PRIMARY FREQUENCY CONTROL

Response to AEMC consultation paper

October 2019

1. Executive summary

Stanwell appreciates the opportunity to provide feedback on the Australian Energy Market Commission's (AEMC's) Mandatory Primary Frequency Response Consultation Paper.

Stanwell recognises the need for effective frequency control in the National Electricity Market (NEM) and considers Primary Frequency Control (PFC) a valuable contributor to maintaining a secure and reliable power system. Stanwell supports continued consideration of longer term incentive-based proposals, in alignment with the FCFR which was jointly agreed by AEMO and the AEMC.

Stanwell also acknowledges the strong message from the Australian Energy Market Operator (AEMO), which has been adopted by the AEMC, that PFC is an immediate system security need. We also acknowledge that frequency control within the Normal Operating Frequency Band (NOFB) has deteriorated faster than expected during the Frequency Control Frameworks Review (FCFR) and consider that incentivising PFC is a priority.

Stanwell opposes the mandatory PFC solution proposed by AEMO. It appears likely to achieve little certainty of improved frequency control, with significant cost and will undermine, if not eliminate, investment signals which are needed to ensure supply of PFC in the future. AEMO has also not clearly demonstrated why PFC provision should be mandated in lieu of other potential options.

Stanwell proposes an alternative approach that can be implemented quickly. Stanwell suggests the AEMC broaden the existing system security service provisions for inertia and system strength to include PFC. This approach would give AEMO the ability to contract for PFC directly with generators. Contracting was identified in the FRFR as a potential interim step and would provide a simple method to efficiently improve frequency performance while allowing time to properly consider an effective longer term solution.

Stanwell has also been active amongst industry in considering how it can use its generators to improve PFC on an interim basis. The aim would be to satisfy the immediate frequency control need, while informing proper consideration of an efficient, longer term solution. With strong support from AEMO this action from industry may be possible, however it is likely to be faster and legally simpler for the AEMC to adopt Stanwell's proposal of allowing AEMO to contract with individual generators for PFC.

Stanwell welcomes the opportunity to further discuss this submission. Please contact Luke Van Boeckel on (07) 3228 4529 or at Luke.VanBoeckel@stanwell.com.

2. Progressing the Frequency Control Frameworks Review

The AEMC's 2018 Frequency Control Frameworks Review (FCFR) examined a range of options to address worsening frequency performance under normal operation. The FCFR also specified a clear work plan that was agreed jointly between the AEMC and AEMO. The apparent lack of progress on that work plan, especially the deferral and cancellation of the mainland trials, have limited the availability of detailed information on the requirements of the system. The AEMO proposal for mandatory provision of PFC appears to be at least in part a reaction to this lack of detailed information.

The FCFR concluded that an incentive-based mechanism was the most appropriate method of procuring the frequency services in the future NEM. Stanwell notes this is in alignment with AEMO's statements at the time, *"Generators would need to be incentivised or compensated for operating in this manner* [providing headroom for primary frequency control]"[1]. Stanwell has been surprised by AEMO's apparent change in approach within one year. Stanwell continues to support the findings of this review and the need for primary frequency response to be properly incentivised. An incentive based approach will support the next generation of investment, ensuring security needs are met into the future.

3. Contracting as an alternate interim approach

How contracting could work

Stanwell supports AEMO having the ability to contract with generators for the provision of PFC, similar to its current authority to contract for inertia and system strength[2]. This is preferable to AEMO having the ability to contract for PFC through the Network Support and Control Ancillary Services (NSCAS) framework as the NSCAS framework is more constraining on AEMO.

As with AEMO's ability to procure inertia and system strength, provision of PFC via contracts would be an interim solution to address the immediate frequency control need while the AEMC, AEMO and industry work towards a more efficient, longer term solution.

AEMO could publish an expression of interest to all generators based on the parameters underpinning its rule change proposal (deadband, droop, sustained duration, etc). AEMO's expression of interest presumably would also include a megawatt (MW) headroom requirement to guarantee the provision of PFC. Generators could then respond with offers to supply the service.

The offers could be structured to comprise an upfront cost as well as an enablement fee for the headroom reserved ($/MW/minute). The upfront cost draws upon AEMO's proposal based on the cost to make plant changes to provide the service (but would not require the administrative overhead and lead time of AEMO approving the basis of the cost and processing the claim).

AEMO could then select the appropriate mix of generators based on location, service/deadband offered, amount of headroom offered, technology, outage rates, price and the determined need. Stanwell proposes that AEMO would then have significant flexibility in selecting the combination of generators to meet the frequency control need. This would allow low cost, non-conforming offers (such as wider deadband or lower droop) to be accepted if they would be beneficial to improving frequency control, in combination with higher cost, conforming offers.

Benefits of contracting

Contracting as an interim solution has a number of benefits:

1. Allows AEMO to procure a guaranteed amount of PFC, including headroom thereby improving frequency performance from current state;
2. Simple solution that can be implemented quickly with immediate benefits;
3. AEMO has the opportunity to build the provision of services over time, observing the impact of each incremental plant on frequency, other plant, system oscillations and to limit the amount of PFC procured to match the quality of frequency control desired;
4. Would likely address frequency issues with a limited number of contracts (certainly the number of contracted generators would be less than near universal provision under AEMO's proposal);
5. Likely to be less expensive than AEMO's proposal given reduced upfront costs from less than 100% provision, and less time and expense for AEMO and participants in upgrading unsuitable plant, applying for exemptions and redoing Generator Performance Standards;

[1] AEMO response to AEMC request for advice, March 2018

[2] For example NER Chapter 4, 4.4.5(a) "(a) *AEMO* may at any time *enable* a range and quantity of *system strength services* to maintain the minimum *three phase fault level* at a *fault level node* when the *three phase fault level* at the *fault level node* would otherwise be below the minimum *three phase fault level* or when reasonably considered necessary by *AEMO* to maintain the *power system* in a *secure operating state*.".

6. Provides a clear price signal to new investment, putting a price on a necessary service for future capability.

4. Concerns with Mandatory PFC proposal

Investment and market impacts

Stanwell is concerned that the mandatory, uncompensated provision of PFC will inhibit further development of a market or other incentive based solution as envisaged in the FCFR. This would have long term implications as without a price signal, new sources of PFC are not incentivised and the system may not have the effective PFC capability it requires. Even if new sources are mandated AEMO acknowledges that the natural headroom available now to provide PFC will decline: *"In the future, as non-synchronous generation continues to displace thermal generation, the 'natural' headroom might be expected to decline, as these generators tend to always operate at their maximum potential output."*[3] This implies that the mandated solution may not be resilient to the future generation mix.

The mandatory proposal will also significantly impact the contingency Frequency Control Ancillary Services (FCAS) market, likely saturating the market, again diluting the price signal for new investment in these services.

AEMO note that they expect the providers to adjust their offer prices to compensate for the non-payment for PFC. Given the size of the contingency FCAS markets and the proposed near-mandatory provision the only potential avenue for cost recovery is through the energy market.

Assuming a similar increase in offer price in either case, the fact that the energy market is far larger than the contingency market means the total cost impact on consumers of increased energy prices compared to increased FCAS prices would be significant.

Not technology neutral

Although the rule change appears to be technology neutral as it applies to all generators, the reality is that PFC is not provided unless headroom/stored energy is available to provide the response.

Stanwell's investigation of the technologies that will have natural headroom available reveals that the some technologies will rarely have headroom available and therefore will rarely provide a PFC raise service. AEMO has noted this as well, *"in order to actually provide upwards headroom, a solar (or wind) generator must be pre-curtailed."*[4] This burdens other technologies with providing the majority of the PFC service, thereby defying the principles of technology neutrality.

AEMO's rule change proposal also emphasises in the section "Optional providers of PFR" that it is large, 200MW+ synchronous generators that are typically online who will have the biggest impact on frequency control. The corollary to this situation is that these technologies will face the largest burden under the rule change.

Batteries also appear to be overly burdened by the rule change. Stanwell understands that the headroom of batteries will be fully utilised, if necessary, until the battery is depleted. In addition, the expected increased and regular cycling due to the rule change will greatly reduce the operating life of the battery.

Headroom/stored energy

AEMO's proposal does not require any headroom or stored energy to be reserved. In the case of under-frequency events such as the sudden loss of a large generator, if a steam generator is operating without headroom (irrespective of whether it is operating at maximum capacity) no primary frequency response can be provided. This is regardless of the droop curve, dead band settings or governor enablement.

To enable the cheapest operating costs for the benefit of consumers, Stanwell routinely operates with minimal headroom, only reserving headroom when we are specifically enabled for contingency raise FCAS or when required for ramping.

With no headroom requirement, AEMO is relying on natural headroom being available (in addition to headroom obtained through the contingency market) but can not guarantee whether it will be available when needed. This appears to negate the effectiveness of the rule change. It also further burdens those generators who through their enablement for contingency raise FCAS are obliged to carry the necessary headroom.

With the mandated tight deadband, contingency providers (providing a primary rather than switched response) will begin responding to frequency changes within the NOFB. If no natural headroom is available, the only generators that will respond in this region of the NOFB will be these contingency FCAS providers.

[3] AEMO response to AEMC request for advice, March 2018

[4] AEMO, *Ibid*

Having contingency FCAS providers used to maintain frequency within the NOFB confuses the purpose of the contingency market. With contingency headroom utilised for PFC there may not be an adequate response to actual contingencies.

Sufficient headroom will also be increasingly important within a high renewables context. During under frequency events, the ability of wind and solar plants to provide a primary frequency response will be limited by their current operational mode of running at maximum potential output at all times.

Impact on ramping

The increasing penetration of variable renewable energy (VRE) sources will necessitate faster ramp rates from existing generation[5], in order to match supply and demand.

As discussed earlier, Stanwell reserves headroom to assist in meeting ramping requirements[6]. If the local frequency exceeds the mandated deadband, Stanwell's headroom reserved for ramping will be utilised for primary frequency response. This may leave Stanwell unable to meet our ramping obligations. Stanwell requests the AEMC clarify whether AEMO's proposal for not penalising generators for providing a beneficial frequency response also extends to ramping requirements.

Near universal provision of PFC

AEMO proposes mandating PFC on all generators, exempted on a case by case basis. This is despite the pre-NEM arrangement in various Australian States where only a selected group of suitable generators were assigned to provide PFC at any point in time, and the rest were not. Indeed PFC obligations were also rotated through the pool of suitable generators to avoid overburdening any one set of machines[7].

In addition, the Tasmanian Frequency Control Test, conducted in isolation from the mainland NEM from 13th–28th May 2018, reduced or removed deadbands on approximately 30%[8] of the available generation capacity and found that this was sufficient to observe a, *"very clear improvement in system frequency performance*"[9] This result was despite the higher degree of frequency volatility normally observed in Tasmania compared to the mainland NEM, as an effect of the smaller market size.

Although the Tasmanian market is very different to the mainland and the results are not directly transferrable, these results do imply that universal provision is likely to be excessive-adding unnecessary cost..

Inevitably in a system there will be low cost and high cost providers. AEMO's proposal is to exempt infeasibly high cost providers but still require customers to pay for all other providers (through upfront upgrades and ongoing costs via costs included in energy market offers). If the actual requirement is even slightly below AEMO's cutoff (of feasibility not efficiency) then consumers are paying too much.

Risk of oscillations

Stanwell is concerned that the rule change proposal does not thoroughly examine the possible interactions of different generators with varied response characteristics and governor attributes providing a near-instantaneous response to system frequency deviations.

Different technologies will have inherently diverse temporal limitations on frequency responsiveness and sustainment. It is important that generators with the headroom to provide a primary response to a local frequency disturbance are capable of sustaining this response prior to secondary frequency controls being initiated. This may not always be possible in an environment dominated by variable renewable energy sources. A mismatch of primary and secondary interactions will result in further frequency oscillations, and likely incur additional wear-and-tear costs to plants, whilst at the same time diminishing system stability.

Stanwell cautions that the application of revised settings to the governors of generating units required to provide PFC should be subjected to a co-ordinated approach under the oversight and approval of the relevant Network Service Providers (NSPs) and AEMO. Failure to do so may give rise to further risk of oscillations between machines and their various controllers (ie governors, excitation systems, power system stabilisers, protection systems etc).

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[5] "..An increasing proportion of the generation mix during the middle of the day is expected to be supplied by solar generation (and to a lesser degree, wind generation). Solar generation can be highly variable – more so than other types of generation – as it responds very quickly to intermittent clouding. Analysis of the existing utility-scale solar farms in the NEM shows that changes in output >50% of rated capacity may be expected to occur within 4 seconds", AEMO response to AEMC request for advice, March 2018

[6] "the lower of 3MW/minute or 3% of the maximum *generation* provided", Chapter 10, Clause 3.8.3A, National Electricity Rules

[7] This was certainly operational practice in the QEC prior to interconnection with NSW. We have not been able to find one of the old faxed daily generation dispatch and frequency control instructions as reference.

[8] 30% is based on nameplate capacity of the reported participants divided by the average daily available capacity in the TAS

[9] Tasmanian Frequency Control Tests Summary Report, F&M Ringrose, December 2018

Cost of PFC provision

The additional costs to plant for remaining primary frequency responsive are two-fold. Firstly, operating at a partial load level in order to provide headroom incurs the opportunity cost of missed energy revenue and potential green certificates. In the absence of a clear headroom requirement, proper incentives which appropriately value curtailed energy must exist in order for generators to provide headroom in future, particularly for those generation technologies which have no intrinsic ability to withhold energy. Secondly, movement costs are incurred as plants constantly adjust output in response to grid conditions. This increases wear-and-tear and ultimately reduces unit efficiency, with thermal generators requiring additional fuel per unit of generation over time.

Included within this movement cost is the cost of movement enablement. For thermal generators, this requires generating extra steam pressure in addition to the steam pressure setpoint maintained to allow ramping to dispatch targets. This higher boiler pressure creates a continuous cost and reduction in efficiency arising from burning fuel to create high pressure steam and then throttling it across a control valve without extracting any valuable energy from it.

It is important that these additional costs are not understated and appropriately compensated in order to secure frequency services and incentivise the next generation of investment.

Given the proposed rule change does not require headroom, the cost of its provision has not been given due consideration. This is a serious practical oversight and represents a risk to both system security and to industry as it will likely compromise the efficacy of the rule change if implemented, thus requiring further addendums. If the rule is to proceed, Stanwell suggests the specification of headroom be removed from AEMO's Primary Frequency Response Requirements document and placed in the Rules. This would give industry certainty that any change to this important requirement would proceed through an AEMC-led consultation process.

International comparison

Declining frequency stability is not an issue unique to the NEM, however, the NEM is unique amongst energy markets in that energy and frequency control ancillary services are solved through co-optimised energy and FCAS dispatch. Additionally, in most other market regions, including the North American Eastern and Western Interconnections, and the Continental European Interconnection, market areas are subsets of entire synchronous systems and optimise their own individual dispatch and frequency maintenance obligations to their tie-line bias control.

Appendix 1 compares the frequency control arrangements in selected international markets. As can be seen, in both Eirgrid and National Grid, which both have a deadband matching AEMO's proposed ±0.015Hz, capacity or headroom is reserved and financially compensated for.

Implementation and exemption issues

Both the process for implementing the rule change, and the process for exempting generators that cannot provide the service (or that by doing so reduce frequency performance - such as through causing oscillations) are unclear.

Stanwell is concerned that the process may be arbitrarily applied. For example, if generators are adjusted one at a time, the earliest adjusted units take on a greater share of the initial frequency burden compared to those generators added later. Also, if generators are adjusted one by one to the point where frequency performance is excellent, there may be no incentive for AEMO to continue working and paying for additional generator adjustments, again leaving the initially adjusted generators disadvantaged. The same disadvantage occurs when the next generator added causes frequency oscillations and is then exempted.

Stanwell's contracting proposal removes these issues as the contracted parties have voluntarily offered to provide the service (including headroom) at a price commensurate with the cost.

Relationship to MASS

AEMO have verbally advised[10] that they intend to revise the Market Ancillary Services Specification (MASS) to recognise the primary frequency response provided by generators contracted for contingency services, from the edge of the mandated deadband. Under this proposal, generators enabled for contingency services will begin providing a primary frequency response from the edge of the mandated deadband, rather than the edge of the Normal Operation Frequency Band (NOFB) as is currently the case. Stanwell questions what this means for actual contingencies (rather than frequency excursions due to normal operation). It may be possible that contingency providers have exhausted their headroom through normal operation and are thereby unavailable for an actual contingency. This inadvertently reduces the resilience of the system.

[10] AEMO teleconference with AEC, 11th October 2019

5. Stanwell active in working with industry on goodwill, voluntary approaches

Stanwell has been a part of discussions to consider whether the provision of PFC on a voluntary basis would be appropriate. Initially these discussions were focussed on reinstating a mainland PFC trial, but later evolved to discussion of whether generators could voluntarily provide PFC that met the needs of the AEMC and AEMO, outside of a trial.

These discussions are a goodwill gesture from industry to improve frequency performance in the short term, allowing the AEMC and AEMO to return their focus to the longer term incentive-based FCFR solutions.

With strong support from AEMO this action from industry may be possible, however it is likely to be faster and legally simpler for the AEMC to adopt Stanwell's proposal of allowing AEMO to contract with individual generators for PFC.

6. Causer pays proposals

AEMO proposes to exempt from causer pays generators that have their frequency response set to provide a PFC service (with no obligation to reserve headroom). Although this proposal now appears redundant, Stanwell does not support it.

The proposal undermines the incentives to meet dispatch targets in a linear fashion and thereby assist with frequency performance rather than responding to it. For example, an exempt generator that is routinely off target has no incentive under the proposal to improve its performance.

The proposal also burdens consumers and generators who are not able to make the frequency change with a greater share of the causer pays cost.

The cost saving for large generators in being exempt from causer pays also does not adequately compensate for the cost of providing primary frequency response. The proposal is therefore not an alternative to a longer term incentive based approach to PFC provision.

AEMO also seeks to clarify in the Rules that strict compliance with dispatch instructions should not take priority over the provision of frequency response. Stanwell supports this change and asks the AEMC to extend it to generators' ramping requirements. As discussed earlier, headroom reserved by Stanwell for ramping could be monopolised by AEMO for frequency response if the mandatory rule change is successful. This means that by providing a frequency response, Stanwell is not able to meet its ramping requirements.

7. Appendix 1 – International comparison of selected primary frequency control arrangements

Jurisdiction	Scheme	Procurement method	Remuneration	Deadband setting	Droop setting	Expected response	Responsibility
Eirgrid	Primary Operating Reserve (POR)	Headroom reservation is a market procured resource; non-contracted units are expected to respond with available headroom and operate in frequency sensitive mode. EirGrid procures long term POR reserve contracts through an auction mechanism whereby awarded generators must reserve headroom	Remuneration for capacity reserved and energy delivered	±0.015Hz	Synchronous: 3–5% Wind: Nominally set at 4%	Response within 5 – 15 seconds (delivered at the frequency nadir)	Transmission System Operator
National Grid (GB)[1]	Mandatory Frequency Response (MFR)	Compulsory for large generators to have capability to provide MFR at time of connection. A Mandatory Services Agreement allows the TSO to instruct service as required.	Remuneration for capacity reserved and energy delivered	±0.015Hz	3–5%	*Primary response*: Response within 2 seconds, full response within 10 seconds of an event, sustained for further 20 seconds. *High frequency response*: Response within 10 seconds of an event, sustained indefinitely.	Transmission System Operator
Italy* (ENTSO-E)	Primary Frequency Control Service	All units with nominal power ≥ 10 MVA, excluding those fed by non-programmable renewable.	Remuneration for energy delivered	Thermal: ±0.010Hz Gas/OCGT: ±0.010Hz	Thermal: 5-8% Hydroelectric: 2-5%	Generators must reach 50% of their final value within 15 seconds with full delivery within 30 seconds	Transmission System Operator
Spain* (ENTSO-E)	Primary Frequency Control	All generating units. Generators incapable of providing primary regulation must provide proof that they have procured their primary regulation obligation from another generating unit.	No remuneration	No intentional deadband	1.5% for a frequency deviation of ±0.020Hz	Response shall be fully delivered within 15 seconds for a deviation < 100 mHz. In case of deviation > 100 mHz - 50% of the reserve must be delivered within 15 seconds - 100% of the reserve must be delivered before 30 seconds with a minimum linear delivery rate between 15 and 30 seconds	Transmission System Operator

* Jurisdictions with a mandatory headroom requirement.

[1] https://www.nationalgrideso.com/balancing-services/frequency-response-services/mandatory-response-services?assessment-process


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