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To: AEMC
Submitted via website

Infigen Energy Limited
Level 17, 56 Pitt Street
Sydney NSW 2000
Australia
T +61 2 8031 9900
F +61 2 9247 6086
www.infigenenergy.com

Re: Response to **Primary Frequency Response Rule Changes – Consultation Paper**

Infigen Energy (Infigen) welcomes the opportunity to make a submission. Infigen owns portfolio of wind and firming capacity across New South Wales, South Australia, Victoria and Western Australia. Our renewable portfolio includes 670 MW of vertically integrated wind plus c90 MW of contracted capacity in Victoria. Infigen also owns and operates a portfolio of dispatchable firming capacity including a 123 MW open cycle gas turbine in NSW, a 25 MW / 52 MWh battery in SA (commissioning October 2019) and will soon take ownership of 120 MW of dual fuel peaking capacity in SA. Infigen has also bought Power Purchase Agreements (PPAs) from wind farms, and is seeking additional wind and solar PPAs. Our development pipeline has projects at differing stages of development covering wind, solar and dispatchable firming capacity.

1. OVERVIEW

Infigen accepts that the greater spread of observed frequencies is a departure from historical performance and AEMO considers that there is an urgent need to restore effective frequency control in the NEM to maintain the safety, security and reliability of the power system[1].

We are very supportive of mechanisms that maintain system safety, security and reliability. However, we consider mandatory requirements can be costly and economically inefficient.

Mandating all capable generators to provide tight deadband primary frequency response (PFR) will mean that the service is not being provided by those that are best able to or at least cost, with a risk of over-consumption and eventually, under-supply (i.e. the usual market characteristics of a mis-priced good). Mandatory requirement for PFR will not value technical and performance capability of emerging

[1] AEMC 19 September 2019 Consultation Paper: Primary Frequency Response Rule Changes page 2

technologies and instead may deter new investment in these capabilities. It is anticipated by AEMO that it will also distort the contingency FCAS markets, and put downward pressure on prices, reducing potential Generator revenues from the market[2]. This means there will be no long-term signals for innovation and development of inverter-based technology for better frequency response such as the recent development in large-scale batteries[3], wind[4] and solar. In our view, regulatory arrangements must be able to remain effective in achieving security outcomes over the long-term in a changing market environment. Unpriced mandatory requirements will not achieve this and could potentially act as a disincentive.

Unpriced mandatory requirements will also not provide appropriate incentives for behaviour that manages frequency. For example, a battery is incentivised to make itself unavailable to the market when not operating reducing the system resilience and capacity reserves for PFR.

Infigen therefore does not support this restoration of frequency control through unpriced mandatory requirements placed on all resources. Rather, the AEMC should seek to develop markets that deliver appropriate incentives for the future generation mix. Providers of PFR should be remunerated for cost of providing the service. This could be by way of organised spot markets or through contracted supply

If short-term action is required, AEMC and AEMO could seek to contract a minimum level of response (e.g., 33% of capacity, as suggested by Undrill) or extend the staged approach while developing a more comprehensive solution. Infigen would support a mandatory wider deadband acting as a safety net to improve system resilience (noting that Infigen's Lake Bonney Battery Energy Storage System is responsive to frequency even when not enabled for contingency FCAS, to both contribute to grid resilience and to reduce operational complexity).

These points are explored in greater detail in the sections below.

2. MANDATORY PRIMARY FREQUENCY RESPONSE

Infigen accepts that the greater spread of observed frequencies is a departure from historical performance. Infigen also accepts that AEMO must have the appropriate frequency services at its disposal to ensure the system remains in a secure state. However, various market participants have raised valid concerns about the impact of costs on generators (vis-à-vis an unpriced mandatory requirement). To date little quantitative analysis on costs and benefits has been presented. In particular:

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[2] ERC0274 page 56

[3] Initial operation of the Hornsdale Power Reserve Battery Energy Storage System, AEMO, April 2018

[4] Hornsdale Wind Farm 2 FCAS trial, AEMO, July 2018

- The cost impact on existing generators of a broader frequency distribution is not clear
- The relative costs of provision from different units or technologies has not been presented
- AEMO has not identified:
    - The volume of PFR likely to be delivered by this Rule Change;
    - the acceptable frequency performance within the NOFB (i.e., how one might redefine the Frequency Operating Standard for an acceptable distribution of frequencies);
    - The actual volume of PFR required to achieve that distribution; or
    - The volume of additional PFR required to respond to various non-credible events and hence the types of events AEMO expects the system to withstand as a result.

This lack of transparency makes it difficult to assess an appropriate response and makes a move to mandatory response from all (scheduled and semi-scheduled) generators seem premature.

2.1 Impact on battery energy storage systems

Infigen is concerned that delivering unpriced PFR from batteries will represent a material adverse impact that prevents batteries from delivering other more valuable services.

It is credible that a mandatory unpriced PFR will delay or reduce the investment case for batteries. Yet the in a transitioning market, batteries provide valuable services to the power system. A mandatory unpriced PFR will do so in two ways:

- Cycle the battery through its warranty without providing any compensation for the cost of degradation; and
- Increase the cost of delivering contingency for a battery and increase uncertainty of the future market value of contingency services.

Cycling of the battery

Batteries have limited cycles over their lifetime. A cycle is characterised by one full discharge and one full charge of a battery's storage. Batteries will typically cycle an average of once per day, as per the warranty.

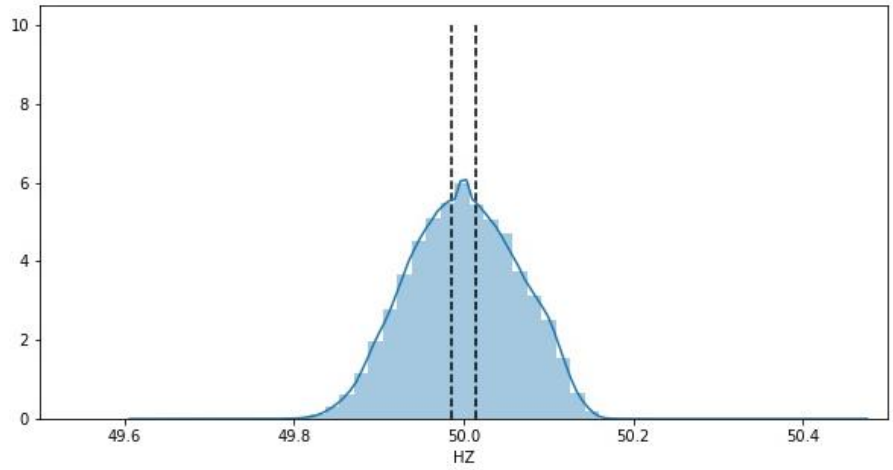
If required to be enabled for PFR, a battery will respond to all frequency disturbances outside of the tight deadband setting. When the battery is not operating for energy or regulation dispatch (i.e., power is at 0MW) it will *still* react to frequency and provide PFR. This response will be within the normal operating frequency band (NOFB) and (under mandatory provision) there will be no compensation for providing this service. The identified difference between a battery and traditional thermal generation is that a battery can be 'always available' to the market even if not enabled for energy or FCAS. However, charging and discharging has a material cost on the battery beyond lost revenues/inefficient charging costs.

Infigen has modelled the operation of a 10MW one hour storage battery with the proposed deadbands of +/-0.015Hz and a droop of 1.7% (typical of batteries built to deliver FCAS services). AEMO has not identified what a “sufficiently good” frequency distribution would look like, so Infigen has modelled two scenarios.

- the 2019 frequency distribution (from 4 second data) and
- a modified narrow frequency distribution if the frequency distribution returned to that in 2005 under the assumption that with most units providing PFR frequency within the NOFB the distribution would be narrower than 2019.

The amount of response mandated from the battery depends on how far and how often frequency is outside of 49.985-50.015Hz. Figure 1 shows the distribution in the NEM for 2019 to-date with the proposed 0.015Hz deadband indicated with dotted black line. Currently, most of frequency sits outside this band and within the NOFB (consistent with the Frequency Operating Standard). This case represents a scenario with limited response – or a future scenario as thermal generation exits the market.

Figure 1 Frequency distribution NEM 2019 (Jan-Oct)



However, mandatory PFR would be expected (and is intended to) tighten frequency performance beyond what is required by the Frequency Operating Standard. AEMO has not provided any indication of what “good” frequency would look like, or what the expected distribution after the Rule Change might be. However, AEMO appears to be comfortable with the 2005 distribution[5]), which is approximately replicated in Figure 2. Most of frequency in this case is within +/- 0.05Hz of 50Hz. This best-case scenario represents all historical governor response being restored and frequency being controlled (within the NOFB) by PFR. We note that total available governor response is significantly lower now than in the past, but also that the proposed deadband is significantly tighter than what was typically applied in the NEM to date.

[5] AEMC 19 September 2019 Consultation Paper: Primary Frequency Response Rule Changes Figure 2.6

Figure 2 Frequency distribution (replicating 2005 distribution)

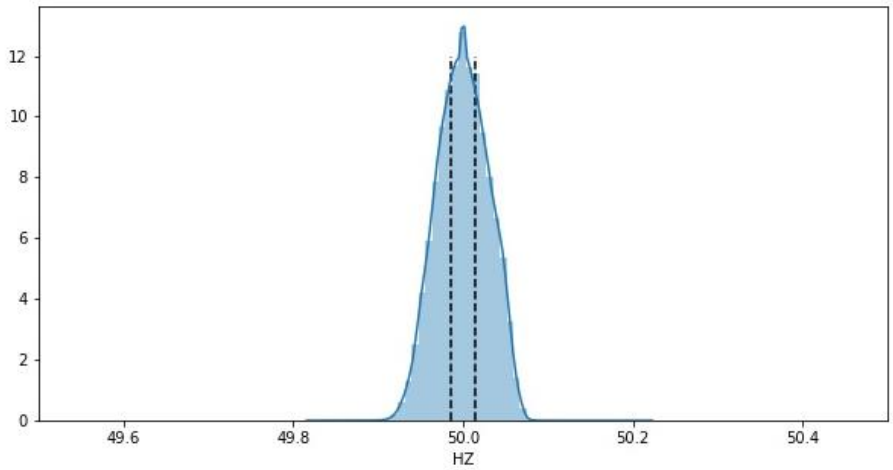


Table 1 summarises the modelling results for three modelled cases. Scenario 1 with the narrow distribution (discussed above), Scenario 2 with the 2019 distribution and Scenario 3 operating in 2019 with the standard settings for a battery registered in contingency (status quo).

The modelling shows that under the improved frequency distribution (Scenario 1), a one hour battery delivering contingency FCAS would cycle around 63 times in a year just responding to PFR, reducing the warranty of the battery by up to 17% over the lifetime of the battery. In practice, a battery delivering other services may be able to deliver some PFR without using cycles, which may reduce this figure somewhat.

The larger the power to storage ratio, the larger the impact PFR will be to the battery's warranty[6]. A 15min battery would cycle 254 time in a year just responding to PFR, using 70% of the warranty. It is highly credible that short-duration batteries such as this are well placed to deliver FCAS in the future – however this is incompatible with unpriced PFR provision.

Table 1 Results of Modelling a 10MW/10MWh battery (1.7% droop) with frequency response

Scenario	Deadband	Frequency distribution	Cycles per year	Percent of warranty
1	0.015Hz	Narrow distribution replicating 2005	63	17.4%
2	0.015Hz	2019	201	55.0%
3	0.15Hz (Status quo)	2019	1	0.3%

[6] Note that the response from a battery is determined by its nameplate capacity, while the equivalent cycles are determined by the hours of storage: more hours of storage mean a greater warranted throughput.

More generally, with tight deadbands, resources (including batteries) enabled for contingency FCAS will be utilised more often – which will presumably increase costs. Contingency FCAS on the other hand effectively ceases as an insurance product for responding to frequency deviations beyond +/-0.15Hz. Instead, providers are cycling during smaller frequency deviations (+/- 0.015Hz), increasing the discharge and charge that a battery would have otherwise done if enabled for contingency FCAS.

The increase cost of delivering contingency, coupled with unknown future contingency market values that follows, creates uncertainty for emerging and rapid responding energy limited resources, including batteries and demand side response. Estimating usage, costs, and revenues will become harder to predict due to the compounding effects:

- PFR charge and discharge amount: there will be an unknown amount of NEM wide reserves to respond in each period, and hence variable response from individual providers; and
- Contingency FCAS price under mandatory (unpriced) PFR requirement

Conclusions

While the financial impacts will require further analysis, it appears to Infigen that there is a material risk to future investment in all generation technologies (in particular battery storage - a critical technology for the transition currently being experienced) arising from implementing a narrow-band, unpriced mandatory PFR requirement.

To be clear, we are not opposed to batteries or other resources delivering PFR, and indeed batteries may be very well placed to do so; but the caveat here is that such services should only be *provided* when there is value in the service. Batteries are a limited but valuable resource – both stored energy and warranted cycles means they must be used where most valuable. Using batteries for a mandatory and unquantified PFR means they can't do other valuable services across the NEM, including delivering low-cost FCAS and price arbitrage, which reduces cost for consumers.

Above all, for a battery to avoid being mis-used in an environment of mandatory unpriced PFR, bidding such plant unavailable would seem to be more than a theoretical possibility – and this is not a desirable market outcome[7].

2.2 Long-term risk of mandatory provision

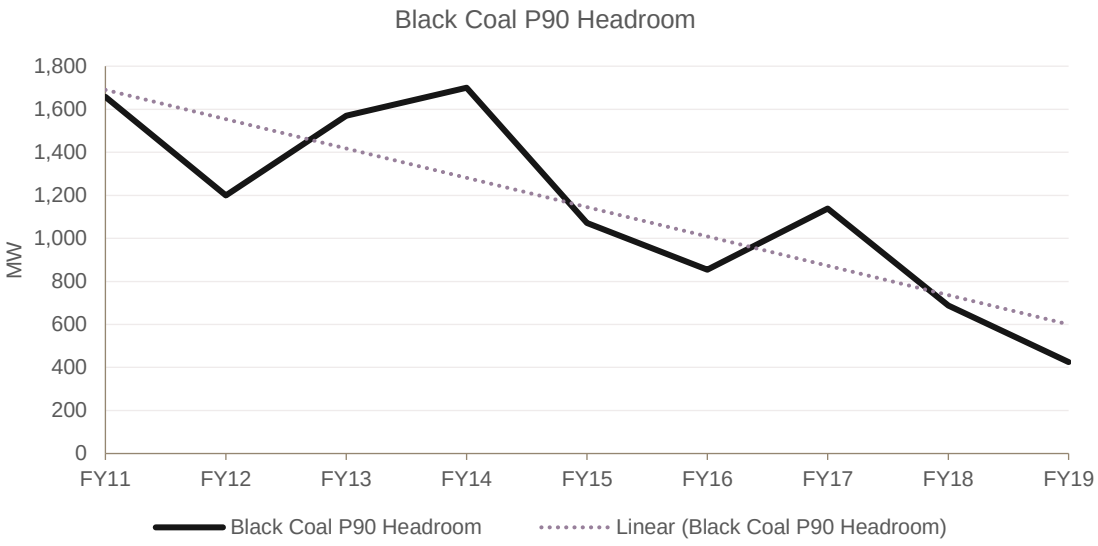
Infigen is concerned that when services are unpriced, mandated *and* not quantified, the risk of system shocks are likely to be higher. For example, inertia and system strength are key system services that were neither quantified nor priced. Coal

[7] Initial operation of the Hornsdale Power Reserve Battery Energy Storage System, AEMO, April 2018, page 7

closures and a changing generation mix across the NEM has exposed urgent security risks and imposed significant costs on market participants. In contrast, if these services were priced, and any shortfalls forecast over time, the power system transition may have been smoother – both existing and future market participants would have had 'clearer' visibility of required services.

Without quantifying or procuring headroom, there will be no guarantee that sufficient response is available over time. Infigen has undertaken high level modelling of the available (Raise) headroom in the system, based on historic generation and plant availability data. While this analysis is simplistic, the modelling shows that the P90 level of Raise headroom from coal generation is declining significantly (see Figure 3). Coal output is being replaced by renewable generation (which has an opportunity cost for providing headroom) and therefore very little headroom is provided naturally. (We note that renewables in the future may face greater curtailment and so have headroom available, however not at all times.) Presumably, a certain minimum level of supply of (mandated) PFR services is important to system resilience. In the short run this can no doubt be achieved regardless of whether it is priced or not. However, in the long run, the appropriate level of PFR supply (over time) will only be delivered by chance if it is unpriced given the ongoing power system transition.

Figure 3 P90 level of Raise headroom from black coal



2.3 Possible pathways

Transparency of capacity reserves needed for PFR, for both normal operation and in time of non-credible events, will ensure that the system has investment signals in the long-term to avoid system shocks and shortfalls in PFR. As above, investment and response for PFR should be met by those best able to provide it and an unpriced mandatory provision for PFR will not achieve productive efficiency for the system.

Infigen recommends that AEMO define the volume and nature of frequency response required and work with AEMC to develop efficient dynamic procurement methods.

A sustainable solution requires clearly defining some form of price/quantity trade-off (or, alternatively, a minimum volume to procure based on a similar calculation). This will require separately defining the need for PFR for tight frequency control and PFR for broader system resilience. Infigen broadly supports the following market mechanisms:

- Contracts for PFR headroom through a competitive procurement process
- Targeted incentives to provide PFR
- New contingency markets to meet tighter deadbands. This would seem the most viable long-term solution. For example, a new FCAS market with a deadband of +/-0.015Hz could be procured in conjunction with an updated Frequency Operating Standard.
- Infigen would support a mandatory wider deadband (e.g., 0.25 Hz) from all capable generation as a safety net to improve resilience after non-credible events. (Noting that this is consistent with AEMO's powers to direct participants if required, but through an autonomous, shorter timescale response.)

We expect that this would be developed in conjunction with a review of the Frequency Operating Standard and Market Ancillary Services Standard.

Near-term response

We acknowledge that AEMO considers this an urgent issue, and Infigen acknowledges that while relatively little quantitative analysis has been undertaken, precautionary near-term action may be prudent.

In the near-term, we consider that a mandatory unpriced response with a wider deadband (indicatively, 0.15 to 0.25 Hz) would be a reasonable response to AEMO's concerns about system resilience.

As a short-term strategy for managing frequency control within the NOFB, AEMO may seek to contract PFR from generators best able to provide it, including batteries, and determine a competitive price. Alternatively, some form of prescribed payment to enabled generators may be appropriate in the near-term if material competition issues exist.

Alternatively, the AEMC could consider a staged approach (similar to AEMO's current proposal) whereby the likely lowest-cost resources are activated first, and higher-cost resources only activate if the identified issues are not resolved. For example while a more comprehensive market solution is being developed, AEMO could:

- Initially, seek a mandatory response from large synchronous units (200 MW+) and observe the resulting frequency performance (6-12 months);
- If insufficient, then seek response from smaller synchronous units;
- Finally, if performance is still unsatisfactory and a market mechanism has not been developed, seek response from non-synchronous units, where cost of provision is likely to be highest.

3. REMOVAL OF DISINCENTIVES TO PRIMARY FREQUENCY RESPONSE

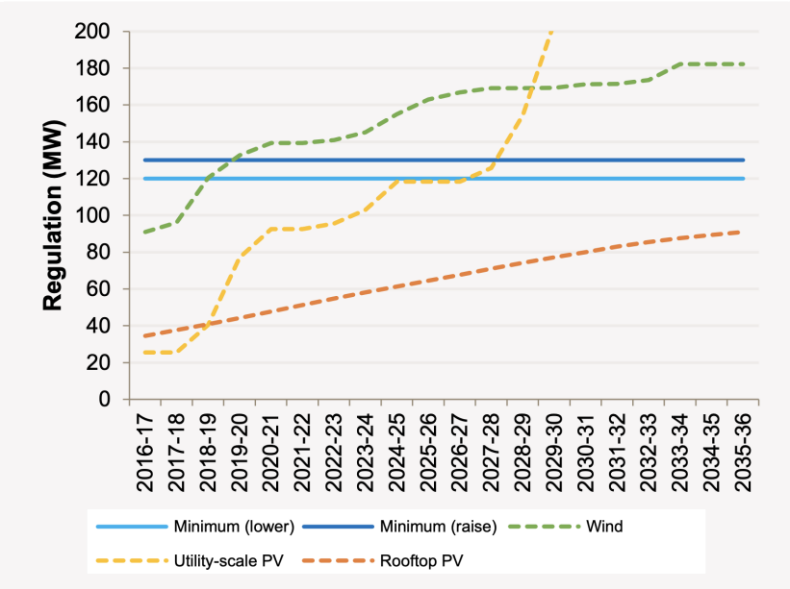
Infigen supports measures to ensure that participants who voluntarily support the system do not incur additional costs and are compliant with the NER.

However, exempting generators that deliver tight deadband PFR from Causer Pays seems out-of-step with the underlying causes of regulation FCAS, and, there seems no logical reason to connect provision of PFR to regulation FCAS cost recovery. Tight deadband PFR does not guarantee that any response will be available (as it depends on headroom). Therefore, some FCAS regulation service will still be required. Conversely, tight deadband PFR does not remove the contribution of that unit to the regulation FCAS requirement.[8] Deviations from dispatch instructions, unplanned outages, and forecasting errors for renewable generators all contribute to the regulation requirement.

AEMO modelling indicates that utility scale solar farms will contribute to both Raise and Lower regulation FCAS requirements. Enabling PFR from such stations would not remove or reduce the contribution to Raise regulation FCAS. Conversely, participants are free to offer into contingency or regulation FCAS services if technically capable.

[8] For example, Section 9 of ROAM Consulting's report to the IMO provides detailed analytics on the contribution of various errors to the load following service in the WEM (similar to regulation FCAS).
https://www.erawa.com.au/cproot/14768/2/ROAM%202014%20Ancillary%20Service%20Standards%20and%20Requirements%20Study%20Draft%20Report.pdf

Figure 4 AEMO modelling of contributions to regulation FCAS requirements[9]



Exempting large portions of the generator fleet from Causer Pays would impose a greater share of costs on consumers, which is not consistent with the NEO.

This rule change would now seem incompatible with AEMO's proposal for *mandatory* tight deadband response. If both were implemented, a majority of the generation sector would be exempt from Causer Pays while still contributing to the need for regulation FCAS.

Infigen recommends that any modifications to Causer Pays be considered later as part of the analysis on correctly valuing these services.

4. CONCLUSION

We look forward to the opportunity to continue to engage with the AEMC. If you would like to discuss this submission, please contact Dr Joel Gilmore (Regulator Affairs Manager) on joel.gilmore@infigenenergy.com or 0411 267 044.

Yours sincerely

Ross Rolfe
Managing Director

[9] From p62, 2016 NTNDP, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2016/Report/2016-NATIONAL-TRANSMISSION-NETWORK-DEVELOPMENT-PLAN.pdf