FAST FREQUENCY RESPONSE SPECIFICATION

RELEASE OF GE ENERGY CONSULTING REPORT

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IMPORTANT NOTICE

Purpose

This document presents AEMO's interpretation of the key findings of a report prepared for AEMO by GE Consulting on a potential fast frequency response service, and outlines AEMO's proposed next steps.

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GE REPORT KEY FINDINGS

Background

The context for this work is provided in the Future Power System Security (FPSS) program *progress report* published in August 2016. In summary, as synchronous generators (who have traditionally provided inertia and frequency control) are displaced by non-synchronous generators with different technical characteristics, it is necessary to find new ways to maintain a secure power system. This may include the definition of new services, enhancing the abilities of conventional technologies, and accessing the technical capabilities of emerging technologies.

As part of the FPSS program, in June 2016 AEMO engaged GE Energy Consulting (GE) to deliver a package of work aiming to:

- Explore the potential value of a Fast Frequency Response (FFR) service in the National Electricity Market (NEM), to help mitigate and manage high Rates of Change of Frequency (RoCoF).
- Provide advice on how such a service should be specified.

The scope of work focuses on the capabilities of non-synchronous technologies to deliver FFR, and their individual technical characteristics and limitations. Conventional technologies are comparatively better understood, and therefore were not explored in this study. However, the aim is ultimately to understand and access the full range of solutions that are available, including all technologies, to give the broadest possible participation in future service provision.

GE has now delivered its report: *Technology Capabilities for Fast Frequency Response*, which AEMO has published on its website to promote stakeholder understanding and engagement in the development of FFR in the NEM.

AEMO's interpretation of GE's findings

GE's report indicates that FFR could increase the range of alternatives to meet the frequency operating standards in future, by utilising the capabilities of technologies that have not traditionally provided frequency control services.

FFR is not a direct substitute for synchronous inertia

FFR and synchronous inertia are technically distinct services due to the timescales over which they act. This means a minimum quantity of synchronous inertia will continue to be required in the short to medium term. However, FFR can compensate for, and help to mitigate, the effects of reduced synchronous inertia on power system frequency control by providing a wider range of options for meeting the frequency operating standards (depending upon a co-optimised consideration of the availability and costs of both services). This suggests that enabling FFR services in the NEM may allow the frequency operating standards to be met with a lower level of synchronous inertia.

Potential role of FFR services in the NEM

FFR services could be considered for two possible purposes in the NEM. First, as a new type of Frequency Control Ancillary Service (FCAS), assisting with the management of credible contingency events. Secondly, FFR could be a part of an emergency response for managing rare, extreme events, such as the non-credible separation of a region. Both are worthy of further analysis, but will likely require different technical specifications and regulatory frameworks.

Speed of FFR response

GE's analysis revealed that several FFR-type technologies, such as batteries, flywheels and supercapacitors, can respond very rapidly to a triggering signal (within 40 milliseconds (ms)). Others, such as inertia-based FFR (IBFFR) from wind turbines (extracting the kinetic energy from the drivetrain, often termed "synthetic inertia") more typically deliver FFR in one to two seconds, although GE notes that this response is highly tailorable.

Although some individual technologies can respond rapidly, the robust *detection and identification* of frequency disturbances within very short timeframes is highly challenging. As the target total response time reduces, the risks of false triggering or failure to correctly trigger escalate significantly. For this reason, GE suggests that total response times (incorporating the time required for robust detection and identification) in the vicinity of 500ms are achievable, while total response times of 250ms are ambitious. Faster response times may be possible with direct event detection methods, and with continued technology development and experience.

Fast response times (in the ambitious range) will likely be required as part of an emergency response mechanism to manage large non-credible events. However, response times faster than 500ms may not be immediately necessary for the management of credible contingency events. For credible events, it may be prudent to gain experience and build confidence in the deployment and response of FFR with relatively slower response times first, progressing towards faster response times as inertia levels reduce further.

Further detailed modelling and analysis is required to determine the optimal response times for FFR to address credible and non-credible events in the NEM.

Other considerations in specifying FFR

Response speed is not the only consideration in specifying an FFR service:

- ***Sustain times*** – GE recommends that FFR should only be sustained as long as required. A sustain time of six seconds would be within the design capabilities of all FFR-type technologies considered, and would be compatible with the existing FCAS framework. When FFR is delivered proportionally (with closed-loop controls), sustain times longer than the frequency nadir may have value and produce better overall control of system frequency. This needs further examination through detailed power system modelling.
- ***Energy negative technologies*** – Some technologies, such as IBFFR from wind turbines, are "energy negative" for the delivery of FFR under some conditions (particularly under lower wind conditions). This means that they have a "recovery period" during which active power delivery will be reduced, often by an amount that exceeds the original energy boost (due to the reduction in efficiency during this brief period). This recovery period will typically occur in the 60 seconds immediately following the disturbance, and therefore is relevant for the timeframes involved in managing a frequency disturbance. The management of this recovery period will need to be carefully considered. A larger quantity of fast contingency FCAS (responding within six seconds) may be required if significant FFR is supplied by resources of this type. Adding to the complexity, the depth and duration of the recovery period depends strongly upon external factors such as wind speeds (for wind IBFFR).
- ***Real-time co-optimisation*** – The amount of FFR available from wind IBFFR during any interval also depends strongly upon wind speeds. This may need to be managed in real time, perhaps co-optimised with system inertia, and the availability of FFR from other sources.
- ***Controls*** – The specification of FFR control systems will need careful consideration. Open-loop (switched) controls are important for delivering a rapid response, while closed-loop (proportional) controls are important for stable system recovery. Hybrid approaches show promise (such as an initial rapid switched response, followed by a transition to a proportional response during recovery).
- ***Demand-side response –*** Facilitation of demand-side participation in FFR should be specifically examined. Demand-side FFR resources are likely to be technically effective, and cost efficient. To allow broad participation, including demand-side resources, it may be important to allow some flexibility in control systems and combine various types of control

systems from different resources to produce the overall system response required, at lowest cost.

- ***Raise and Lower*** – It is important that raise and lower services are specified as separate services. Most technologies are highly asymmetric with regards to the costs of providing raise and lower services. This dual specification is consistent with the current FCAS markets.

How much FFR service might be feasible?

Where FFR is delivered by dedicated technologies, such as batteries, flywheels, and supercapacitors, the amount of FFR service available will depend upon the capacity installed for each technology. For demand-side providers, the amount of FFR service will depend upon the availability of interruptible loads.

For wind and utility-scale photovoltaics, the amount of FFR service available will depend upon the capacity of those technologies installed, where those providers include FFR capabilities. The 2016 National Transmission Network Development Plan (NTNDP)[1] projected around 10,000 MW of new wind generation capacity entering the NEM by 2033. Wind IBFFR can typically provide up to a maximum of 10% of power production. This suggests that a maximum of 1,000 MW of IBFFR could be available in high wind periods by 2030, if all new turbines included IBFFR capability. Assuming wind development is suitably geographically distributed, this could be sufficient to deliver all of the FFR required in some periods, although the amount available in any dispatch interval will depend upon wind speeds. Dispatch intervals with higher wind speeds (and therefore more IBFFR available) could be expected to correlate somewhat with lower inertia periods, when larger quantities of FFR are most valuable.

The economic factors in scheduling FFR from different resources in different intervals (and the co-optimisation with inertia requirements and other operating constraints) could be assessed via production cost modelling.

NEXT STEPS

AEMO is in the process of developing a larger package of work that builds upon the findings by GE, working towards a more detailed specification of a possible FFR service in the NEM, for assisting with management of credible contingency events. This will further explore the points raised above as requiring further analysis.

This work will also continue to be used to feed into the process underway by the Australian Energy Market Commission (AEMC) to assess the merits of an FFR service as part of its System Security Markets Framework Review.

AEMO is collaborating with ElectraNet to investigate the feasibility and design of a system protection scheme for the Heywood interconnector, with a response time fast enough to prevent separation, or to ensure a stable island. The possible utilisation of FFR resources is under consideration in the scheme design.

[1] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2016/Dec/2016-NATIONAL-TRANSMISSION-NETWORK-DEVELOPMENT-PLAN.pdf