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Mr John Pierce
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Australian Energy Market Commission
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Dear Mr Pierce

Re: Operating Reserves and Fast Frequency Response Rule Change

Infigen Energy is submitting two Rule Change requests that address growing concerns about uncertainty and volatility in the NEM. This Rule Change request proposes the development of a new Fast Frequency Response Ancillary Services market, procuring fast-acting reserves (1-2 second response).

We consider that the development of a formal market for fast response will increase the efficiency of dispatch by increasing the tools available to AEMO to manage system security, and accelerate the provision of valuable flexibility from both generation and demand side resources – supporting the National Energy Objective.

We look forward to working with the Commission to progress this proposal.

Yours sincerely

Ross Rolfe
Managing Director

Part A – Operating Reserves

1. Context for the Rule Change Request

The NEM's plant stock was historically dominated by synchronous generators but in response to falling costs and environmental objectives, the NEM has seen sharply rising levels of asynchronous generation, particularly wind and solar PV (Variable Renewable Energy; VRE). VRE has progressively displaced certain aging synchronous generation units, and AEMO's Draft 2020 Integrated System Plan shows this trend continuing under all scenarios.

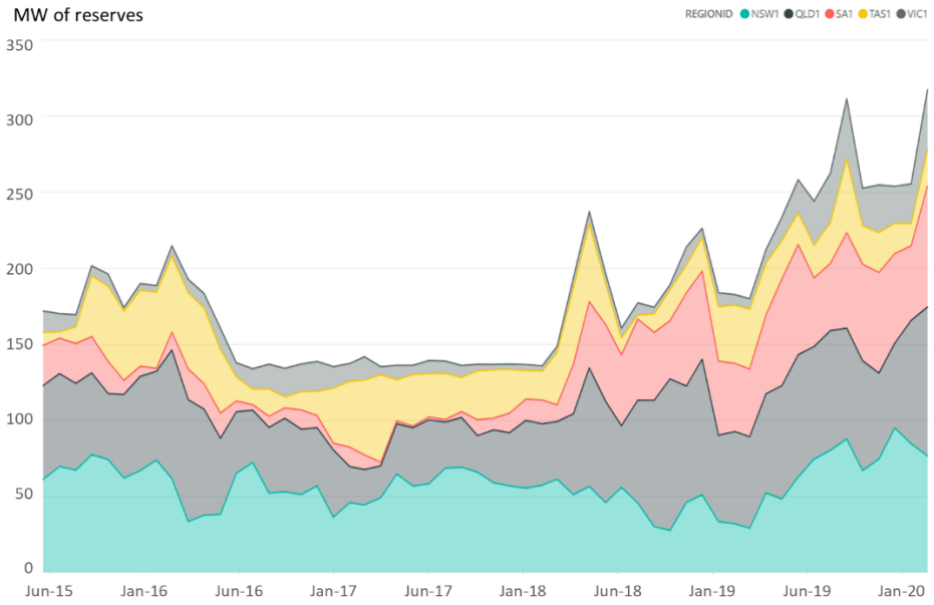
This has led to a reduction in other services that were previously provided for free along-side energy production from synchronous units, including inertia, system strength and tight deadband primary frequency control.

Furthermore, new and unknown modes of failure, extreme weather conditions and major network events have resulted in greater focus on Contingency events that have traditionally been classified as *non-credible*. The timescale for responding to some events is measured in milliseconds (exacerbated by lower inertia conditions) and AEMO does not currently appear to have the ability to procure fast-acting services on shorter timeframes.

These challenges have manifested in several ways:

- AEMO has increased the quantity of Regulation FCAS procured (Figure 1) in response to reduced Frequency performance;
- Increased occurrence of Lack of Reserve (LOR) periods, characterised by low Operating Reserves and more frequent procurement and activation of Reliability and Emergency Reserve Trader (RERT) reserves;
- Changed acceptable operating envelope, including reclassifying non-credible Contingencies and a recent rule change request for a Mandatory Primary Frequency Control response from all capable assets with a very tight deadband of +/-15mHz; and
- Increase operational headroom required for prudent management of the power system – including local requirements for Contingency FCAS with AEMO considering regional requirements for Contingency FCAS under normal conditions

Figure 1 - Increase in quantity of procured reserves - Average by Month (Source: AEMO)



In our view, it is critical to address these issues now, and before they further impact the reliability of the power system or, alternatively, require greater and more disruptive market changes or interventions. In particular, we consider that:

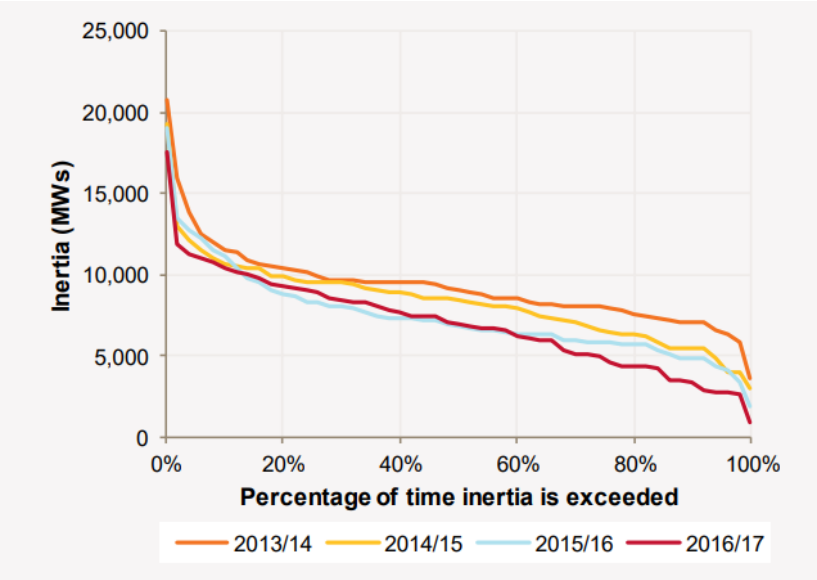
- Historically, power system 'modes of failure' were well understood, and an N-1 approach to system operations within the current suite of FCAS Regulation & Contingency services was entirely appropriate. But new modes of failure now exist and are not well understood and difficult to predict – these will need to be responded to very rapidly;
- Potential future shortfalls need to be addressed pre-emptively and 'early' rather than in response to a crisis, and the best approach to do this is via creating transparency through markets for required services.

2. Problem Statement – Fast Frequency Response

System inertia has declined significantly as the NEM transitions from conventional fossil-fuel generation to flexible, asynchronous resources. Inertia is a measure of the ability of the system to slow the rate of change in Frequency due to sudden changes in supply and demand. It is provided by synchronous generators such as coal, hydro and gas-fired power stations as well as synchronous condensers. South Australia has experienced a steady decline in inertia over the last six years. Figure 2 shows this decline from FY14 to FY17, and this trend has continued with a rising 'asynchronous to synchronous generation' ratio. In FY17, minimum inertia levels fell below 1000MW.s. on 21 December 2018. AEMO declared an inertia shortfall in the South Australia sub-network.[1]

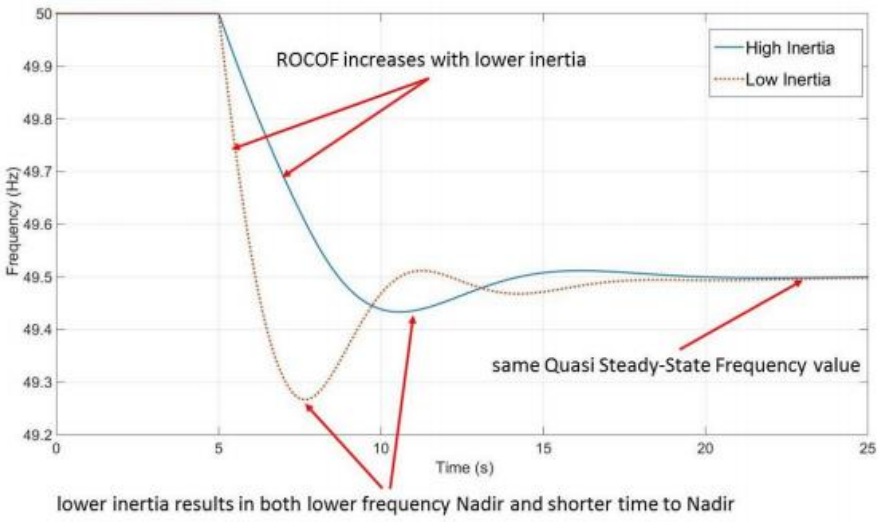
[1] Notice issued by AEMO under clause 5.20B.3(c) of the Rules

Figure 2 - Reduction in inertia over time (Source: AEMO)



Inertia from synchronous generators provides an inherent response to slow the Rate of Change of Frequency (RoCoF) of the system. If the Frequency changes too fast, existing protection systems (including Regulation FCAS and Contingency FCAS) cannot respond quickly enough to "catch" the system, potentially leading to load shedding. As shown in Figure 3, Frequency falls further and faster in a low inertia system, reducing the time available for Frequency responsive resources to deliver the requisite arresting power necessary to create an acceptable Frequency nadir. In some regions, the amount of 6 Second Contingency FCAS is increased during periods of low inertia, whereas introducing a faster acting response may mitigate this requirement.[2]

Figure 3 - Impact of reduced inertia on frequency performance



[2] FFR working paper pg 28

The need for Fast Frequency Response (FFR) has been explored extensively by AEMO[3], AEMC[4], external consultants, and several trials have been initiated. In our opinion, it is critical to establish an appropriate market sooner rather than later, and provide a clear market signal to market participants. This will reduce the risk of major disruptions when possible but unexpected events occur (such as was the case in South Australia when the last remaining coal power station closed and no contingency planning had been undertaken).

While FFR does not (currently) avoid the need for physical inertia, it provides for a broader operating envelope for the grid – allowing for operating with larger contingency events at lower levels of inertia.

3. Proposed Market for Fast Frequency Response

Infigen's rule change proposal focuses on resources responding to changes in frequency in order to counteract the effect of reduced inertial response[5]. Specifically, Infigen sees merit in developing a new FFR service, procuring resources to deliver:

- A rapid increase or decrease by generation or load triggered by a locally sensed Frequency deviation at a defined level; and
- Reaching full response in a timeframe less than 2 seconds.

Infigen proposes the implementation of two new FCAS markets: FFR Raise and FFR Lower. These services would be procured by AEMO in a similar fashion to the current Contingency FCAS markets. Whereas the contingency FCAS markets require a response in within 6s/60s/5min, additional FFR would respond rapidly to meet a response in less than two seconds.

FFR participants would be able to continue to participate in all Contingency markets (as the current design allows) and pass on the response from FFR to 6s, 60s and 5mins. This provides an incentive to technologies capable of Fast Frequency Response to rapidly respond after a contingency, reducing the frequency nadir and ensuring the system is more resilient. Effectively, FFR provides AEMO with an additional "lever" to be able to operate the system in low system inertia conditions.

To deliver maximum value to consumers, this market must be a two-sided market with generators and loads able to participate in providing FFR. Whilst FFR is a new capability, generators and loads have both proven the ability to provide FFR services[6]. Having a two-sided market will likely drive sufficient competition in an emerging capability and ensure low cost delivery of the service in the long-run.

3.1.1. Trigger of procurement

FFR would always be procured alongside existing Contingency FCAS markets. FFR procurement would be modelled on the existing Fast Raise and Fast Lower Contingency services

3 For example, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/2017/FFR-Working-Paper---Final.pdf
4 For example, https://www.aemc.gov.au/markets-reviews-advice/frequency-control-frameworks-review
5 Synthetic inertia verses fast frequency response: a definition
6 Source of Ireland FFR load, batteries wind farms etc etc

3.1.2. Volume to procure

There is a delicate interaction between the levels of FFR, Primary Frequency Response (PFR), and inertia required to support a secure system[7]. Procuring the right amount of FFR becomes particularly important as inertia decreases. Understanding the marginal economic benefit of procuring additional FFR compared to imposing constraints on power system operation (reducing Contingency size) or procuring additional inertia (e.g., directing on units or procuring synchronous condensors) is required to provide clear price signals for trading-off each service. In our view, the volume of FFR service procured should be calculated based on Contingency size with the consideration of system inertia.

3.1.3. Eligibility of FFR providers

We propose that the appropriate response time should be determined in the Market Ancillary Services Specification (MASS). AEMO has indicated that full response is feasible from some FFR resources in 250ms, but a response time of 0.5-2 seconds may be appropriate to maximise the pool of supply-side options (and market participation).

Enabled (and activated) resources should be required to sustain response until the next FCAS Contingency market response time (i.e. up to 6 seconds, the existing Fast Contingency FCAS market).

3.2. How this rule change will address the issues

3.2.1. Contribution to the NEO

The proposed market for FFR market will contribute to the NEO through:

- Providing a market price signal for Fast Response to frequency deviations, supporting the resilience of the system with low inertia;
- Improving transparency in the market by clearly pricing the trade-offs between different options for managing system security. I.e., AEMO will be able to co-optimise in the NEMDE the level of inertia, FFR, and transmission flows (i.e., largest credible contingency) based on offered bids;
- Accelerate the transition to a two-sided market by providing further opportunities and value for Demand Response, which (in some cases) can deliver very rapid reductions in load that are not fully valued under PFR; and
- Agreeing on a clear framework and market for FFR will allow project developers to model the future value of FFR, and accelerate the uptake of these technologies, including incremental upgrades to proposed projects to deliver FFR.

3.2.2. Costs and benefits

The cost of FFR procurement will need to be recovered from consumers, and will represent an additional cost. However, we expect in general FFR will only be procured where it is least-cost to do so – i.e., based on AEMO's constraints and offers for energy and FFR (and other FCAS services), FFR is procured and reduces total system costs. Any fixed component of FFR procurement (e.g., to manage unexpected events) would need a separate cost-benefit calculation. The availability of FFR will ultimately benefit consumers by delivering additional tools for managing system security, that will allow more efficient dispatch particularly under low-inertia conditions (e.g., by allowing greater production from low marginal cost wind and solar resources). Consumers may also benefit from improved system resilience to (historically) non-credible events.

7 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/2017/2017-03-10-GE-FFR-Advisory-Report-Final---2017-3-9.pdf

The rule change will require changes to AEMO's dispatch and settlement systems, including NEMDE. AEMO will also need to determine the appropriate specifications for the FFR service, and how the volume of FFR to be procured should be cooptimised with other services or NEMDE constraints.

Flexible, dispatchable resources including demand response will have their value recognised. Participants in the new market will need to develop appropriate procedures to respond to the Reserve signals, and updated settlement procedures. For some resources, additional high-frequency metering may be required to participate in the FFR market.

3.2.3. Stakeholder Support for introducing FFR in the NEM

Many independent, industry, and government bodies in Australia support the notion of introducing an FFR market. The Finkel Review, CSIRO and Energy Networks Australia noted there will likely be a need to amend the existing service definitions in the NEM to ensure previously inherent services, such as inertia and Fast Frequency Response, are explicitly identified and secured. The Generator Group submission to the AEMC on the Frequency Control Framework Review supported the idea that given greater VRE generation, the current approach of frequency control in the NEM is no longer appropriate, and accordingly, there are potential requirements and opportunities to introduce new services such as fast FCAS. The Clean Energy Council also supports Fast Frequency Response to be pursued pre-emptively.

AEMO prepared a working paper in 2017 to facilitate discussion of the technical characteristics and capabilities of potential sources of FFR. The working paper explored opportunities and roles for FFR and identified a set of possible services that could provide value in the NEM. In addition, AEMO provided advice to the Essential Services Commission of South Australia that enabling FFR services in the NEM may allow the Frequency Operating Standards to be met with a lower level of synchronous inertia, and potentially a lower long-term cost.

The Commission will recall that it published the Frequency Control Frameworks Review in July 2018. The AEMC Review examined the broader structure of the existing FCAS markets and determined FFR and inertia services needed to be incorporated as the nature of the NEMs supply and demand dynamics continue to change. The Commission concluded that the best approach to the procurement of frequency services in the longer-term needs to be performance-based, dynamic, transparent, and included analysis of pricing mechanisms that could incorporate a range of frequency services including inertia. FFR has been identified as an ongoing program of work for the AEMC and AEMO to undertake to address the identified issues before or as they emerge.

3.2.4. Undervalued Resources

A rapid response following a Contingency event becomes a valuable option for maintaining the Frequency Operating Standard in a power system with lower inertia.[8] Conversely, emerging resources (batteries, Demand Response) have increased capabilities that can deliver fast services but are not valued (or utilised) in our current market design.

An excellent practical example relates to utility-scale battery energy storage systems. Battery response times to a frequency event are limited by their droop setting. By way of specific example, a 50MW (50MWh) Battery may be eligible for as little as 20 MW of 6

[8] FFR working paper pg 27

Second Contingency FCAS (due to its droop setting), despite being capable of delivering up to 100 MW of response (from charging to discharging) in milliseconds if required.

3.2.5. The need for a market mechanism

AEMO recently developed Rule changes proposing a mandatory tight deadband response from all capable market generators. We accept the need for greater Primary Frequency response. However, in our view this approach is flawed because it does not identify how much response is required, does not ensure headroom will be available to deliver the response, and does not follow sound market design principles for adequately pricing the required resources. A generally accepted principal in economics is that a mis-priced good will be under-supplied in the long run.

A clear market mechanism will reduce the risk of further ad hoc interventions and inefficient obligations in the future.

3.2.6. Clearer assessment framework for trials and funding

AEMO and ARENA have supported development and trials of technologies that deliver FFR. Recent projects that have received funding from ARENA and have demonstrated the value and capability of FFR include:

- ESCRI-SA Battery Energy Storage;
- Hornsdale Power Reserve; and
- Hornsdale 2 Wind Farm.

We consider the technology is now at a point where an established market will provide a framework for future funding and trials, improving clarity for the market and better focussing funding.

APPENDICES

4. Appendix A - International FFR experience

Declining inertia levels are not unique to the NEM. Internationally it has been recognised that system inertia is decreasing as synchronous generators become displaced by VRE. Power systems around the world are therefore facing challenges caused by low inertia including[9] Ireland / EirGrid & SONI, Central Europe, Nordic grid, Ercot and Hydro-Quebec.

In Australia the issue is particularly pertinent in South Australia which has very low levels of synchronous generation and is loosely interconnected to the rest of the NEM. One way to manage the risk of a high RoCoF is to 'constrain on' synchronous generators in order to maintain some minimum level of synchronous inertia. But, this will become increasingly expensive as levels of VRE increases. Consequently, several power systems are considering and/or implementing FFR to arrest any Frequency decline[10]. The Table[11] below provides an overview of international equivalent FFR services and the mechanism is which they are procured.

System	Service	Mechanism
Hydro-Quebec	Inertia-based fast frequency response for all wind farms connecting to its system	Mandatory
National Grid	One second response from batteries via droop response and tight dead band	Tendered
PJM	Fast regulation response through AGC signals	Scaled price by how rapidly they respond
New Zealand	One second contingency market delivered by demand response	
ERCOT	Fast frequency response 1 and 2. Delivered in full 0.5 seconds sustained for 15mins and as long as needed respectively.	
EirGrid	Two second FFR, sustained for eight seconds	Started with regulated tariffs in interim phase and transitioned to long term contracts issued through an auction. Payment basis for all services will be on an 'availability' basis. Scaled payment for faster response

9 Foundations and Challenges of Low-Inertia Systems, Milano, Dorfler, Hug, Hill and Verbic, 2018

10 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/2016/FPSS---International-Review-of-Frequency-Control.pdf

11 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Future-Energy-Systems/2019/AEMO-RIS-International-Review-Oct-19.pdf