

32 Pacific Hydro, submission to issues paper, p. 7.

33 S&C Electric Company, submission to issues paper, p. 5.

34 Snowy Hydro, submission to issues paper, p. 6.

35 Australian Energy Council, submission to issues paper, p. 2.

36 Tesla, submission to issues paper, p. 3.

37 Pacific Hydro, submission to issues paper, p. 7.

38 Ibid.

39 Hydro Tasmania, submission to issues paper, p. 6.

that a market cannot and will not deliver the engineering controls necessary to correct frequency control problems in isolation.[40]

Noting that several overlap with those set out by the AEMC in the issues paper, AEMO's submission set out its assessment principles for the review, including:[41]

- Frequency control requirements should be defined in terms of the fundamental power system needs.
- Target flexibility and adaptability.
- Ensure services are predictable, verifiable and assessable.
- Adopt a performance-based approach to procurement and payment.
- Be willing to implement solutions in the short and medium term while progressing longer-term solutions.
- Consider all options.
- Inclusiveness and ease of entry/exit.
- Ensure energy delivery is not systematically prioritised over system service delivery.

2.5 Drivers of change

Chapter 3 of the issues paper set out the AEMC's views on the drivers of change that give cause to explore whether the existing market and regulatory frameworks for frequency control remain fit for purpose.

Several stakeholders considered that the AEMC had adequately highlighted the drivers of change affecting frequency control.[42] EnergyAustralia noted that the recent rule change to introduce mandatory minimum levels of inertia,[43] and related rule change requests are likely to impact frequency control requirements, as inertia in the system reduces the requirement for faster frequency response.[44] Meridian Energy submitted that forecasting was an area where substantial, and easy, improvements could be made to improve the balance of supply and demand in the NEM, which would substantially reduce the requirement to procure additional regulating and contingency FCAS.[45]

40 Ibid.

41 AEMO, submission to issues paper, pp. 10-11.

42 Submissions to issues paper: Energy Queensland, p. 5; Snowy Hydro, p. 6.

43 See: http://www.aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque

44 EnergyAustralia, submission to issues paper, p. 4.

45 Meridian Energy, submission to issues paper, p. 3

The Australian Energy Council expressed disappointment that the AEMC did not make a rule on the *Non-scheduled load and generation* rule change request, as it considered that this would have assisted with addressing the daily ramping requirements as described in section 3.2.1 of the issues paper. It submitted that another driver of change was the AEMC's decision to change the settlement period for the electricity spot price from 30 minutes to five minutes. It submitted that when this rule comes into effect there will be less plant available to meet the power system's ramping requirements, as conventional fast-start plant (unable to respond to five minute settlement period and defend its cap products) will withdraw, compromising market responsiveness.[46]

46 Australian Energy Council, submission to issues paper, p. 2.

3 Primary frequency control

Through the *Frequency control frameworks review*, the AEMC is considering the appropriateness of the existing market and regulatory arrangements that relate to the control of power system frequency. Investigations commissioned by AEMO have confirmed that a reduction in the provision of primary frequency control within the normal operating frequency band is contributing to a degradation of frequency performance during normal operation.

This chapter sets out:

- the Commission's progress towards identifying the issue, associated risks and potential remedial actions
- stakeholder feedback on the issues paper
- next steps on this issue.

3.1 The issue

All generation, transmission, distribution and load components connected to Australia's power system are standardised to operate at a nominal system frequency of 50 Hz. To maintain a stable system frequency, AEMO must balance the supply of electricity into the power system against the consumption of electricity at all times.

The Commission is aware that the frequency performance of the power system, in both the mainland and in Tasmania, has declined in recent times. Specifically, there is some evidence that the power system increasingly operates further away from 50 Hz than has historically been the case.

AEMO engaged DIgSILENT in May 2017 to investigate and report on the likely causes of the degradation of frequency performance in the normal operating frequency band, and report on the materiality and potential consequences of this.

AEMO have confirmed through DIgSILENT's analysis, and further monitoring and investigations, that:

- An increased incidence of exceedance events (where the power system frequency falls outside the normal operating frequency band) has occurred for both the NEM mainland and Tasmania.
- A small number of slow, unstable frequency oscillations have been observed. The confirmed events involved the undamped oscillation of the power system frequency by ±0.05Hz with a period of oscillation of around 25 seconds. The average frequency during these events was at the lower end of the normal operating frequency band (49.85 Hz – 50.15 Hz) and they persisted over multiple

dispatch intervals, for around 5 - 10 minutes. Further investigation is required to determine the causes of these oscillatory events.[47]

DIgSILENT's analysis concluded that the root cause of the long term degradation of frequency performance is a reduction in the level of primary frequency control[48] provided during normal system operation. It attributes this to a decline in governor response provided by generators within the normal operating frequency band.[49]

This decline is understood to have taken place gradually over a period of years as a result of generators making various changes to their control systems. Section 3.1.4 of the issues paper summarised DIgSILENT's analysis of these changes, the drivers that are causing some generators to make such changes, and the consequences of deteriorating frequency control.

The DIgSILENT investigation identified a number of risks associated with this reduction in primary frequency control and associated degradation of the frequency distribution. These risks include:

- Generator impacts including:
  - an increase in the rate of wear and tear on mechanical generating equipment for those generators that respond to frequency changes
  - a decrease in the operational efficiency of mechanical generating equipment, especially where a generator continues to be responsive to frequency.
- An increase in FCAS costs as the quantities and utilisation of existing FCAS products increase to control power system frequency.
- System security implications including:
  - increased potential for frequency oscillations
  - difficulty in AEMO meeting the performance standards set out in the frequency operating standard
  - potential for increased rate of change of frequency and maximum deviation in response to contingency events
  - increased variability of interconnector flow on network interconnectors following contingency events.[50]

47 DIgSILENT, Review of frequency control performance in the NEM under normal operating conditions, final report, 19 September 2017, pp. 34-35.

48 Primary frequency control is explained in section 2.3 of the issues paper.

49 DIgSILENT, Review of frequency control performance in the NEM under normal operating conditions, final report, 19 September 2017.

50 Ibid., section 5.3.

The issues paper sought stakeholder views on the materiality of the issues related to primary frequency control, and set out a number of potential changes to market and regulatory frameworks that could improve frequency control under normal operating conditions, should any such change be warranted, including:

1. Mandatory provision of primary frequency control during normal operation.
2. Contract-based procurement of primary frequency control during normal operation.
3. Market-based options for primary frequency control during normal operation.
4. Changes to AEMO's automatic generation control (AGC) system and causer pays arrangements.
5. Frequency monitoring and reporting by AEMO.

3.2 Summary of stakeholder submissions on issues paper

3.2.1 General comments

There was agreement from some stakeholders that further analysis is required to determine the materiality of the risks associated with the reduction of primary frequency control.[51] EnergyAustralia noted that:[52]

> "the goal of frequency management needs to be clearly defined before solutions are developed to improve frequency control."

AEMO advocated for an approach that:[53]

> "starts from examining in detail the fundamental needs of the system in terms of frequency control. This would then feed naturally into specifying services that match these needs, and finally into an exploration of procurement options."

The Australian Energy Council noted that while there has been a degradation of frequency performance within the normal operating frequency band, at present the frequency operating standard is still being met. It noted that:[54]

> "If significant variation within the normal operating frequency band were to be an unacceptable outcome, as assessed by the Reliability Panel, then the frequency operating standard would need revision, rather than the framework within which the frequency is controlled."

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51 Submissions to issues paper: Australian Energy Council, p. 2; AEMO, p. 1; Snowy Hydro, p. 6.

52 EnergyAustralia, submission to issues paper, p. 1.

53 AEMO, submission to issues paper, p. 1.

54 Australian Energy Council, submission to issues paper, p. 1.

In its submission, ENGIE noted that investigations and discussions held through AEMO's ancillary services technical advisory group have identified a number of other contributing factors to the degradation of frequency performance during normal operation, including:

- the performance of AEMO's AGC system
- the interaction between the mainland NEM and Tasmania via the Basslink frequency controller.[55]

A number of stakeholders indicated support for the AEMC conducting further investigation of international arrangements for primary frequency control.[56]

3.2.2 Options for improving frequency control during normal operation

A number of stakeholders expressed support for mandatory primary frequency control.[57] Pacific Hydro submitted that constant frequency, (along with constant voltage and reliability) is a core characteristic of operating a power system, and that mandatory primary frequency control is necessary for effectively controlling power system frequency. According to Pacific Hydro, such mandatory response would not only support good frequency control but also increase the resilience of the power system to abnormal system events and large contingencies.[58]

The South Australian Department of the Premier and Cabinet suggested that the Commission work towards achieving the reintroduction of mandatory primary frequency response and that it more clearly draw out the differences between the provision of energy (the actual response) and capacity (maintaining headroom).[59]

In addition to supporting mandatory provision of primary frequency control, some stakeholders indicated support for payments to incentivise the provision of primary frequency response.[60]

S&C Electric Company indicated support for procuring primary frequency control via mandatory response, bilateral contracts or a new market service. Its submission set out the principles for the provision of primary frequency control as being adequate remuneration for providing the service and transparency around the procurement arrangements, including publication of the details of any bilateral contracts for primary

55 Engie, submission to issues paper, pp. 3-4.

56 Submissions to issues paper: EnergyAustralia, p. 2; Energy Networks Australia, p. 6; Energy Queensland, p. 7; S&C Electric Company, p. 6.

57 Submissions to issues paper: Pacific Hydro, pp. 8-11; S&C Electric Company, p. 6; TasNetworks, p. 5.

58 Pacific Hydro, submission to issues paper, p. 9.

59 Department of Premier and Cabinet, Government of South Australia, submission to issues paper, p. 2.

60 Submissions to issues paper: Pacific Hydro, pp. 8-11; S&C Electric Company, p. 6.

frequency control. In the absence of such transparency, they did not support the use of bilateral contracting.[61]

On the other hand, a number of stakeholders advocated against the introduction of any mandatory primary frequency response and expressed support for the market provision of this ancillary service.[62] Snowy Hydro submitted that:[63]

> "The relevant services should be recompensed according to their opportunity cost and, if possible, this should be done by incorporating these services directly into the market arrangements."

TasNetworks recognised the benefits of mandating the capability for primary frequency response from all generators where the technology and physical attributes of the plant do not present a limitation. However, it proposed that the enablement of primary frequency control be incorporated into a revised FCAS market framework based on the required control characteristics.[64] It defined two groups of frequency control services:

1. Primary frequency control: incorporating fast frequency response, fast governor response and slow governor response.

2. Secondary frequency control: incorporating sustained (delayed) governor response and AGC/integral response.

Snowy Hydro commented that AEMO's specification of the required level of regulation FCAS has lowered over the last few years, and suggested that the review investigate the impact of this change on frequency performance.[65]

Hydro Tasmania supported further assessment of a market mechanism for the procurement of primary frequency control within the current normal operating frequency band.[66]

Meridian Energy supported the use of the existing FCAS markets along with narrowing the frequency operating standard to trigger a primary frequency response closer to 50Hz.[67] It noted that:[68]

> "It is important to remember the frequency operating standard is [currently] being met and so the degradation of frequency across the NEM

61 S&C Electric Company, submission to issues paper, pp. 6-7.

62 Submissions to issues paper: AGL Energy, p. 3; Energy Queensland, pp. 7-8; Clean Energy Council pp. 1-2; Origin Energy, p. 1; Snowy Hydro, p. 7; Tesla, pp. 4-5.

63 Snowy Hydro, submission to issues paper, p. 8.

64 TasNetworks, submission to issues paper, pp. 5-8.

65 Snowy Hydro, submission to issues paper, p.10.

66 Hydro Tasmania, submission to issues paper, pp. 2, 7, 8.

67 Meridian Energy, submission to issues paper, pp. 6-7.

68 Ibid, p.9.

> isn't a result of insufficient FCAS supply but rather the inefficient utilisation of the available capacity."

TransGrid was of the view that the ancillary services that support the power system should be obtained at lowest cost. It submitted that one option for ancillary service procurement not identified in the issues paper is a model where ancillary services are coordinated and procured by TNSPs for a commensurate return.[69]

Pacific Hydro's submission expressed strong disagreement with the potential of market provision of primary frequency control services, noting that:[70]

> "There is no guarantee that a market under interconnected normal operating conditions will source frequency control services in all areas in the amount necessary to ensure that an event will be correctly managed."

3.2.3 Frequency monitoring and reporting

Stakeholder submissions expressed broad support for AEMO publishing regular frequency monitoring reports to provide additional understanding and oversight of power system operational performance and long term trends.[71] Meridian Energy suggested that frequency monitoring reports should include information about how the behaviour of individual market participants contributed to frequency deviations outside the normal operating frequency band.[72]

3.3 Next steps for this work stream

The issues paper identified a reduction of primary frequency control that operates within the normal operating frequency band (49.85Hz – 50.15Hz) as a primary contributor to the recent degradation of power system frequency in the NEM. The issues paper also set out a number of potential policy mechanisms that may help address this withdrawal of primary frequency control and help support "good frequency control" in the NEM.

Each of these potential policy mechanisms will vary in the efficiency and effectiveness with which it may address the recent degradation in system frequency. Similarly, some of these mechanisms may be able to be implemented over the short-term through changes to systems and procedures, while others may require a longer period of design and implementation through changes to the NER. Further, the policy mechanisms are not mutually exclusive and may be implemented as a package of measures, either in unison or through a staged approach. As such, some may be implemented within the time frames of this review, where the changes involve adjustment to existing

69 TransGrid, submission to issues paper, p. 2.

70 Pacific Hydro, submission to issues paper, p. 10.

71 Submissions to issues paper: Energy Networks Australia, p. 8; Hydro Tasmania, p. 9; Pacific Hydro, p. 11; Snowy Hydro, p. 10; S&C Electric Company, p. 8; TasNetworks, p. 9.

72 Meridian Energy, submission to issues paper, pp. 7-8.

procedure or processes. Others may require further consideration and assessment through additional work or rule change requests that might be recommended at the conclusion of the review as part of a longer term plan to address relevant issues. Nevertheless, any measures implemented in the short term through changes to systems or procedures will need to be undertaken in the context of potential longer term changes to regulatory or market frameworks.

In response to the issues paper, stakeholders expressed a range of views on their preferred policy mechanisms to address the recent degradation of power system frequency. Justification for the adoption of any particular policy position has largely been based on the extent to which stakeholders view the recent degradation in power system frequency as an issue of system security with material associated costs. The Commission considers that, in order to determine an appropriate response to the degradation in power system frequency, an assessment of the materiality of the issue will be required.

In order to better understand the materiality of the costs and risks associated with the provision of primary frequency control (or lack thereof), the Commission will undertake an economic assessment of the impact of requiring or procuring some level of primary frequency control to assist with frequency control during normal operation. The economic assessment will seek to describe the potential system security and economic benefits that may be realised through the provision of primary frequency control during normal operation along with any costs associated with the provision of such a service. This economic assessment will be informed by technical advice to be provided by AEMO. The technical advice will consider how primary frequency control contributes to power system security and what operational trade-offs exist between primary frequency control and other market ancillary services, such as regulating FCAS.

The economic assessment will build on the results of the AEMO and DIgSILENT *Review of frequency control performance in the NEM under normal operating conditions*, which identified the types of costs associated with degraded frequency control, as summarised in section 3.1. The Commission will present the result of the economic assessment in the draft report for this review, scheduled for publication in March 2018.

The results of this economic assessment will be used to support the Commission's draft recommendations for addressing the degradation of the power system frequency during normal operation in the NEM. The draft report will provide further detail in relation to the policy mechanisms identified in the issues paper and indicate the Commission’s direction on a proposed policy response to support the ongoing safety, security and reliability of the power system.

The Commission is also working with AEMO to develop an understanding of the broader system needs over the next ten to fifteen years. This assessment will attempt to identify the future characteristics of the power system and identify the technical challenges or "needs" to be met in order to maintain a safe, reliable and secure power system. These system needs will then be used to define what system services are likely to be required over the outlook period. This assessment will provide context to the

Commission's consideration of potential changes to the market and regulatory frameworks in relation to frequency control. It will also provide indicative timing for the planning of future work by the market bodies to adapt the market, regulatory and operational procedures to the changing needs of the power system.

4 FCAS markets

This chapter provides a progress update on the FCAS markets work stream of the review, namely:

- the issues being considered
- relevant stakeholder comments made in submission to the issues paper
- the next steps for this work stream.

4.1 The issue

The main issues identified as likely to impact on the optimum design of FCAS markets include: integration of new technologies, decreasing levels of system inertia and reduction in availability of conventional sources of regulating and contingency FCAS as discussed below.

Integration of new technologies

As the generation fleet changes and the needs of the power system evolve, the required services needed to maintain power system security are also likely to evolve.

The existing frequency control frameworks were largely established when the technical characteristics and capabilities of the generation mix were very different. There may now be opportunities for the new energy technologies being connected to provide services that help support power system security, including frequency control.

These challenges and opportunities call into question the need for changes to frequency control frameworks to make sure they remain suitable and sufficiently flexible so as not to preclude the participation of emerging technologies.

Lower levels of inertia

Inertia is naturally provided by conventional electricity generation technologies, that are synchronised to the frequency of the grid. Inertia determines how fast frequency changes immediately following a contingency event.

Newer electricity generation technologies, such as wind and solar PV, are connected to the power system via electrical inverters and are not synchronised to the grid. International experience suggests that it is currently not possible to operate a large power system without some synchronous inertia, and that "synthetic" inertia from non-synchronous generators does not provide a direct replacement.

Historically, most generation in the NEM has been synchronous and, as such, the inertia provided by these generators has not been separately valued. However, as the generation mix shifts to include smaller and more non-synchronous generation, inertia

is not provided as a matter of course. This is making it increasingly challenging for AEMO to maintain the power system in a secure operating state.

Reduction in availability of regulating and contingency FCAS

The withdrawal of synchronous generation also contributes to a reduction in the availability of ancillary services in the NEM, including FCAS. Additionally, the increasing variability of supply and demand is likely to be met with increased frequency control requirements from the market.

The market has historically attracted regulation and contingency FCAS from synchronous generation. If this synchronous generation is displaced (either permanently or temporarily), the level of FCAS it provided will have to be procured from other sources.

In the event that insufficient FCAS is available to manage the risk of a credible contingency event, AEMO may use other means to maintain the secure operation of the power system. Alternative means include the pre-emptive constraining of interconnector flows or generation output to reduce the size of the possible contingency event, and/or to require additional reserve capacity to be available to respond to a contingency event.

As the size of system disturbances increases and as the amount of inertia decreases, the amount and speed of FCAS response needed to keep system frequency within the frequency operating standards (and avoid load or generator shedding) increases. New technologies, such as wind farms and batteries, offer the potential for frequency response services that act much faster than traditional services, perhaps as quickly as a few hundred milliseconds. Such fast frequency response (FFR) services would act to arrest the frequency change more quickly than the current fastest acting contingency FCAS service, which has a response time of up to six seconds. Although FFR services could be procured through the existing six second FCAS contingency service, this does not necessarily recognise any enhanced value that might be associated with the faster response.

4.2 Summary of stakeholder submissions on issues paper

The Commission recognises that there are many overlapping issues between primary frequency control (discussed in chapter 3 of this progress update) and FCAS markets as discussed in this chapter. For completeness, relevant submissions referred to in chapter 3 have also been referred to in this chapter.

4.2.1 Approach to consideration of FCAS markets in the review

In its submission to the issues paper, AEMO was of the view that consideration of the procurement strategy for FCAS (including potential market structures or contracting/mandating actions) should only be considered after clear FCAS performance (or standards) are established and services are defined to achieve that performance. As such, its submission did not explicitly comment on existing or future

procurement arrangements but instead focused on explaining the principles and review process that it believes should guide the review.[73]

4.2.2 Mandatory provision of governor based primary frequency control

As set out in section 3.2.2, a number of stakeholders did not support a mandatory approach to providing frequency control services, and rather indicated strong support for market-based approaches.[74] Meridian Energy Australia expressed support for a combination of mandating generators to reinstate primary governor control within the normal operating frequency band with a narrowing of that band.[75]

Pacific Hydro argued that market-based sourcing approaches are unlikely to be adequate by themselves and as such provision of the service should be mandatory where possible. For example:[76]

> "Market mechanisms aim for competitive minimisation of service. The control of the eastern seaboard requires firm tight control from all areas of the grid. There is no guarantee that a market under interconnected normal operating conditions will source frequency control services in all areas in the amount necessary to ensure that an event will be correctly managed. … Setting a regional requirement is unlikely be cost effective due to the market power of some generating companies. The underlying controls need to be active to stop the synchronous units hunting against each other."

And:

> "Inverter controlled devices and asynchronous units can have controls that mimic the actions of governors and all active power control should be done with consideration to frequency control and not in ignorance of it as is the case now with the energy dispatch."

S&C Electric Company considered that frequency control should be prioritised over energy while inertia and primary response need to be mandatory services for relevant connectees.[77]

The South Australian Department of the Premier and Cabinet indicated that "the reintroduction of mandatory governor requirements in the NEM would likely reduce

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73 AEMO, submission to issues paper.

74 Submissions to issues paper: AGL, p. 3; Clean Energy Council, p. 2; ENGIE, p. 3; Hydro Tasmania, p. 7; Origin Energy, p. 1.

75 Meridian Energy Australia, submission to issues paper, p. 1.

76 Pacific Hydro, submission to issues paper, p. 10.

77 S&C Electric Company, submission to issues paper, p. 11.

overall costs." As such, it asked the Commission to focus its work on reintroducing mandatory governor requirements.[78]

4.2.3 Procurement approach for FCAS

AEMO did not discuss procurement options to any great extent as it argued this should only be considered after standards are established and services defined. However, it did recommend eight assessment principles, one of which is to "adopt a performance-based approach to procurement and payment."[79] The aim is to align financial incentives with the usefulness of the providers frequency responsiveness.

AGL supported continued use of market-based approaches to sourcing FCAS and suggested that consideration should be given to simplifying FCAS markets (in a manner similar to New Zealand), as this may enhance the number of participants and market liquidity.[80]

The Clean Energy Council indicated that a sub-one second market for primary frequency control should be introduced with the aim of rewarding participants for speed and accuracy.[81]

EnergyAustralia considered that the existing FCAS market structure is sufficient to support the introduction of fast frequency support services.[82]

Energy Queensland supported the establishment of a new primary regulating service to provide primary frequency control within the normal operating frequency band, separate form contingency FCAS.[83]

Origin Energy indicated that, where an FFR service is to be introduced, it has a preference for a simplified market structure where a 0-2 second response is captured under one FCAS market.[84]

TasNetworks provided a detailed plan to reconfigure existing FCAS markets (with no change to the frequency operating standard) based on a move away from the current concept of regulating services and contingency FCAS services to a model based on primary and secondary frequency control.[85] This proposed framework incorporates primary frequency control involving local measurement and local action, outside of +/- 0.05 Hz effectively comprised of FFR (including conventional governor response and fast response from inverter connected assets such as batteries), six second and sixty

78 Government of South Australia, Department of the Premier and Cabinet, submission to issues paper, p. 2.

79 AEMO, submission to issues paper, p. 11.

80 AGL, submission to issues paper, p. 5.

81 Clean Energy Council, submission to issues paper, p. 3.

82 EnergyAustralia, submission to issues paper, p. 6.

83 Energy Queensland, submission to issues paper, issue 12.

84 Origin Energy, submission to issues paper, p. 3.

85 TasNetworks, submission to issues paper, p. 7.

second services similar to the current contingency FCAS fast and slow services. Additionally the proposed framework includes what it terms 'secondary frequency control', which would encompass a slow governor response (outside +/- 0.05 Hz) equivalent to the current five minute contingency FCAS service and an AGC response equivalent to the current regulating service. A key difference with the current framework is that these services would operate outside of a narrow +/-0.5 Hz band unlike current contingency services that operate outside +/-0.15 Hz. In TasNetworks' view, these services would be delivered by a market-based framework, as at present

Pacific Hydro argued that the existing system should be fixed prior to giving any thought to development or incorporation of new services. It considered that:[86]

> "Fast frequency response is simply asking for good primary control action from new technologies, which can be faster than large thermal or hydro units. However, the response from the new technologies will be quickly swamped if the large unit responses are inappropriate or contrary to good control."

S&C Electric Company indicated a preference for market-based approaches and indicated concern over using bilateral contracting for services on the basis that such arrangements may lack transparency. It indicated a preference for the development of a new service (in addition to existing FCAS services) for providing primary frequency control within the normal operating frequency band. S&C Electric Company submitted that a new FFR service should be developed, but that this should only occur once all issues with inertial and primary response from currently connected synchronous generators have been resolved, because any resolution such as synchronous generators returning to the provision of primary frequency response will modify the amount of FFR required.[87]

Snowy Hydro supported the continued reliance on markets to deliver frequency control. For example:[88]

> "The market-based approach is the best way to provide a positive contribution to the ongoing development of the market processes in the NEM."

The South Australian Department of the Premier and Cabinet supported the inclusion of new, faster responding technologies into contingency and regulation FCAS markets. It suggested that the introduction of a one or two second response service that need only be sustained until the existing six second service has responded would be consistent with existing market arrangements and would be well suited to participation from wind farms.[89]

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86 Pacific Hydro, submission to issues paper, p. 12.

87 S&C Electric Company, submission to issues paper, p. 9.

88 Snowy Hydro, submission to issues paper, p. 9.

89 Government of South Australia, Department of Premier and Cabinet, submission to issues paper, p. 3.

Hydro Tasmania considered that, at present, incorporating fast frequency services within the existing six second service was preferable and that consideration should be given to introducing a new inertia service.[90]

Tesla argued that any service should have a value attached to it irrespective of whether it is mandated to be supplied or is delivered through a market framework.[91] It commented that:

> "Attaching value to new, or currently un-monetised, services – either in a competitive market, or through competitive bilateral contracts, improves the competitive position of new fast responding technologies that can provide frequency support in a market with high renewable energy penetration."

4.2.4 FCAS cost recovery issues

Regulation FCAS costs are recovered via a causer pays framework, which is currently the subject of an AEMO review.[92]

The Clean Energy Council indicated significant concerns with the application of the causer pays framework to wind generators, given the way in which the wind energy forecasting system works.[93]

Meridian Energy Australia indicated some concern with the current application of the causer pays framework, and suggested that the causer pays approach should reflect a participant's contribution to any frequency excursion at the time of that excursion.[94]

Pacific Hydro argued that the causer pays framework is flawed and has contributed to units actively removing primary control from the power system. It suggested that as a principle, any generator that acts to counter a frequency change should not be penalised for doing so. It also considered that contingency FCAS cost recovery is flawed and undermines the reliability of the power system as generators are getting paid for services that aren't effective. Pacific Hydro submitted that a more preferable approach would be some form of performance-based payment.[95]

S&C Electric Company argued that there is a mistaken perception that wide dead bands limit a participant's contribution factors under the causer pays framework, and that there needs to be education/communication to convince participants that this is

90 Hydro Tasmania, submission to issues paper, p. 10.

91 Tesla, submission to issues paper, p. 4.

92 See: https://www.aemo.com.au/Stakeholder-Consultation/Consultations/Causer-Pays-Procedure-Consultation

93 Clean Energy Council, submission to issues paper, pp. 3-4.

94 Meridian Energy Australia, submission to issues paper, p. 7.

95 Pacific Hydro, submission to issues paper, p. 13.

not the case.[96] It expressed concern that the existing arrangements are not well understood and create concern amongst participants. S&C Electric Company considered that some services that are purchased may be ineffective, and suggested that increased performance compliance should be undertaken.[97]

Snowy Hydro supported improvements to the causer pays framework, and noted the need for a clear statement of the problem that is being sought to be solved prior to any such work. It submitted that the arrangements for the recovery of contingency FCAS costs should provide a price signal that incentivises market participants to act in a way that minimises the need to procure these services.[98]

The South Australian Department of the Premier and Cabinet expressed concern about the existing causer pays framework as they apply to local regional (state) FCAS requirements. It suggested that the AEMC keep a watching brief on AEMO's review of the causer pays procedure with the aim of potentially addressing this issue in the *Frequency control framework review*. It also indicated concern over the current approach to the recovery of contingency FCAS costs and indicated a preference for development of a causer pays method that assigned costs of contingency FCAS to those participants who have caused the need for the service.[99]

4.2.5 Co-optimisation

Energy Networks Australia indicated support, if practicable, for co-optimisation between services such as inertia, system strength or system stability with FCAS markets but noted that the NEM dispatch engine (NEMDE) might not be capable to manage and co-optimise all potential markets.[100]

Hydro Tasmania indicated that they assumed other system services such as inertia and system strength would become reflected in NEMDE constraints and that this could incentivise adding inertia and system strength to relieve constraints although the best outcome would be to have market sourcing of inertial service.[101]

Pacific Hydro indicated that the first and most important step is to return to good engineering control practices and that tightening the system frequency control will strengthen the response of the units and solve many issues that appear on the system.[102]

96 S&C Electric Company, submission to issues paper, p. 8.

97 Ibid., p. 10.

98 Snowy Hydro, submission to issues paper, p. 9.

99 Government of South Australia, Department of Premier and Cabinet, submission to issues paper, p. 4.

100 Energy Networks Australia, submission to issues paper, p. 9.

101 Hydro Tasmania, submission to issues paper, p. 11.

102 Pacific Hydro, submission to issues paper, p. 14.

The South Australian Department of the Premier and Cabinet indicated that any long term market design will need to consider how FCAS can best be co-optimised against inertia.[103]

TasNetworks considered that there is scope for inertia and FFR to be co-optimised, but that any such co-optimisation would need rigorous analysis both from a technical and market frameworks perspective.[104]

Tesla stated that it is important to co-optimise energy, FCAS and any emerging frequency markets as we shift towards a services based energy market as doing so will encourage the uptake of technologies that can provide a range of different services.[105]

4.3 Next steps for this work stream

The AEMC will continue to work with stakeholders to better understand both concerns with existing arrangements and opportunities for FCAS markets to support frequency control management aims.

Importantly, there is a strong theme within submissions that changes to FCAS markets should not be rushed and that the initial priority should be on understanding the issue, what is contributing to the issue, and to potentially resolving any underlying system causes. There is nevertheless significant value in continuing to develop our understanding of the role that FCAS markets can play in supporting the secure operation of the NEM as it transforms over the coming years.

This includes identifying potential market structures capable of incorporating new technologies which offer the potential to provide more rapid response while also supporting investor certainty consistent with the NEO.

The Commission intends to further explore the range of requirements which need to be met when considering changes to FCAS market frameworks including:

1. Appropriate incorporation of new technologies which offer the potential for the efficient provision of FFR services

New technologies, such as wind farms and batteries, offer the potential for frequency response services that act much faster than traditional services, perhaps as quickly as a few hundred milliseconds. Potential changes to FCAS markets should consider how faster response services can be incorporated and valued efficiently.

2. Investor certainty and flexibility

Markets put consumers at the heart of decision making. Markets are generally the most efficient mechanism to further the interests of consumers through allowing efficient

103 Government of South Australia, Department of Premier and Cabinet, submission to issues paper, p. 4.

104 TasNetworks, submission to issues paper, p. 15.

105 Tesla, submission to issues paper, p. 6.

price discovery and production decisions based on competitive market dynamics, even where consumers do not directly participate, as is the case in FCAS markets.

The existing design of regulating and contingency FCAS markets has worked well to date in providing efficient market outcomes. It has achieved this through the real time optimisation of the provision of FCAS by dispatching in accordance with a merit order of enablement.

However, the conventional pricing model where FCAS is treated as a minor secondary revenue source for existing generators may not remain appropriate as the market becomes increasingly dependent on frequency control services being provided from less conventional sources, such as wind farms and batteries. As conventional generators retire, and newer technologies take their place, there may be a greater priority on FCAS income as a bankable revenue stream to be included in project financial proposals. As such, greater certainty in FCAS revenue may be needed to encourage investment in frequency control services.

3. Co-optimisation of services to manage system security challenges and provide the most efficient outcome for consumers

Currently, FCAS markets are co-optimised with the energy market. FCAS may increasingly need to be co-optimised against dynamic system characteristics, such as the presence of inertia.

However, as levels of inertia decline into the future, a level of inertia will be required to manage contingencies across the NEM as a whole (e.g. loss of the largest generator). Consequently, any long term review of FCAS markets will need to consider how inertia provision can best be co-optimised against FCAS, with this potentially requiring the development of additional inertia services. It should be noted that in September 2017, the AEMC published a final rule to place an obligation on Transmission Network Service Providers (TNSPs) to procure minimum required levels of inertia or alternative frequency control services to meet these minimum levels. This may impact the need, and arrangements, for co-optimisation.

Co-optimisation presents considerable technical complexities given that system inertia is provided by synchronous generators (that is, non-inverter connected generators) that are currently operating and synchronised with the network. As such, inertia is effectively provided on a binary basis, that is, an entire generating unit's inertia is either online or offline and the speed at which that inertia can be brought online reflects the start and synchronisation time of each generating unit. As high inertia units are invariably steam turbines with long start times, in practical terms, this is likely to require day-ahead commitment for the provision of an inertia service.

This may present considerable technical complexities given the different characteristics of providers of frequency control. As such, there are significant technical and regulatory issues that will need to be addressed in order to deliver a co-optimised solution.

4. **Consideration of other system security constraints such as system strength and system stability**

The Commission recently determined not to make a rule to establish a market mechanism for inertia at this time.[106] One of the reasons for this decision was that further consideration needs to be given as to how inertia can be accurately valued with the application of constraints to manage other system security requirements, such as system strength and system stability, and with the provision of alternative frequency control services, such as fast frequency response.

Potential changes to the design of FCAS frameworks will need to consider how potential changes will impact on system security constraints on the system as a whole.

AEMO is working to further understand the limits of power system operation with low levels of synchronous capability and is considering how system security constraints can be developed to address these issues in a holistic manner.

106 See: http://www.aemc.gov.au/Rule-Changes/Inertia-Ancillary-Service-Market

5 Participation of distributed energy resources in system security frameworks

This chapter provides a progress update on the work stream of the review considering distributed energy resources, and their participation in system security frameworks. It provides a summary of:

- the issues being considered
- relevant stakeholder comments made in submission to the issues paper
- the next steps for this work stream.

5.1 The issue

As the power system changes many of the services needed to operate the power system may need to be sourced from new providers. In addition to the withdrawal of large synchronous generators, there has been a rapid and ongoing uptake of distributed energy resources. This has predominantly consisted of distributed solar photovoltaic systems, but will increasingly include other technologies such as batteries and electric vehicles. These technologies bring with them challenges and opportunities for power system security.

The AEMC's focus through the *Frequency control frameworks review* is on the opportunities for distributed energy resources to participate in system security frameworks, not their impacts on power system security.

The Finkel Panel Review, published in June 2017, recommended that by mid-2019 the AEMC "review the regulatory framework for power system security in respect of distributed energy resources, and develop rule changes to better incentivise and orchestrate distributed energy resources to provide essential security services such as frequency and voltage control".[107]

The potential for distributed energy resources to support power system security has also been recognised by AEMO through its Future Power System Security work program, the AEMC in the final report of its *Distribution market model* project and Energy Networks Australia in its *Electricity network transformation roadmap*.[108]

This review seeks to build on this work to further understand how distributed energy resources can participate in the NEM's system security frameworks. The issues paper outlined the AEMC's views on some of the regulatory, technical and commercial opportunities and challenges associated with this.

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107 Independent Review into the Future Security of the National Electricity Market, final report, June 2017, pp. 62-63.

108 See: AEMO, *Visibility of distributed energy resources*, January 2017, p. 17; AEMC, *Distribution market model*, final report, p. 72; Energy Networks Australia / CSIRO, *Electricity network transformation roadmap*, final report, April 2017, pp. 52-63.

5.2 Summary of stakeholder submissions on issues paper

In the issues paper, the Commission considered frameworks pertaining to the connection and operation of distributed energy resources. The issues paper explored:

- a range of system security services that could be provided by distributed energy resources
- the arrangements for connecting distributed energy resources as set out in the NER, Australian Standard 4777 and the requirements of individual distribution network service providers
- existing regulatory frameworks that facilitate the participation of distributed energy resources in system security frameworks
- other issues that may be relevant to sourcing system security services from distributed energy resources, including technical and commercial challenges.

We asked stakeholders for feedback on a number of questions, with a focus on determining the extent of any barriers that may limit the ability for distributed energy resources to provide system security services.

In submissions to the issues paper, stakeholders were generally supportive of increased participation of distributed energy resources in system security frameworks.

AEMO considered that the growing penetration of distributed energy resources and other non-synchronous generation will affect the needs of the system, and hence the design of frameworks. It noted that there are likely to be times over the next ten years when few of the remaining synchronous generators are online due to high levels of distributed energy resources generation.[109]

AEMO submitted that the design of a frequency control framework will need to be suitable for the system now, but also for a system that might reasonably be expected in say 15 years when penetration levels of distributed energy resources could be up to 22 per cent of total installed capacity.

5.2.1 System security services

Stakeholders generally supported the view that distributed energy resources will likely have a role in providing future system services.[110] Snowy Hydro and the Australian Energy Council suggested that in doing so, there should be effective market mechanisms for procuring the desired services in a technology neutral manner, allowing for the least cost provision of system security services.[111] Energy Queensland

109 AEMO, submission to issues paper, p. 8.

110 Submissions to issues paper: AEMO, p. 9; Energy Network Australia, p. 2; Tesla, p. 8; TasNetworks, p. 2; Snowy Hydro, p.12; Australian Energy Council, p. 2.

111 Submissions to issues paper: Snowy Hydro, p.12; Australian Energy Council, p. 2.

shared a similar view, submitting that while the regulatory framework does not necessarily inhibit distributed energy resources from providing system services, it hasn't been explicitly considered to date, so it is likely that incentives will be needed for distributed energy resources to provide capability beyond any minimum requirements.[112]

S&C Electric Company asked the Commission for evidence of the ability for distributed energy resources to provide system restart services, a service that was suggested distributed energy resources could provide in the issues paper. It noted that they were not aware of any aggregated small-scale systems that have successfully delivered black start services.[113] S&C Electric Company also suggested that inertia would not be able to be provided by distributed energy resources, and that it is unlikely that they would be able to provide primary frequency control. However, it noted that frequency control on longer time scales (e.g. secondary[114]) may be possible, noting that it cannot be assumed that all distributed energy resources, regardless of size, can deliver a frequency service and that the primary operational intent of distributed energy resources is managing energy costs.[115]

5.2.2 Connection arrangements

Tesla submitted that the connection approval processes and metering arrangements should be different and appropriate for the size of the installation being connected.[116] TasNetworks agreed that consistency between large and small generators should be applied at a policy level, but noted that attempting to apply the specific technical requirements in the NER for distributed energy resources will most likely not work in practice.[117] Energy Queensland shared a similar view.[118]

S&C Electric Company noted the disparity between the connection arrangements for large scale generators and distributed energy resources. It noted that network charges do not reflect the costs that distributed energy resources could impose.[119]

TasNetworks and Energy Networks Australia submitted that the connections framework for distributed energy resources has, to date, focussed on addressing DNSP issues. Both noted that this may limit the ability for an aggregator to utilise the flexibility of the inverter fleet to provide network support or security services.[120] Meridian Energy was of the view that there are difficulties for distributed energy

112 Energy Queensland, submission to issues paper, p. 11.

113 S&C Electric Company, submission to issues paper, p. 2.

114 For an explanation of the different time frames of frequency control services, see page 13 of the issues paper.

115 Ibid, pp. 11-13.

116 Tesla, submission to issues paper, p. 7.

117 TasNetworks, submission to issues paper, pp. 16-17.

118 Energy Queensland, submission to issues paper, p. 19.

119 S&C Electric Company, submission to issues paper, p. 14.

120 Submissions to issues paper: TasNetworks, p. 16; Energy Networks Australia, p. 3.

resources to participate in the market due to the "the friction associated with excessive requirements from distributors, which are out of balance with the associated consequences".[121] Energy Networks Australia suggested that changes to these arrangements would support distributed energy resources providing system security services, but should maintain consideration of the distribution network.[122]

Meridian Energy also argued that the connection framework inhibits the ability of the owners of distributed energy resources to provide system security services because it requires SCADA level data that is difficult for these resources to provide. It asked that the AEMC give consideration to how distributed energy resources could provide FCAS without the requirement for uneconomic metering.[123] Tesla raised a similar comment, noting that AEMO requires "industrial-grade meters" for demand side participation, which is cost-prohibitive for residential distributed energy resources.[124]

Tesla also submitted that the lack of consistency in the interpretation of Australian Standard 4777.2 and Chapter 5A of the NER results in inconsistent opportunities for distributed energy resources in various jurisdictions.[125] It suggested that increasing consistency between jurisdictions would be a valuable step in facilitating the participation of distributed energy resources.[126] Energy Networks Australia suggested that the AEMC consider working with Standards Australia to facilitate a further review of relevant aspects of Australian Standard 4777. It submitted that the standard has a number of features that should be considered further if distributed energy resources are to be integrated into system security frameworks.[127]

5.2.3 Existing regulatory arrangements

Some stakeholders noted that there are likely to be challenges associated with incorporating distributed energy resources into system security frameworks.

TasNetworks noted that the ability of distributed energy resources to provide frequency control services has not been proven at scale. Energy Networks Australia suggested that aggregated distributed energy resources do not currently provide a firm service, but may be able to in the future. Both Energy Networks Australia and TasNetworks suggested that the minimum FCAS bid of 1MW posed a barrier to entry for trials of aggregated distributed energy resources.[128]

121 Meridian Energy, submission to issues paper, p. 10.

122 Energy Networks Australia, submission to issues paper, p. 3.

123 Meridian Energy, submission to issues paper, p. 10.

124 Tesla, submission to issues paper, p. 7.

125 Tesla, submission to issues paper, p. 8.

126 Ibid, p. 7.

127 Energy Networks Australia, submission to issues paper, p. 5.

128 Submissions to issues paper: TasNetworks, p. 16; Energy Networks Australia, p. 3.

Tesla submitted that the provision of system security services should be incentivised through aggregated platforms that can interact with AEMO and DNSPs' remote signalling.[129]

TasNetworks noted that aggregators of distributed energy resources have typically not provided system security services. It suggested that careful consideration of appropriate regulatory frameworks should accompany greater participation of aggregated distributed energy resources in providing these services.[130]

TasNetworks noted that the issues paper did not consider customer preferences in providing system security services. It suggested that the customer perspective of commercialising these services needs further consideration because overcoming all of the technical and regulatory issues may still not deliver the desired outcomes if there is not a willingness to participate.[131]

5.2.4 Technical challenges

Stakeholders noted a number of technical challenges associated with the participation of distributed energy resources in system security frameworks.

Both Tesla and TasNetworks suggested that there might be value in undertaking more trials to assess the capability of aggregated distributed energy resources.[132] TasNetworks noted the need for adequate fault ride through performance from distributed energy resources if they are to be relied upon for the provision of various system services.[133]

Energy Networks Australia was of the view that aggregated distributed energy resource capacity is not currently sufficiently firm for aggregators to be able to provide system services, but that it may be in future. It considered that there is a need for more research to prove what levels of distributed energy resource control is required to provide such services.[134] Origin Energy suggested that there may be merit in requiring aggregators to assume responsibility for the distributed energy resources under their control. For example, a distributed energy resource owner would have to meet a certain technical standard in order to qualify for inclusion in the aggregator's portfolio.[135] AGL noted that distributed energy resources may not be as firm as large-scale generation, but there is high probability that if a segment of the fleet is not available then assets in other locations are available. It considered that the role of the

129 Tesla, submission to issues paper, p. 8.

130 TasNetworks, submission to issues paper, p. 16.

131 TasNetworks, submission to issues paper, p. 17.

132 Submissions to issues paper: Tesla, p. 3; TasNetworks, p. 17.

133 TasNetworks, submission to issues paper, p. 17.

134 Energy Networks Australia, submission to issues paper, p. 10.

135 Origin Energy, submission to issues paper, p. 4.

aggregator is to manage the availability of distributed energy resources and to bid their services into the market in a way that reflects what can be delivered with certainty.[136]

Energy Networks Australia and Energy Queensland were of the view that communications and control equipment formed a large portion of the technical challenges of distributed energy resources participating in system security frameworks.[137]

TasNetworks and S&C Electric Company noted that an aggregated response from distributed energy resources is likely to cause issues, including voltage and thermal loading, in the distribution network.[138] Energy Networks Australia recommended that the review recognise the need to ensure local supply quality and security is not compromised in enhancing wider network stability.[139] AGL considered it necessary to investigate and determine how to manage conflicts between local and system-wide priorities. It noted that, under the current arrangements, if the local voltage is high during a raise event, any attempt to dispatch distributed energy resources may result in those resources disconnecting from the grid and failing to provide the service. AGL was of the view that this can be factored into the availability function, but may result in reduced opportunities for participation by customers.[140]

5.2.5 Commercial challenges

Some stakeholders spoke about the commercial challenges involved in the provision of system security services by distributed energy resources.

S&C Electric Company considered that, at the "un-aggregated" level, the value to each individual provider is small and therefore may not be sufficient to motivate participation.[141] Energy Queensland submitted that the value offered for providing system security services may be lower than other competing values, such as network congestion, tariff arbitrage or wholesale market participation. It noted that the aggregator would likely act in the customer's interest and prioritise the most financially attractive signal.[142]

Meridian Energy noted that there are always commercial challenges associated with competing commercial players, differing market objectives and complex commercial drivers, but that the market is expected to resolve these issues if there is a stable regulatory framework in place.[143]

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136 AGL, submission to issues paper, p. 7.

137 Submissions to issues paper: Energy Networks Australia, p. 5; Energy Queensland, p. 11.

138 Submissions to issues paper: TasNetworks, p. 17; S&C Electric, p. 14.

139 Energy Networks Australia, submission to issues paper, p. 3.

140 AGL, submission to issues paper, p. 7.

141 S&C Electric Company, submission to issues paper, p. 14.

142 Energy Queensland, submission to issues paper, p. 11.

143 Meridian Energy, submission to issues paper, p. 11.

Origin Energy considered that the barriers to entry are primarily due to the infancy of the distributed energy resources market, especially around aggregators, and the lack of knowledge by owners on the types of services that their systems can offer.[144]

5.3 Next steps for this work stream

In undertaking this work stream, the Commission acknowledges that the potential large-scale provision of system security services by distributed energy resources is a relatively recent consideration, for which the technical requirements are not fully understood and may evolve over time. This may place some limitations on the extent to which frameworks for the provision of system security services can be properly formulated through this review.

Nevertheless, the Commission maintains that the continued consideration of the regulatory arrangements for the provision of system security services from distributed energy resources should continue to be investigated as the technical understanding increases. The Commission understands that AEMO is considering many of these technical issues, including through its *Integrated system plan*,[145] and will collaborate with AEMO to incorporate that work within the time frames of this review.

In progressing this work stream, the Commission will consider:

- how effectively the existing regulatory arrangements that allow the participation of distributed energy resources are working
- how distributed energy resources might be able to provide other market ancillary services in addition to the services currently being provided
- the regulatory and technical arrangements that facilitate aggregated distributed energy resources participation
- the capability of distributed energy resources to provide future system security services.

The Commission will consider any further responses from stakeholders in submissions to the issues paper. The Commission is also interested in further stakeholder consultation through bilateral meetings.

Current regulatory frameworks

Recent changes to regulatory frameworks have made it possible for distributed energy resources to provide some system security services. By registering as a Market Ancillary Service Provider, aggregated distributed energy resources are able to offer frequency control ancillary services. Market Ancillary Service Providers are currently

144 Origin Energy, submission to issues paper, p. 3.

145 See: http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan

offering market ancillary services. This participation is recent and thus, we intend to seek feedback from participating Market Ancillary Service Providers and AEMO.

Providing other market ancillary services

Participation of distributed energy resources in market ancillary services to date has been limited to contingency FCAS.

Certain distributed energy resources such as interruptible loads, are well suited to providing contingency FCAS as it requires a sudden change in consumption which can be achieved by disconnecting a load. These distributed energy resources may be less suited to providing regulating FCAS. Generally, to provide regulating FCAS, the provider needs to be able to follow instructions from the AGC to increase and decrease output (or consumption) to correct small deviations in frequency. Loads tend not to have processes that can readily increase or decrease consumption on a dynamic, incremental basis. However, other distributed energy resources, such as aggregated residential batteries or embedded generators, may be more suited to providing regulating FCAS.

The Commission will seek to better understand the capability of distributed energy resources to provide regulating FCAS, and any limitations imposed by the current frameworks.

Arrangements to facilitate distributed energy resources participation

We will also seek to understand whether the communications and technical requirements of participating in centralised system security service markets inhibit distributed energy resources participation. It is important that a service provider has appropriate communications and monitoring equipment in place when it is providing system security services. However, monitoring individual units in an aggregated collection of distributed energy resources may not always be appropriate, and is likely to be costly. In future, it may be feasible for aggregated distributed energy resources to interface with AEMO through a single point of communication that allows participation without imposing significant technical and monitoring costs.

Future system services

In the issues paper, we proposed a range of possible system security services that could be provided by distributed energy resources. The Commission notes that the services may be unlikely to be provided by distributed energy resources in the short term. However, we are interested in understanding any limitations under the current regulatory arrangements that may inhibit future participation.

6 Next steps for the review

6.1 Summary of work program

In undertaking this review, the Commission acknowledges that a properly designed frequency control framework must be suitable for the system now as well as into the future. As the power system continues to evolve, with the increased take-up of non-synchronous generating technologies and distributed energy resources, flexibility in market and regulatory frameworks is likely to lead to more efficient outcomes.

As highlighted by AEMO through its Future Power System Security program, these changes to the power system are challenging the conventional technical understanding of power system operation. The Commission is therefore aware of the risks of undertaking wholesale changes to regulatory and market frameworks, which may compromise the ability for future potential providers of frequency control services to actively and efficiently participate. This may place some limitations on the extent to which recommendations for changes to frameworks for the provision of system security services can be properly formulated through this review. Some changes may require further consideration and assessment through additional work or rule change requests prior to implementation.

Nevertheless, the Commission maintains that the continued consideration of the regulatory arrangements for the provision of frequency control services should continue to be investigated in parallel with AEMO's consideration of the future needs of the system. This will allow for the thinking around frequency control frameworks to remain fluid and relevant as the technical understanding of the power system evolves. The work identified by AEMO as being currently on foot to consider security needs will be an invaluable and essential input into its own thinking of how existing regular and market frameworks will need to evolve.

Further, there may be some changes which could be achieved in the short term, which may have a measurable impact on improving the control of power system frequency, and which may not compromise longer term changes to frequency control frameworks. It is possible that these changes may be undertaken through adjustments to systems or procedures and may not necessarily involve changes to the NER.

The AEMC's work program will be informed by the comments made by stakeholders in meetings with us and in their submissions to the issues paper.

6.2 Stakeholder consultation

The next formal stage of public consultation for this review will be the draft report, which is due to be published in March 2018. However, we always welcome meetings with stakeholders. Those wishing to meet with the AEMC should contact Claire Richards on (02) 8296 7878 or at claire.richards@aemc.gov.au.

The AEMC has established:

- a reference group comprising senior representatives of the AEMC, AEMO, the Australian Energy Regulator (AER) and the Senior Committee of Officials (SCO) to provide high-level input and strategic advice to the AEMC
- a technical working group comprising representatives from the AER and AEMO, consumer groups, large energy users, conventional generators, renewable energy generators, retailers, energy service providers, and transmission and distribution network service providers to provide technical advice to the AEMC and assist with the development of recommendations for the review.

The AEMC will convene meetings with these two groups as needed throughout the review process.

6.3 Review timeline

The timeline for this review is set out in Table 6.1 below.

Table 6.1 Review timeline

Item	Date
Publication of issues paper	7 November 2017
Close of submissions on issues paper	5 December 2017
Publication of progress update to COAG Energy Council	19 December 2017
Publication of draft report	March 2018
Publication of final report	Mid-2018

AUSTRALIAN ENERGY MARKET COMMISSION

AEMC SYSTEM SECURITY ACTION PLAN

WORK PROGRAM UPDATE NOVEMBER 2017

Final: Mar 2017 ✓
Emergency frequency control scheme rules
Enhanced schemes to act as a last line of defence in an emergency

Final: Jan 2017 ✓
System security market frameworks review
Recommendations to deliver a stronger and more resilient system with better frequency control as the generation mix changes

Final: Sep 2017 ✓
Managing the rate of change of power system frequency rule
Makes networks provide minimum level of inertia

Final: Sep 2017 ✓
Managing power system fault levels rule
Makes networks provide services necessary to meet minimum levels of system strength

Final: Sep 2017 ✓
Generating system model guidelines rule
Requires detailed information on how generators and networks perform

Final: Mar 2018
Inertia ancillary service market rule
Considering delivery of inertia above minimum levels where there is market benefit

Stage one final: Nov 2017 ✓
Reliability Panel review of frequency operating standards
Assessing whether the existing standard is appropriate to maintain a secure power system as the generation mix changes

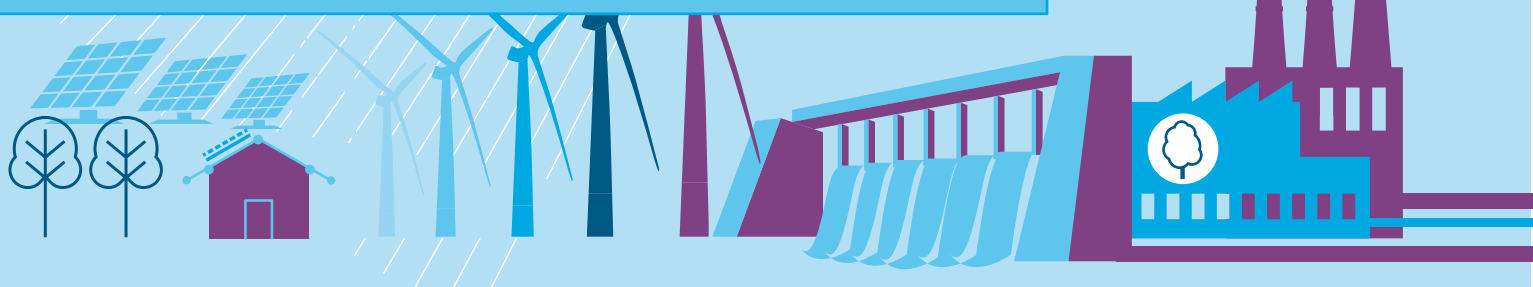
Final: mid-2018
Frequency control frameworks review
Looking at ways to integrate new technologies and demand response to help keep the system secure

Draft: Early 2018
Generator technical performance standards
Updating the technical performance standards for connecting generators and the process for negotiating them

Underway
Review of the system black event in South Australia on 28 September 2016

SYSTEM SECURITY

Keeping the lights on: Measure of the power system's capacity to continue operating within defined technical limits, even if a major power system element disconnects from the system.



PROGRESS AGAINST RECOMMENDATIONS MADE IN *SYSTEM SECURITY MARKET FRAMEWORKS REVIEW*

RECOMMENDATION	STATUS
A STRONGER SYSTEM	
Require network service providers to maintain system strength at generator connection points above agreed minimum levels, and require new generators to 'do no harm' to previously agreed levels of system strength.	Final rule on *Managing power system fault levels* made 19 September 2017.
Consider requiring inverters and related items of plant within a connecting party's generating system to be capable of operating correctly down to specified system strength levels.	Consultation paper on *Generator technical performance standards* rule change published 24 October 2017.
RESISTING FREQUENCY CHANGES	
Require transmission network service providers to provide minimum required levels of inertia, or alternative equivalent services.	Final rule on *Managing the rate of change of power system frequency* made 19 September 2017.
Introduce a market-based mechanism to realise the market benefits that could be obtained through the provision of inertia above the minimum required levels.	Draft rule on *Inertia ancillary service market* published 7 November 2017. Further consideration through the *Frequency control frameworks review.*
BETTER FREQUENCY CONTROL	
Assess whether mandatory governor response requirements should be introduced and investigate any consequential impacts of this.	For consideration through the *Frequency control frameworks review.*
Review the structure of FCAS markets, to consider: • any drivers for changes to the current arrangements, how to most appropriately incorporate FFR (fast frequency response) services, or alternatively enhancing incentives for FFR services within the current six second contingency service • any longer-term options to facilitate co-optimisation between FCAS and inertia provision.	
Assess whether existing frequency control arrangements will remain fit for purpose in light of likely increased ramping requirements, driven by increases in solar PV reducing operational demand at times and leading to increased demand variation within a day	
Consider placing an obligation on all new entrant plant to have fast active power control capabilities.	Consultation paper on *Generator technical performance standards* rule change published 24 October 2017.
FACILITATING THE TRANSFORMATION	
Continue to scope further power system security issues likely to arise from the ongoing transformation of the market, such as the impact on system restart ancillary services of decreasing levels of synchronous generation and the adequacy of current voltage control arrangements.	AEMO to further scope these issues.