Amendment of the MASS - DER

Evergen response to draft report and determination

August 2021

1. Executive summary

Evergen thanks AEMO for the opportunity to respond to this draft determination. As outlined in this submission, Evergen believes the draft determination, if accepted as it stands, will represent a backward step for energy industry collaboration in Australia and for Australian innovation and leadership in the energy sector generally.

The energy transition is accelerating globally beyond expectations, and the world is looking to Australia for technical leadership and innovation that can support a rapid electrification and decarbonisation of the energy system.

The move from small numbers of large generators dispatching power, to many thousands of inverter connected devices doing so as part of a harmonious system requires new ways of thinking and new approaches to system orchestration. We show in this submission that **measurement resolution concerns and connection point concerns outlined in the draft determination are unfounded at the fleet level.** These concerns as outlined in the draft determination represent legacy, single dispatch type thinking and as such are misguided and overstated.

In terms of system security we outline that there are categorical differences between the battery inverters that comprise the VPPs participating in AEMOs demonstration program and many legacy PV inverters in the field today, and that **system security is best served by more data and visibility of DER, not less.**

We have also shared some details on the consumer benefits and outcomes delivered by the VPP demonstration program, benefits that will be lost if the draft determination is accepted and consumers are no longer able to actively participate in this part of the market.

It is still our strong belief that the VPP demonstration program alternative requirements should be adopted as a formal requirements specification for all DER-based VPP participation in FCAS. Failing that, Evergen seeks a path that nurtures the excellent collaboration and data gathering that has occurred to date due to the relaxed rules of the VPP demonstration program, rather than the current draft determination that will extinguish it. Given all the investment from all parties in participation in the VPP trial (and the valuable learnings), our alternative recommendation would be that at the very least the trial is extended to allow greater learning, inclusion of additional technologies, and the opportunity to include additional market participants behind the trial participants, to enable additional industry, consumer, and asset participation.

Specific additional recommendations

1. Amend the FCAS verification to use the trapezoidal rule for estimating delivered FCAS energy, instead of Riemann sums.
2. Amend the method for estimating t0 to use the midpoint method described in Section 3 of this submission to avoid bias towards overestimating FCAS delivery.
3. Persist with AEMO's original suggestion of adopting 'Option 2' requirements for fast FCAS verification measurement resolution of 1-second for DER-based VPPs, since this resolution presents no barrier to effective verification.
4. Revise and automate the verification process, using contemporary data handling methodologies more suited to this task than spreadsheet-based assessment that has a bias against DER fleet-based FCAS provision.
5. Persist with AEMO's original suggestion of adopting 'Option 2' assessment at the DER inverter rather than the site connection point, since this aligns with the NEO by affording greater visibility of registered assets and reduced costs of compliance.
6. AEMO should omit consideration of alleged oscillatory responses from their determination due to the implausibility of effects manifesting at the fleet level, and lack of evidence the issue is widespread.
7. AEMO should devote resources to re-commissioning the APIs established for the VPP demonstration program, update API documentation, provide an adequate API staging/test platform, conduct regular analysis (including automated analysis) of this data and share findings with industry on a half-yearly basis.

8. AEMO should consult on mandating compliance with AS/NZS 4777.2:2020 for all systems upon registration for FCAS.
9. AEMO should adopt in its decision-making a minimum of $500 as an estimated cost of compliance with option 1 (assuming no install cost), plus operational expense of $48-$120 per NMI per year.
10. AEMO should note an opportunity cost as high as $465 per year to each customer should their DER capacity be reserved to maximise FCAS participation and revenue when evaluating the cost/benefit of imposing additional compliance requirements.
11. As active participation of DER for grid services gradually advances, AEMO should acknowledge that increased visibility and learning-by-doing is preferable to halting progress and neglecting the visibility over real-world data that is on offer.
12. If implemented, the interim arrangements should omit the proposed penalty on fast market participation since there is no barrier to adequate verification.
13. If implemented, interim arrangements should allow participants to increase their fleets to a maximum of 10MW (or existing size if already larger).
14. If implemented, interim arrangements should allow new participants, new technologies and also allow new retailers to engage in FCAS via VPP participants.
15. If implemented, interim arrangements tshould waive the cost of adding additional NMIs to replace churn if not re-enrolling at a larger biddable fleet size, in recognition of the costs and practicalities faced by VPP participants compared to traditional FCAS providers.

2. Introduction

In June 2019, AEMO in collaboration with the Australian Renewable Energy Agency (ARENA), the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER), and members of the Distributed Energy Integration Program (DEIP) established the virtual power plant (VPP) demonstration program.

This demonstration provided the opportunity to trial the capability for distributed energy resources (DER) to deliver contingency FCAS through registration of orchestrated VPPs comprising DER as ancillary services loads.

The VPP Demonstrations FCAS specification made two key changes to remove barriers to entry for VPPs looking to increase market participation:

- Decrease in the granularity of the measurement resolution requirements for fast FCAS from 50ms to 1s (with one high speed meter required per jurisdiction); and
- Allow for performance to be measured at the device level rather than at the connection point.

With Australia deploying new renewables ten times faster per capita than the global average and four times faster per capita than in Europe, China, Japan or the US[1], the embrace of the energy transition is generally seen as a good thing for Australia, generating opportunity and innovation, while looking to capitalise on active participation of DER to help smooth the transition.

The VPP demonstration program has enabled industry to come together and solve technical issues, brought new value streams for consumers, and provided near real-time data streams to AEMO to enable the industry to move forward together in exploring how DER can contribute to grid services and deliver a benefit for all parties, from consumers to networks and market operators.

Evergen has been a strong supporter of the review of the MASS to better utilise DER and VPPs in FCAS markets, and has been orchestrating VPPs as an active

[1] https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Mar/IRENA_RE_Capacity_Statistics_2020.pdf

participant in the program since December 2021. Evergen operates the only VPP for FCAS in Victoria on behalf of the retailer Members Energy, and operates the only VPP in the demonstration program composed of multiple device types. Both Evergen and Members Energy participated in this program at considerable expense, including providing a large volume of valuable data to AEMO at no cost, data not normally accessible to either AEMO or DNSPs.

Evergen did this in good faith, in the interests of learning, and on the assumption that if the demonstration program proved the capability of VPPs to successfully deliver contingency FCAS, that this would likely assist AEMO in progressing towards formalising these arrangements more broadly in the MASS.

Evergen was a strong supporter of the initial MASS review Option 2 proposal in early 2021 to adopt the VPP demonstration program alternative requirements as a formal requirements specification for all DER-based VPP participation in FCAS markets under the MASS. We believe this would enable continued collaboration with consumers, hardware manufacturers, energy retailers, DNSPs and regulators among others, and is in keeping with AEMO's intentions of supporting a transition to a two-way grid where consumers and other asset owners can play a part in delivering services back to the grid. We noted that a majority of submissions to the first round of consultation also supported the adoption of either Option 2, or else Option 2 with some variation.

With this in mind we were surprised that the Draft Report appears to disregard the innovation, lessons learned and industry investment from the 2 year in-market demonstration. Furthermore, it appears to seek to exclude broader adoption of consumer DER participation in contingency FCAS markets for the foreseeable future, and leaves existing VPPs stranded and uneconomical.

The VPP demonstrations and associated knowledge sharing reports have clearly shown that VPPs are technically capable of providing FCAS market services, and that aggregators bid in these markets appropriately, as AEMO acknowledged in their initial MASS Review report.

The primary concerns raised in the subsequent Draft Determination Report are:

- Measurement time resolution for fast FCAS delivered by DER;
- Location of measurement point for FCAS delivered by DER; and
- System security concerns

In this submission Evergen outlines why the measurement time resolution, location of measurement, and system security concerns raised are not based on sound analysis, and represent a backwards step for AEMO in terms of both modernisation and the transition towards two-way markets. Our rationale can be found in sections 3, 4 and 5 respectively.

We also address the financial considerations and impacts of this decision on consumers in section 6, impacts that would render contingency FCAS participation for VPPs comprising fleets of small DER unviable for the time being.

Evergen contends that Australia needs to continue to utilise the best minds from across the industry to jointly work together to engineer two-way electricity grids that are capable of running at 100% penetration of renewables by 2025, the recently stated objective of AEMO's CEO Mr. Westerman.

Evergen firmly believes all Australians should benefit from energy diversity and energy security across a wide portfolio of assets.

These trials are enabling greater visibility of DER and capture data as to how DER performs and impacts the grid. We should be growing this visibility, not turning it off. Lack of visibility is bad for system security, innovation, and ultimately delays the transition to a lower cost, more flexible, more decentralised energy system.

3. Measurement error

AEMO's draft determination found that there was a large measurement error associated with sampling at 1s versus sampling at 50ms, contributing to their decision to retain the 50ms sampling requirement for all DER-based FCAS VPPs. AEMO's findings were supported by analysis contained in Reposit's initial submission to the MASS review, with additional research commissioned by AEMO from University of Melbourne (Mancarella, Zhang & Wang, 2021).

AEMO characterises this error as a "measurement error", a term Evergen regards as somewhat misleading. VPPs to date have consisted of hundreds of devices, and as such there are an excess of measurements at hand for verifying delivery. Any error is more appropriately characterised as a shortcoming of the existing verification approach, rather than a sampling rate deficiency or measurement error.

Evergen has identified two key shortcomings in AEMO's verification approach, in addition to the shortcoming of using Riemann sums instead of the trapezoid method[2]):

1. AEMO's current approach for locally estimating frequency disturbance start time introduces bias; and
2. omitting most of the mandated measurement data from the verification methodology causes avoidable verification error.

The next sections cover these points in detail, and we suggest amendments to the verification approach.

The following analyses use a simulated DER response - a sigmoid function, similar to the response profile depicted in the Mancarella et al. study.

[2] Evergen will not comment further on the choice of integration method for calculating energy, since this was well-covered in the draft determination and first round consultation. Evergen fully supports adopting the trapezoid method as the standard form of integration for calculating delivered FCAS energy for verification.

3.1 Estimating frequency disturbance time

AEMO defines the frequency disturbance time as the time when the frequency leaves the normal operating frequency band (NOFB). We will refer to this as *t0-actual*. Each DER is required to monitor grid frequency locally, and each responds in accordance to its local measurements, so t0 needs to be estimated locally for each DER.

3.1.1 AEMO's existing verification approach to estimating t0-actual

AEMO's approach to estimating frequency disturbance time (we will refer to an estimate as *t0-estimate*) is to use the timestamp of the first sample where frequency falls *outside* of the NOFB as t0-estimate. This means that t0-estimate will *always* be some time *after* t0-actual.

This approach is named the 'relative window approach' by Mancarella et al., (2021). With this approach, the error in t0-estimate will not be uniformly distributed around zero across the devices comprising a DUID, it will include a bias, and a subsequent bias in estimation of FCAS delivered energy.

As shown in the Melbourne University study, the relative window approach results in FCAS energy delivery being biased towards *overestimation*.

Inverters sense frequency much more often than once per second, even if storing and transmitting recorded data for verification is only achieved at 1-second intervals. So batteries have time to begin ramping up their response prior to the commencement of the FCAS-assessable period, which starts at t0-estimate.

This systemic bias towards over-estimation of FCAS delivery is larger for coarser sampling rates. For 1-second sampling for verification, the error in t0-estimate could be as much as 1 second after the battery commences its response (or close to zero seconds if a sample occurs a very short duration after t0-actual).

This range of errors is depicted in Fig. 1 below. A sampled FCAS response might occur anywhere between the two depicted edge cases - always resulting in an over-estimate of FCAS delivered energy (the area under the curve over the assessable 6-second period).

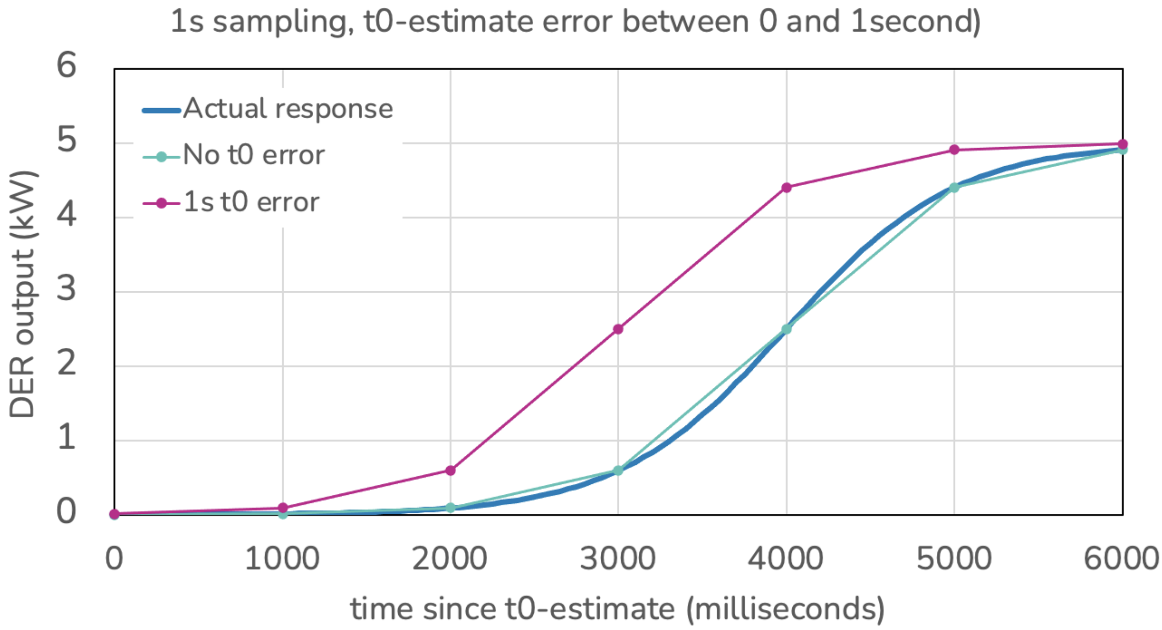

Fig. 1. Range of sampled FCAS responses resulting from possible t0-estimate errors using AEMO's current "relative window" approach. Errors skew towards t0-estimate being later than t0-actual, and an overestimate of FCAS delivery.

3.1.2 Two superior alternatives

Mancarella et al. included an examination of how FCAS delivery error is distributed if the error in t0-estimate could be eliminated, such that t0-estimate = t0-actual (see Fig. 20 and Fig. 21 from Mancarella et al. 2021).

They referred to the ideal case as the 'universal window' approach. It can be seen in Fig. 21 from their report that the error in FCAS for the universal window approach has a mean very close to zero in most cases, with a reasonably even distribution of errors either side of zero.

This is to be expected: with no bias from erroneous t0 estimation and using the trapezoidal approach to estimating delivered energy, the error associated with calculating energy by sampling power is neutral, not skewed towards overestimation.

The universal window approach provides a useful benchmark, but cannot be implemented practically, since it relies on perfect time-keeping for each device.

Evergen proposes two simple, no-regrets alternatives to the 'relative window' approach. Either approach would remove the systemic bias towards over-estimation that is inherent in AEMO's present approach, and both would also *halve* the size of the maximum possible error in t0-estimate, with a commensurate halving of the error in FCAS delivery verification compared to the relative window approach.

Method 1 - midpoint

Use the midpoint between the time of the last sample where frequency is *inside* the NOFB, and the time of the first sample when the frequency is *outside* of the NOFB, as t0-estimate. Calculating FCAS energy will therefore involve taking half of the first trapezoid, followed by a number of full trapezoids, followed by a final half trapezoid to reach 6 seconds of energy. See Fig. 2 below. A sampled FCAS response would occur anywhere between the two edge cases, with a mean t0-estimate error of approximately zero (i.e., the actual response is in the middle of this range).

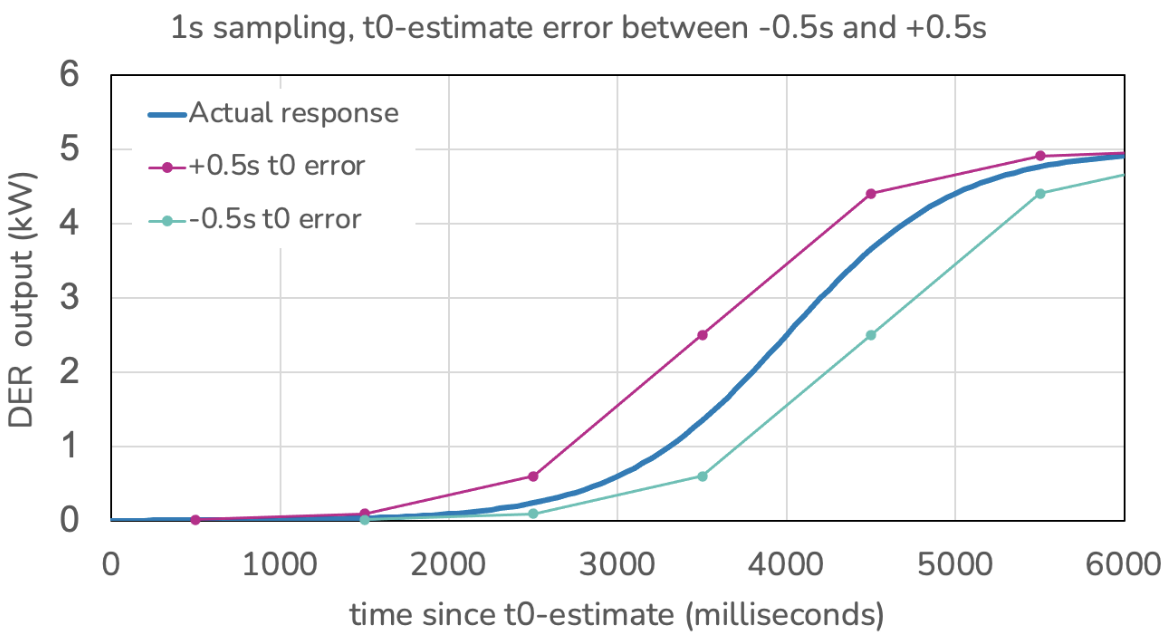

Fig 2. Range of possible sampled FCAS responses across possible t0-estimate errors using alternative Method 1. Errors range from an overestimate to an underestimate, with a mean error of approx. zero. Note that 1s samples are offset compared to AEMO's approach by 0.5s. E.g., at 500ms, 1500ms etc, instead of 0ms, 1000ms etc. The FCAS delivery calculation involves taking half of the trapezoid between the -0.5s sample and the 0.5s sample.

Method 2 - average
Calculate FCAS energy twice: once using the timestamp on the first sample where the frequency is *outside* the NOFB as t0-estimate, and once using the start time as the timestamp on the last sample where frequency is *inside* the NOFB as t0-estimate. Calculate delivered FCAS energy as the average of the two.

Both of these alternative approaches ensure that instead of a maximum error as big as a single sample interval (i.e. 1 second for the sample rate adopted for the VPP demonstration program), the maximum error in t0-estimate will now not exceed 0.5 sample intervals (0.5 seconds for a 1-second sample rate).

For AEMO to implement either of these methods into their verification approach is a 'no regrets' change. The logic for the change is simple and straightforwardly an improvement on the existing approach.

By eliminating systemic bias, a change to t0 estimation in this way also means that 1-second sampling at each DER will be more than sufficient for VPPs comprising numerous DER to meet AEMO's tacit verification accuracy benchmark, provided AEMO improves their verification approach, as follows.

3.2 Sample rate, accuracy and number of devices

The benchmark for accuracy that AEMO is willing to accept is communicated in MASS v6.0. Namely, data from a single-plant DUID, sampled at 50ms, with a measurement accuracy for each sample of -/+2%, is deemed to hold sufficient information to meet AEMO's requirements for accuracy of verification.

Evergen has conducted analysis that shows that there is sufficient information in the many individual measurements taken across a DER-based VPPs consisting of *n* devices, each sampled every 1 second over 6 seconds, to **match or exceed** the accuracy AEMO would accept from a single device sampled at 50ms intervals (120 measurements over 6 seconds). This applies for a wide range of values of *n*, certainly for any of the VPPs participating in AEMO's VPP demonstration program.

We provide an analysis of the number of DER required to exceed AEMOs tacit information content standard in the section below. Table 1 provides a guide to the number of measurements obtained for various sample intervals and fleet sizes, for comparison.

Table 1. Number of measurements recorded per six seconds for various VPP configurations and sampling rates. The MW figures in parentheses assume 5kW size for individual devices, and is indicative of a fleet of residential-scale batteries. 120 samples over 6 seconds for a single plant, each measurement subject to up to 2% error, is acceptable to AEMO for verification purposes.

Sampling interval	1 device	100 devices	250 devices (1.25 MW)	1000 devices (5MW)	10,000 devices (50MW)
50ms	120	12,000	30,000	120,000	1,200,000
100ms	60	6,000	15,000	60,000	600,000
200ms	30	3,000	7,500	30,000	300,000
1000ms	6	600	1,500	6,000	60,000

3.2.1 AEMO's existing verification approach

AEMO requires VPP operators participating in the VPP demonstration program to collect 1-second telemetry from every individual DER.

However, for verification, AEMO only makes use of a single time series, created by aggregating all the individual DER time series. For the VPP owner to perform this aggregation, individual DER time series are time-aligned using the t0-estimate for each DER, so that the power measurement in each time-aligned 1-second interval can be summed. The aggregate time series, which will consist of only 6 data points over a 6-second window, is what AEMO uses for verification (of course in addition to the balance of 54 seconds, for the full fast market sustained response).

This is despite requiring that thousands of data points be recorded across a VPP comprising hundreds or thousands of DER.

3.2.2 Alternative approach

FCAS delivered energy could be calculated on a per-device basis, and the FCAS energies summed. If the bias towards over-estimation were eliminated as discussed in Section 3.1, then summing these energies would result in a reduction in error.

This is because, as was shown in the previous section and in Mancarella et al's analysis of the universal window method, the mean error across all devices approaches zero if the error is unbiased, and summed errors distributed evenly around zero tend to cancel one another with a big enough fleet.

Using an artificially-generated response curve based on a sigmoid (as in Fig .1, and similar to the FCAS response curve considered by Mancarella et al.), and assuming that any individual measurement is subject to a measurement error within -/+ 2%, we show that, for a single device, sampled every 50ms over 6 seconds, the error in calculated FCAS energy using the trapezoid method has a 95% confidence interval of -/+ 1.4% error (see Appendix A for a detailed calculations). This is the benchmark accuracy implicitly accepted by AEMO for good verification.

We assume an onerous -/+25% error in calculating the delivered FCAS energy for a single DER, arising just from using 1-second sampling instead of 50ms sampling. This error is much larger that what Mancarella et al. found when using the trapezoid method and universal window method for calculating FCAS energy, it is among the worst cases considered in the Mancarella et al. study.

Even with this assumed large error per individual DER, we determine that for an aggregation using the proposed alternative verification approach and the proposed midpoint method for estimating frequency disturbance time, **only 213** such DER would result in the same 95% confidence interval error range of -/+1.4%. If the error per device arising from sampling at 1s were only 10%, then aggregating across **only 35** DER with 1-second sampling achieves similar accuracy to sampling a single device at 50ms intervals over six seconds. Again, sampling a single device at 50ms intervals sets the benchmark for what AEMO regards as sufficient information for acceptable verification.

Further results are included in Table 2, for a range of device-level estimation errors versus fleet-level estimation errors.

Table 2: The minimum fleet size and 1-second measurement interval to achieve the fleet-level error indicated for each column. E.g., only 17 DER, each with a 10% error, would result in a 2% fleet-level error when aggregated.

Assumed sampling error per device	2% error (fleet)	1.4% error (fleet)	1% error (fleet)
10% error	17	35	67
25% error	105	213	417
50% error	417	851	1667

3.2.3 Recommendations regarding verification approach

A simple desktop analysis (see Appendix A in addition to this Section 3) readily shows that if AEMO were to fully utilise all of the data that they require VPP operators to collect as part of the VPP demonstration program, they would have sufficient information to conduct highly accurate verification, provided AEMO updates and improves its verification approach.

Evergen recommends that AEMO take this opportunity to modernise the current outdated approach to FCAS verification. Parts of industry have already suggested to AEMO that their spreadsheet-based verification tool is opaque, and not fully specified in the MASS itself. That its use by AEMO for verification is manual and labour-intensive would lead to a high risk of introduced errors during data handling, not to mention being a time sink and pain point for AEMO staff.

Its use creates conditions which clearly and unfairly bias AEMO towards favouring single-plant DUID rather than VPPs composed of many DER. AEMO understandably lacks the resources to use such a cumbersome tool to validate the FCAS response of individual DER, hence requiring DER-based VPPs to aggregate first, throwing away device level data and magnifying verification error.

VPPs represent a new approach to delivering grid services, and industry is devoting millions of dollars to exploring and understanding the possibilities of using VPPs to deliver FCAS and near real-time operational data feeds across thousands of devices to AEMO. We believe AEMO should consider devoting internal resources commensurate with what industry is providing to modernise their alarmingly outdated tools. It is concerning that a major NEM-wide compliance process would be governed by manual copying of data received by email into a spreadsheet.

3.3 Oscillatory response

In the draft determination, AEMO indicated that an additional power system security risk associated with 1s data is that the occurrence of inverter sub-second oscillatory behaviour would only be apparent to AEMO with a shorter sampling interval of 50ms. It appears that this risk was raised in Reposit's initial response to the MASS review, where they provided one example of an inverter delivering an oscillatory response. Reposit indicated that although the frequency injection tests required for Option 2 compliance prior to registration could identify and exclude devices showing oscillatory response behaviour, this behaviour may theoretically only eventuate subsequent to this test. There is no current evidence on the likelihood of this behaviour, or how it may vary by technology or age of equipment.

Mancarella et al. (2021) included analysis of a DUID response with superimposed oscillatory response. Evergen notes that inclusion of this oscillation did not always result in an increased verification error in their study. Mancarella et al. did find an increased verification error resulting from the oscillatory response when using the trapezoidal rule and universal window method.

3.3.1 DER oscillations would not manifest at the fleet level

AEMO indicates concern about oscillatory behaviour in individual DER inverters, and yet AEMO's existing verification approach does not consider data from individual inverters, it only considers the fleet aggregation. As a result, AEMO would never see oscillatory behaviour among individual inverters during verification, even with mandatory 50ms measurement intervals. Requiring VPPs to sample at 50ms therefore imposes a cost on industry without materially improving verification of the FCAS response of VPPs regarding this specific issue.

In a fleet aggregation, oscillatory behaviour in individual DER inverters would at best appear as almost imperceptible noise in the aggregated fleet time series for battery power. A sub-1Hz oscillation of -/+5kW in an aggregated fleet power of 1000kW (or even higher) is of no consequence.

For AEMO to observe significant oscillatory behaviour at the fleet level:

- Many inverters would need to deteriorate and begin exhibiting oscillatory behaviour, and
- The oscillations for each inverter would need to be both in phase and at the same frequency of oscillation after time alignment to the same frequency disturbance time, to ensure the superimposed oscillations reinforce rather than destructively interfere with each other.

The idea that these conditions would occur is not plausible. Not only is there no evidence that this behaviour is widespread, but even should it be, oscillations at the DER level would not deliver a concerning oscillation at the assessable fleet/DUID level.

Oscillatory behaviour would notionally be more of an issue for individual large BESS with a single inverter to deliver the behaviour than it ever will be for a VPP comprising many DER. But single-plant DUIDs are not eligible for Option 2 coarser sampling regardless.

AEMO sought advice from the University of Melbourne on the impact of an oscillatory response at the fleet level (an oscillation with a huge magnitude of 30%, or 1.5MW for the 5MW fleet considered!). Mancarella et al. state that they included this case as a 'stress test' of the different integration methods (trapezoidal, Riemann sums etc). However, they also suggest that this response pattern "...might be seen in less diverse aggregates of inverter-based providers", (Mancarella et al., 2021, p. 10 footnote).

This is misleading, because 'less diverse' is an understatement. It is implausible that a VPP would consist of a majority of devices that each failed in the same way such that the fleet aggregate would see such a significant oscillation. The faulty inverters would need to be identical in their failure, and in their response and oscillations at each time point. This is not 'less diverse', it is 'perfectly uniform'.

Figs. 3 and 4 show an example of how, even for an extreme edge case of a VPP consisting of 250x5kW DERs, where **every** DER suffers the same oscillatory response, would not result in a significant impact to the aggregated fleet response if all the oscillatory noise waves for each DER were not perfectly in phase. In the unlikely event that all DER had the same issue in the first place, it is not plausible they would all be in phase.

As can be seen in Fig.4, individual oscillatory responses destructively interfere with one another to dampen the possible oscillation at the fleet level when not *perfectly* aligned.

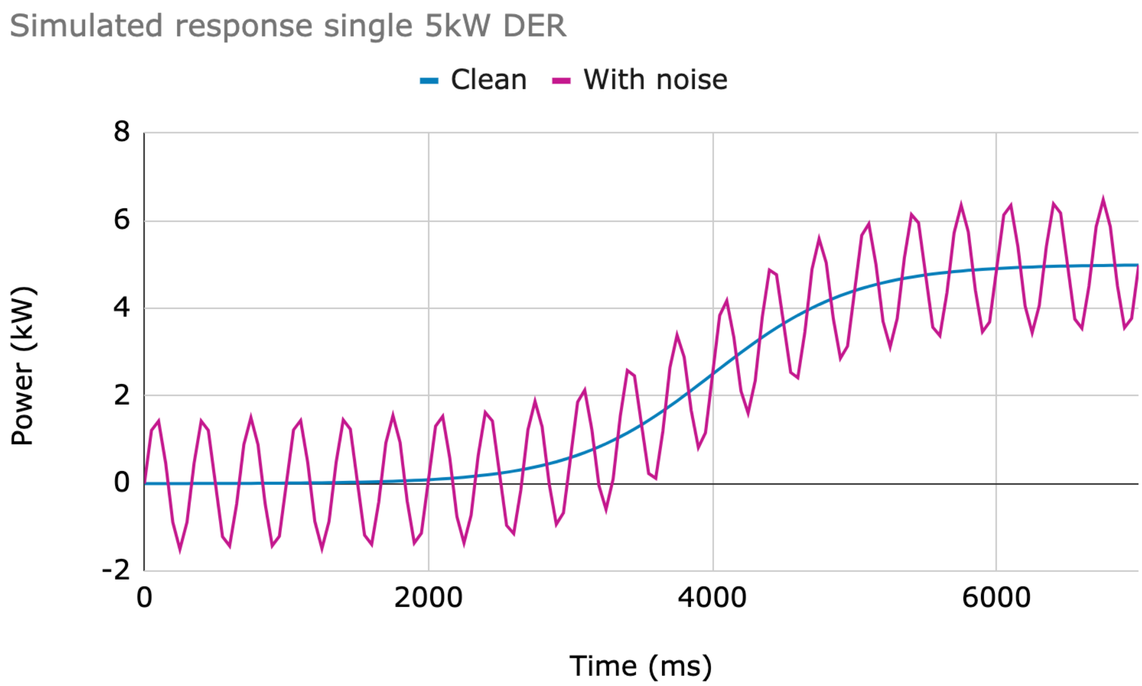

Fig. 3. Simulated raise response of a single 5kW DER, with and without oscillatory noise. The noise is a superimposed sine wave with 3Hz frequency and amplitude of 30% of 5kW.

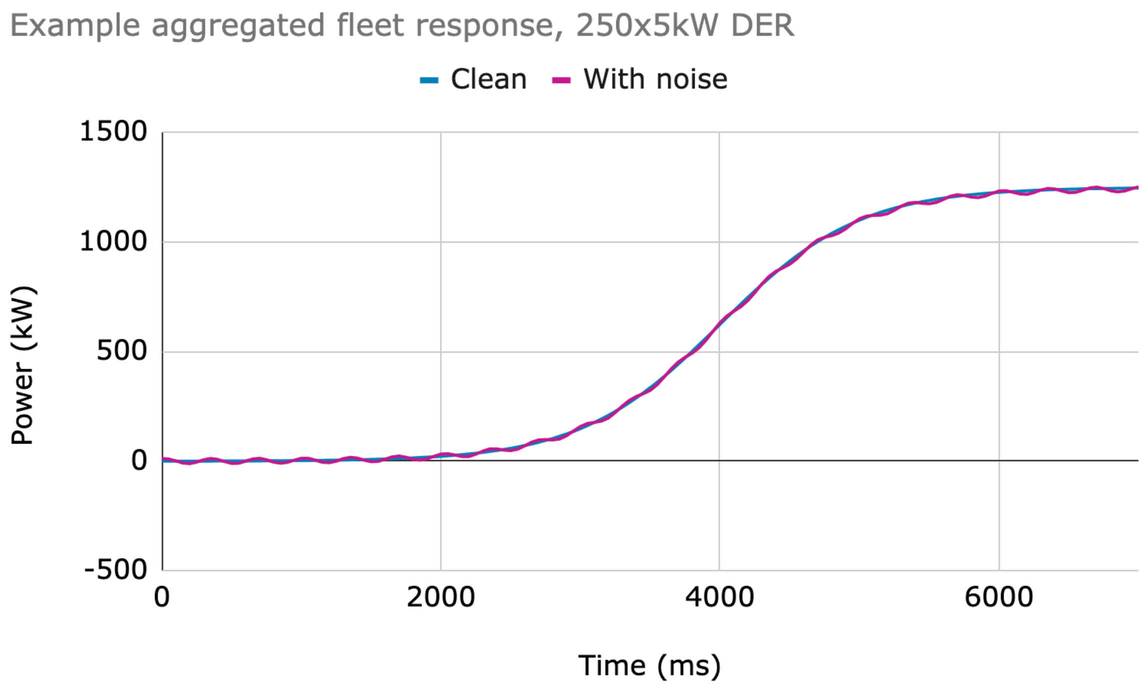

Fig. 4. Aggregated power of 250x5kW DER, with and without noise. For the 'with noise' condition, the oscillatory noise added to each DER is offset by a time randomly chosen from the range 0 to 333 milliseconds. We did this since it is implausible that oscillatory noise in each DER would be perfectly in time sync. The result provides an example that even for the extreme edge case of every single DER in the fleet suffering from the same oscillation problem to the same amplitude and with the same period of oscillation, the aggregation of oscillations is subdued since they do not combine into a large oscillation over many DER when not perfectly time aligned.

In summary, it can be concluded that alleged oscillatory behaviour that has been suggested may occur among some small inverters in a VPP consisting of many DER is of negligible consequence to either the aggregated fleet FCAS response, the verification of this response by AEMO (whether using 50ms or 1s granularity data), or overall power system security.

4. Measurement Location

In the draft determination AEMO elected to retain measurement at the connection point (Option 1) rather than asset level measurement (Option 2). Issues contributing to this decision include:

1. The possibility of gaming with asset level measurement;
2. Poor orchestration of multiple assets at one site with asset level measurement;
3. The objection to connection point metering was one of cost, but the VPP demonstration program already required connection point metering.

Before addressing these points, Evergen would like to clarify what the issues are.

Whether measured at the connection point or the asset, FCAS delivery is assessed against a baseline. For example, if a 5kW battery were discharging at 5kW to meet household load immediately prior to a low frequency disturbance, it would have no possibility of delivering an assessable FCAS raise contribution, since its baseline is already at maximum discharge. If a site were already exporting at a 5kW export limit on a sunny day due to PV output, then there would be no net FCAS raise response possible because 5kW is already being output at the connection point.

Given this, it is of no relevance to FCAS assessment that particular assets at a site might be doing different things, or that the end user's load might absorb a battery discharge without any resultant grid export. A battery discharge in response to an FCAS event that is absorbed by the load behind the meter still contributes an FCAS response to the grid if the battery response results in a **net** change in grid import at the site in response to the frequency disturbance.

The possibility that does need addressing relates only to the much narrower circumstance that different assets on site might respond near simultaneously to the same frequency disturbance event.

4.1 Is 'gaming' a possibility with asset level verification?

Evergen assumes that by 'gaming' AEMO is suggesting that a VPP operator might deliberately seek to avoid offering a material response to a frequency disturbance, while maintaining the appearance of compliance.

For 'gaming' to occur, a VPP operator would need to:

1. Detect a frequency disturbance;
2. Have one asset (such as a battery) respond to that disturbance; and
3. Implement a control such that a second asset (e.g., a controlled load) would also immediately act to counter the first device response.

While technically possible to execute this, the idea that a VPP operator would deliberately do this is, as EQ highlighted in their first MASS Review submission, an implausible scenario. FCAS participants are paid on enablement, not on their actual response to an event. The only benefit of gaming and risking the regulator's ire and associated penalties, would be to avoid any costs to the customer associated with import/export for the duration of the FCAS bid period. These costs, given the sparseness of actual frequency disturbances and their duration, are insignificantly small. Motivated gaming of the system makes no sense.

4.2 'Gaming' and connection point verification

Measuring FCAS response at the connection point is not immune to gaming. It is arguably more susceptible than for asset level measurement and verification.

With connection point verification, battery-based VPPs will be able to bid very comfortably into the raise market on sunny afternoons, because a low frequency event will result in a DER transitioning from a starting condition of solar charging the battery with no grid import/export, to a condition where the combined output of both the uncontrolled solar and battery discharging will contribute to grid export and measured FCAS response. Despite registering an FCAS fleet based on battery capacity alone, the VPP operator will be able to use solar generation unrelated to their registered ancillary service load to deliver a compliant response.

Similarly, VPPs will be able to bid very comfortably into the lower market in the evenings when local uncontrolled load is likely to be high. The DER will transition from a starting condition of battery discharging to meet load, with low grid import, to a condition where the combination of battery charge + load will result in a large grid import. The VPP will be able to rely on unregistered and uncontrolled load to achieve compliance.

The 'gaming' here is perhaps not really a concern, because the VPP would still be delivering to the grid what it had promised. However, the challenge with these scenarios is that AEMO will be registering ancillary service loads based on battery capability (for example), but it will not necessarily be the battery that delivers the FCAS response. There will be a clear and readily 'gamed' disconnect between AEMO's ancillary services load registration process and subsequent verification. The result is that AEMO has less control and visibility over the actual devices participating in the provision of FCAS.

4.3 'Solar sponge' hot water system controls and interaction with batteries for FCAS

There are hot water systems (HWS) on the market and already in the field that include the useful function of minimising solar export by instead diverting any export to the hot water load. In effect, the hot water heater acts somewhat like a 'solar sponge'. This is an extremely attractive capability for solar-only households, particularly where the grid feed-in price is much lower than the import price, which will increasingly be the case as more rooftop solar is deployed.

This facility is somewhat less useful for end users who have a separate battery installed on site, particularly if they are on a TOU tariff and the HWS is on a separate controlled load circuit/tariff. Batteries can both charge and discharge, meaning they can shift load from peak to off-peak times while soaking up solar. Batteries can more readily replace avoided solar export (e.g. 10c/kWh) with reduced peak-tariff import (e.g. 50c/kWh), for high-value benefit, while a HWS system on a controlled load tariff would be replacing a solar feed with reduced controlled-load import (perhaps 16c/kWh), which is less benefit to the customer per kWh.

A potential conflict occurs for customers that have a solar sponge HWS and also seek to use their battery to export to the grid for whatever purpose. A customer wish to do this for arbitrage purposes (e.g. if they are on a spot-price tariff), or because the end user is contributing their battery to a VPP for grid services (FCAS raise or otherwise).

Since the HWS likely will not differentiate types of grid export, the scenario presented is that a battery might be triggered by a low frequency disturbance to discharge, but the HWS then immediately responds by soaking up the attempted grid export. This is not so much 'gaming' the system as simply two incompatible operations: battery-based FCAS + HWS solar-export sponge.

AEMO has suggested that measuring at the connection point will allow them to verify FCAS response regardless of this behaviour. However, it will not solve the problem. A battery-based FCAS fleet where a substantial portion of sites include an export-responsive HWS will be non-compliant whether assessed at connection point or asset, and there has been no suggestion that AEMO will consider this as part of battery-based VPP ancillary services load registration.

This is a practical difficulty. It is resolved via customer preference and VPP terms and conditions: if a customer wishes to participate in a battery-based VPP for delivering FCAS, then they can be granted entry to the VPP on the proviso that their HWS does not have an active HWS solar sponge function enabled. Alternatively, if the customer wishes to retain the HWS export sponge function then they could be precluded from participating in a battery-based VPP for FCAS. AEMO can require VPPs to demonstrate that they address this specific issue in their terms and conditions with customers at time of registration as an ancillary service provider.

Evergen stresses that this is not an issue of unfair competition or exclusion, an idea raised in some AEMO–industry forums. Rather, it is just a practical conflict that two devices performing two competing functions behind the one connection point (FCAS raise vs. solar sponge) cannot operate in unison. The customer themselves is free to select which mutually exclusive offering they wish to adopt.

This issue is not resolved by verifying FCAS at the connection point, and should not form a rationale for the draft determination decision on verification measurement point.

4.4 Multiple controlled devices behind the one connection point

The Intellihub submission to the first round of consultation suggested FCAS assessment at the connection point was preferable in case of sites containing multiple controllable assets that may each contribute an FCAS response.

Such a scenario relies on some big commercial assumptions. Namely, that it is commercially viable for end users to install a complex piece of hardware to collect telemetry, control and orchestrate multiple devices for delivering compliant FCAS responses, while balancing multiple uses for each device. Alternatively, for a 'no additional hardware required' VPP operator such as Evergen, orchestration would involve developing commercial arrangements and API integrations with each appliance vendor at the site to facilitate cloud-based monitoring, control and orchestration. The costs and complexities of these multi-device-at-one-site orchestrated arrangements may preclude them in the short term, certainly when the financial case for even the straightforward case of battery-based VPP's for FCAS is still subject to a good deal of uncertainty (see Section 6 of this submission).

In the short-term, a much more likely scenario is that sites will only have a single DER involved in FCAS, and where there are multiple devices at a site that are looking to participate in VPPs, they will quite possibly be independently operated by separate VPPs (e.g., a HWS-based VPP and a battery-based VPP).

Given this, a more conservative verification approach would rely on individual asset monitoring to afford AEMO maximum visibility of each asset on the site. Connection point monitoring could be used instead at AEMOs discretion for the yet-to-be demonstrated case of multi-asset orchestration at each site by a single VPP.

Evergen suggests AEMO would still want to retain visibility of asset-level telemetry if this eventuates, since developing an assessment methodology for registering FCAS capability for a VPP composed of multi-asset orchestrated sites may prove challenging, and maintaining visibility of each asset could prove important for fostering confidence.

4.5 Do VPP demonstration program participants already meter at the connection point?

AEMO suggested that VPP participants are already required to measure power at the connection point, and that this would alleviate any concerns with the requirement to verify FCAS at the connection point.

Although this is the case, there are several factors that mean additional hardware is still required for participating in the fast market if FCAS is verified at the connection point:

1. existing power meters at the connection point are capable of 1-second sampling, but the draft determination mandates 50ms sampling for fast market participation;
2. Even if the meters are capable of sensing power every 50ms, they would need to communicate this back to the inverter, and the inverter+internet gateway would need appropriate control software and on-site memory to allow the handling of far greater volumes of telemetry to support 50ms verification;
3. existing connection point meters for the VPP demonstration sample power but not necessarily frequency. The draft MASS requires that frequency also be measured at or close to the connection point. This means that existing VPPs will not even be able to participate in slow or delayed markets without additional hardware, contrary to what AEMO implies across facts #1, #2 and #3 of their MASS consultation information sheet[3].

Therefore, although existing VPP demonstrations already measure power at the connection point at 1s sample rate, this does not alleviate the cost of complying with the draft determination requirements.

Evergen is currently unaware of any off-the-shelf solution to metering both power and frequency at 50ms at the connection point that is affordable, given the possible revenue per NMI from participating in fast FCAS. Costs are further covered in section 6 of this submission.

[3]https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/second-stage/aemo-fcas-verification-uom.pdf

4.6 Can utility meters perform measurements for FCAS verification?

In theory utility meters can sample power and grid frequency at 50ms, a fact reiterated in several submissions to the first round consultation on the MASS review. This service will not be provided by utility meter vendors at zero cost to VPP operators.

Most residences do not have a smart meter for remote data collection, so the cost of smart meter installation will need to be borne (whether by customer, retailer or VPP operator).

50ms data sampling, local storage, transport to the cloud, storage in a database, filtering to only retain frequency disturbance relevant telemetry, and availability via API or otherwise are functions that represent additional costs to smart meter providers. They will seek to recover from VPP operators, plus a profit to motivate participation. Evergen estimates that smart meter providers looking to offer FCAS data as a service will charge in the vicinity of $4-$10 per NMI per month ($48-$120 per NMI per year), and/or a percentage of the revenue from FCAS participation. There will be additional costs for both parties to negotiate and maintain commercial relationships. These costs will be extracted from the payments to the end user.

Costs might become more economical for larger fleet sizes. However, that assumes that every site in a VPP uses the same company's smart meter. This assumption would not hold for existing VPPs, necessitating either commercial agreements and API integrations with multiple smart meter vendors, or else prohibitively expensive smart meter retrofitting.

It is Evergen's current position that at best the notion that smart meter providers can play a key role in facilitating fast FCAS VPPs is 'hopeful', not yet commercially tested. The jury is out on whether the arrangement could deliver a realistic value proposition for all participants, including end user customers, VPP operators, and battery/inverter control platform providers, who would each be required to work with the smart meter vendor to deliver the FCAS verification capability.

4.7 Isn’t there already a DER-based VPP complying with the existing MASS, so compliance with Option 1 must be economically viable?

Evergen is aware of only one VPP-based FCAS participant (Reposit) who has a hardware-based solution that bundles battery monitoring and control with FCAS metering at the connection point to achieve Option 1 requirements. Reposit is to be commended for this accomplishment, which no doubt required a lot of effort, technical expertise and expense to achieve. However, their example can not be regarded as an unambiguous indication that installing hardware to facilitate fast FCAS for VPPs is economically viable, for the following reasons:

- Reposit received $445,000 in ARENA funding to develop and roll out their product. For a 10MW fleet averaging ~4kW per device, that amounts to $178 per device. https://arena.gov.au/projects/intelligent-storage-for-australias-grid/
- The cost per hardware device has, at least to date, been borne by the customer. This cost would be prohibitively expensive if the only justification for it were the revenue from fast FCAS participation.
- Purchasing a Reposit device offers benefits beyond fast FCAS market participation, however, these other benefits (such as monitoring, battery optimisation, non-FCAS VPP-based grid services etc) do not require additional hardware. Evergen offers similar benefits to end-use customers at no charge. So it is arguable that for most VPPs the costs that Reposit spreads across multiple customer benefits would instead be borne solely for fast FCAS market participation.
- When Reposit bundles their hardware with a full solar-battery installation, the subsidies, credits or interest-free loans such installations attract can be used to offset the cost of the monitoring hardware.

AEMO should gain no reassurance in their determination from the existence of one VPP provider complying with the existing MASS. It is almost certainly the case that winding back the VPP demonstration program and deferring on modifying the MASS in recognition of DER-based VPPs will simply bring the growing momentum for DER-based contingency FCAS services to a halt, causing stagnation and thwarting AEMO’s own publicly stated intention to assist in transitioning towards a two-way market for electricity services.

5. DER behaviour (and potential impact on network stability)

AEMO raises some concerns about the impact on power system security posed by DER. Evergen notes that these risks do not change whether Option 1 or Option 2 measurement requirements for DER-based VPPs are adopted. These concerns include:

A. Research conducted for AEMO suggests that legacy solar inverters are not compliant with recent standards and are prone to disconnecting from the grid under conditions of voltage and/or frequency disturbance. If this were to occur with FCAS-enabled battery-based DER, it would cause non-compliance and jeopardise system security;

B. AEMO shares concerns of DNSPs that multiple DER acting in unison to deliver FCAS might exceed secure distribution network operation limits;

C. DNSPs apply connection requirements to DER which may include limits on export (whether static export limits or dynamic operating envelopes) and Volt-VAr response. AEMO is concerned that complying with these requirements may conflict with FCAS deliverability and wishes to clarify the hierarchy of control commands; and

D. Measurement error resulting from sampling at 1s may fail to identify oscillatory patterns that allegedly may occur in some battery FCAS response profiles, which could impact system security. (This issue has been addressed previously in Evergen's response, we demonstrate that it is a non-issue and will not cover it further in this section).

5.1 Behaviour of PV inverters vs battery inverters

In May 2021, AEMO published a compendium of analysis conducted over the last 3 years in conjunction with UNSW, examining the behaviour of PV inverters over the

course of various grid disturbances. Available at:
https://aemo.com.au/-/media/files/initiatives/der/2021/capstone-report.pdf

The report found evidence of extensive disconnection of legacy PV inverters during voltage disturbances. The report also found low levels of disconnection during frequency disturbances where frequency remained above 49.5Hz, and a greater degree of disconnection for larger frequency disturbances below 49.0Hz.

The report focuses solely on PV inverters, many of which would be many years old, given that grid-connected residential solar across Australia has been ramping up over the past 20+ years.

The report specifically excluded study of battery inverters.

Compared to rooftop PV, residential batteries and their inverters will be newer, and therefore more likely compliant with recent standards. For example, the Tesla Powerwall 2 was released in 2016. The two types of battery-inverter system comprising the two VPPs operated on behalf of Members Energy by Evergen have each only been available in Australia for less than two years, and are already compliant with the voltage ride through requirements specified in AS4777.2:2020.

There are categorical differences between the battery inverters that comprise the VPPs participating in AEMOs demonstration program and the PV inverters considered in AEMO's study.

Therefore, it is questionable whether the findings of this report bear great relevance to concerns over whether FCAS fleets will ride through grid disturbances in sufficient numbers to deliver on their FCAS enablements.

A far more relevant source of information on how battery inverters in VPPs respond during system disturbances is the VPP demonstration program itself. AEMO has previously indicated across three knowledge sharing reports and its initial MASS review documentation that **the VPP demonstration program has shown that VPPs can deliver compliant FCAS bids**. Further, the VPP demonstration program afforded AEMO an enhanced view of local telemetry such as local voltage readings which could facilitate further research.

As indicated in the draft determination, AEMO has identified that AS4777.2:2020 compliance could further improve certainty over inverter disturbance ride-through performance, and Evergen supports pursuing this, towards requiring all DER be AS4777.2:2020 compliant to be registered as ancillary service loads.

5.2 VPP-based FCAS exceeding network operating limits?

The risk posed by battery-based FCAS VPPs to distribution networks is dwarfed by the risk posed by the millions of rooftop PV systems already installed around the NEM. These PV systems all generate power in unison on a sunny day in a given area of the network and across the NEM.

That rooftop PV is magnitudes more significant than battery-based VPPs delivering FCAS is not just the current circumstance, but will be an enduring condition. It is almost never the case that a residential battery would be installed without a rooftop PV system, and there is no plausible scenario under which this would change.

For this reason it is ineffectual to use the MASS to render support or benefit to DNSPs in managing network constraints.

There are industry processes that are completely independent of and unrelated to the MASS that are already underway to grapple with the impact of large volumes of rooftop PV on distribution networks. These include the widespread imposition of export limits and solar curtailment measures (switching off of rooftop PV systems) by DNSPs, and investigation of dynamic operating envelopes as a more flexible alternative to export limits. Evergen does not see how battery based VPPs would be able to circumvent these measures without the explicit permission of incumbent DNSPs.

AEMO seems focused on trying to establish an industry-wide 'control hierarchy' before it will countenance modifying the MASS in line with Option 2 requirements. By control hierarchy, AEMO refers to the potential conflicts between FCAS response and controls such as export limits. We will respond to this in the next section.

5.3 The 'control hierarchy'

AEMO wishes to determine a control hierarchy to establish which battery commands will take precedence when both DNSPs and VPP operators bidding for FCAS request potentially conflicting battery actions.

In Evergen's view, DNSP controls should take precedence over market-based actions such as delivering FCAS, and should be assumed by VPP operators to take precedence. It is incumbent on the VPP operator to be aware of the potential for conflicting controls, and manage their fleet and moderate their FCAS bidding strategy accordingly. Managing risk is a responsibility of the VPP operator, not something that AEMO and DNSPs need to excessively regulate at the individual DER level.

That DNSPs have Volt-VAr requirements and export limits is a known consideration. These are not limits that any VPP operator would simply assume can be ignored or not complied with. Rather, they are limits to bid around.

Voltage issues that may necessitate a VAr response are localised often down to individual feeders, while FCAS fleets are region-wide. As seemed to be the case when considering measurement error for FCAS verification, AEMO is identifying an apparent issue at the individual inverter level, then improperly over-simplifying in magnifying that issue up to a fleet-wide issue. Potential conflicts for a portion of individual DER across a fleet can be mitigated with an appropriately conservative bidding strategy, and AEMO can enforce good bidding behaviour using existing compliance measures.

Since it should be clear that DNSP connection requirements take precedence over market-based activities, and competing controls at individual DER can be mitigated by the VPP operator and already enforced by both DNSPs and AEMO compliance measures, Evergen sees no reason to delay moving to Option 2 MASS requirements for DER-based VPPs based on system security concerns.

5.4 Export limits and dynamic operating envelopes

VPPs already behave conservatively, and export limits are simply another input to bidding logic. For example, if devices in a VPP are export limited to 5kW, then this could and should be readily incorporated into bidding logic. The end result may be that a VPP does not bid 1MW of FCAS until it has 1.5MW available. VPPs already manage uncertainty in battery state due to the challenges with forecasting load and solar output, and must conservatively assume that some portion of their fleet will not be available when making bids. DNSP requirements such as Volt-VAr response requirements are no different. AEMO and DNSPs can simply set the connection and compliance requirements and allow VPP operators to freely satisfy these constraints as they see fit.

The same applies for the advent of dynamic operating envelopes. VPP operators would incorporate knowledge of DOEs into their bidding and rebidding strategies.

5.5 Managing risk and learning by doing

VPP operators must already deal with the uncertainty of battery state, household load and solar output when day-ahead bidding and subsequent rebidding in FCAS markets. This uncertainty is accommodated with an appropriately conservative bidding strategy to ensure compliance. Incorporating unavailability of some DER due to Volt-VAr behaviours can be readily incorporated into bidding strategy risk management.

VPP operators routinely have grid voltage and power factor measurements as part of their operational telemetry, and can also determine export limits from operational telemetry if it is not already apparent in DNSP published requirements for grid connection. VPP operators are well-positioned to recognise the possibility that a portion of their fleet will be hampered in delivering an FCAS response - whether it is from lack of battery storage/headroom, insufficient solar output to charge the battery, communications issue, or localised competing DNSP controls, and conservatively bid around these issues.

Over the VPP demonstration program Members Energy and Evergen began by adopting a very conservative approach to bidding to ensure compliance, and were in fact advised by AEMO to consider being less conservative in order to participate and learn.

The only way to properly undertake this learning is through participation. The cessation of the VPP demonstration program and adoption of this draft determination will prevent this learning from continuing in a well-monitored and orderly fashion.

To move from excessive conservatism to comfortable and efficient compliance, the most important prerequisite for VPPs becoming skilled at managing these varied constraints and conditions is experience, and AEMO and DNSPs can better assist this if they have improved visibility at the local level of system characteristics such as voltage.

Lack of visibility is bad for system security.

6. Customer value for VPP participation

6.1 Business case for a battery

The expansion of DER has proceeded on the back of excellent customer returns. Rooftop solar is 'in the money' due to avoided grid offtake and feed-in revenue paid by retailers. Batteries, an essential component for the ongoing stability of the grid, are typically more marginal than a stand-alone PV system, though this varies from customer to customer. VPP participation has been hotly pursued by installers and innovative retailers as a way to tip the economics in favour of batteries.

Batteries typically have a 10 year warranty, thus the initial capital outlay warrants a ten year payback period. Applying additional hardware requirements makes it less likely that a customer can achieve this payback period. Following discussion with our hardware partners, Evergen calculates up front cost of additional hardware at $500[4] plus install costs. Further, there will be additional monthly costs of $4-$10 per month per NMI (or $48-$120 per year per NMI) for handling data volumes, increased system monitoring, additional cloud infrastructure, and charges from either the inverter or revenue meter company to provide a service that offers remote access to 50ms FCAS data. Thus, applying additional hardware requirements to participate in the FCAS market has a chilling effect on battery uptake.

The business case for batteries is at its best when there is value-stacking, combining the savings from reduced grid-offtake, exports at high prices and FCAS enablement. Households, markets and hardware are highly diverse, so there is no single business case for investing in battery systems. FCAS revenue alone will not cover the capital outlay of the battery for many customers. It is a combination of savings and revenues that make batteries a solid investment.

[4] Advice from our hardware partners aligns broadly with reported pricing for the Reposit hardware solution of $700-$1,800 depending on install costs https://www.techguide.com.au/news/renewable-energy/reposit-can-help-pay-less-electricity/.

6.2 Overestimating FCAS value

FCAS revenues are variable. While the inclusion of FCAS revenue helps the business case for investing in batteries, AEMO may be overestimating the value of FCAS for a VPP participant and thereby overestimating customers' willingness to invest in costly high-end metering. There are a few reasons for this overestimation.

High FCAS revenues have been demonstrated (see VPP demonstration program knowledge sharing report #1[5]) in SA with some customers estimated to be earning $1000+ per NMI per year. This is partly due to system events in SA, such as the February 2020 SA islanding incident. FCAS earnings are lower in other NEM regions. However much of the VPP learnings have been gained in SA, skewing the results published in the knowledge sharing reports. The adjustments to primary frequency response requirements in October 2020 combined with a mild Summer has meant that FCAS revenue was low over late 2020 and into 2021. A realistic appraisal of future FCAS earnings in regions outside SA are likely to be much lower than $1000, even for an 'ideal FCAS enablement' scenario, where batteries are prioritised for FCAS. The 'ideal FCAS enablement' is in itself quite unrealistic.

Customers have differing capacity to provide FCAS. A customer with an oversized battery can readily provide their excess capacity to the FCAS market and the customer will suffer no reduction in savings arising from self-consumption. Customers with a smaller battery would need to often make a trade-off between self-consumption and FCAS enablement. This trade-off also applies for a customer with a battery that doesn't allow FCAS enablement to be run concurrently with other battery modes. The value of self-consumption differs by distribution network (network tariffs being a key driver of peak retail rates), by household load and hardware capability. In many examples, self-consumption is far more valuable than FCAS enablement.

As shown in Table 3, reserving capacity for FCAS represents a significant opportunity cost to the end user, which might be as much as $465 per year, if the customer reserves 3kWh of a larger battery, which would otherwise have been used to store solar and avoid peak tariff imports. Thus the 'ideal FCAS enablement' scenario is not in the best interest of customers and is unlikely to persist into the retail marketplace.

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[5] https://aemo.com.au/-/media/files/electricity/der/2020/aemo-knowledge-sharing-stage-1-report.pdf

Table 3. *This shows the cost to the consumer if part of their battery (storage + headroom) is reserved to maximise the availability of the battery to participate in FCAS. If no battery capacity is reserved, then the battery will often be unavailable for raise services (battery empty) or unavailable for lower services (battery at full charge).*

	Low impact scenario	High impact scenario
kWh of battery capacity reserved for FCAS	1	3
Solar export tariff per kWh	$0.020	$0.095
Off-peak tariff per kWh	$0.13	$0.18
Shoulder tariff per kWh	$0.17	$0.27
Peak tariff per kWh	$0.35	$0.52
Yearly opportunity cost, assuming 1 cycle per day:		
If customer use/generation happened to not draw on reserve	$0*	$0*
If reserve had replaced solar export with avoided off-peak import	$40.15	$93.08
If reserve had replaced solar export with avoided shoulder import	$54.75	$191.63
If reserve had replaced solar export with avoided peak import	$120.45	$465.38

* This occurs in the event that the customer's normal PV generation + consumption would naturally keep the battery within the reserve limit (very rate condition), or else the customer opted to reserve both storage and headroom for their own purposes anyway (customers reserving headroom does not happen).

The upshot is that many households have limited battery capacity to offer to the FCAS market, they aren't situated in SA and they will not be able to earn $1,000 per year. They may be earning $50 per year. That $50 per year could form part of the business case for the battery, but it is unlikely to warrant investment in high-end metering equipment with the sole benefit of granting fast FCAS participation.

FCAS revenue can also be overestimated by failing to differentiate between FCAS revenue at the portfolio level and FCAS revenue apportioned to customers. Revenue from FCAS participation is divided between customers, and the parties that make that participation possible. This may include VPP facilitators such as Evergen, VPP operators such as Members Energy, the market customer (e.g., Energy Locals, who is the market customer for multiple VPPs in the demonstration program). If monitoring for FCAS verification were provided from an additional party, such as a revenue meter provider (who would need to deliver cloud infrastructure to pipe data to the FCAS provider), this would be an additional party who's contribution would need to be funded from FCAS revenue.

Customers are unlikely to invest in high-end metering (estimated $1,500 over ten years) when FCAS revenue won't cover that outlay.

6.3 Summary

The VPP demonstration program allowed a diverse range of VPP retail offers to be created. Revoking the rules governing the VPP demonstration program will lead to fewer customers being able to participate, as both batteries in general, and an FCAS-ready battery in particular, are less likely to be 'in the money'. This reversal of fortunes will thin VPP participation and investment from retailers and a decline in innovative retailer competition is likely to result.

By enforcing the need for high-end meters, a large number (likely the majority) of battery owners will be barred from contributing to system stability. AEMO is effectively undermining a key component of the business case for small scale asset VPPs. **This is not the appropriate course of action if genuinely preparing for a decentralised and renewables-powered electricity system that is stable, flexible, and equitable.**

7. Proposed interim arrangements for VPPs

It is our strong belief that the VPP demonstration program alternative requirements should be adopted as a formal requirements specification for all DER-based VPP participation in FCAS. However, should AEMO finalise their draft determination without change, their approach would put in place transitional arrangements for existing VPPs participating in the VPP demonstration program. As we have argued, Evergen does not accept that the draft determination in its current form is justified. Nevertheless we wish to comment on the draft transitional arrangements in the interests of completeness.

Evergen does not believe that the draft transitional arrangements are fair or appropriate.

Evergen seeks a path that nurtures the excellent collaboration and data gathering that has occurred to date due to the relaxed rules of the VPP demonstration program, rather than the current draft determination and interim arrangements that will extinguish it entirely and undermine the path to innovation that the energy system in Australia and internationally so badly requires.

7.1 No justification for penalising fast FCAS participation in the interim

AEMO proposed that VPPs participating in fast markets should have a 20% reduction applied to their verified FCAS delivery in light of measurement error, as part of interim arrangements.

Evergen demonstrated (see Section 3 of this submission) that there are sufficient measurements for verification, and **the shortcoming is not one of measurement, but one of verification methodology.** There is therefore no justification for penalising VPP program participants who sample at the device level at 1s.

Evergen therefore recommends that no discount be applied to VPP demonstration program participants in the fast contingency FCAS markets as part of interim arrangements.

Further, Evergen recommends AEMO take the opportunity to work with demonstration program participants to update and improve their approach to FCAS verification for DER-based VPPs, with a view to extending an improved approach more widely after testing via the demonstration program. AEMO's current approach is outdated and not fit for the purpose of verifying FCAS delivered by VPPs.

There is no indication from the VPP demonstration program to date that VPP participants cannot deliver an effective fast market FCAS response, and it is entirely within AEMO's power to develop an improved approach to verification to more effectively maintain visibility of this.

7.2 A cap on fleet size rather than a freeze

AEMO proposes that existing VPP participants should not be able to increase their FCAS registration size. This disproportionately impacts newer, smaller VPP demonstration program participants who have nevertheless still invested significantly and in good faith to be able to work with AEMO to drive progress on VPP-based FCAS.

AEMO has disallowed the addition of NMIs to these fleets for the last 8 months unless as part of a re-enrolment at larger ancillary services load size (in 1MW increments). That is, AEMO has not allowed addition of NMIs to cover customer churn without re-enrolment.

The result has been that newer, smaller VPPs have been operating at a significant loss while working to accrue sufficient customers for re-enrolment at 2MW.

As of June 2021, AEMO now also disallows re-enrolments at increased size for VPP demonstration program participants. This leaves newer VPP program participants who originally registered with a base level 1 MW fleet with an increasingly marginal fleet as customers churn. If the draft interim arrangements come into force, churn could be replaced at a fee of $2,000. Even should this fee be waived, the small fleet size is not sustainable. The significant investments made by VPP operators to establish control, integrate with AEMO and undertake the expense of customer acquisition will not be recouped. This is especially disappointing given that VPP operators have been working with AEMO in good faith and are in position to continue to contribute telemetry and knowledge sharing to AEMO.

Given AEMO's MASS review proposed option 2, and first round feedback was a majority in favour of incorporating either Option 2 or a hybrid of Option 2 into the MASS as AEMO proposed, it is arguable that AEMO has disregarded the trust, lessons and momentum for the transition towards two-way markets it has built together with VPP operators and the broader community.

Rather than freeze re-enrolment at larger sizes for these VPPs, Evergen recommends that AEMO instead put a cap of 10MW (or else current fleet capacity if it is already above 10MW) on VPP demonstration program participants. This is a more equitable arrangement while still meeting AEMO's overt intention of limiting in the short term the penetration of DER-based VPPs into the FCAS market.

7.3 New participants and new device types

With a fleet size cap in place, AEMO should continue to permit new entrants and new device types (e.g. new battery models) to the interim arrangements. Learning by doing is the way forward for progressing VPP-based FCAS delivery. The barriers to entry under the draft determination aside from being unnecessary and driven by flawed analysis, are also too high to facilitate extensive VPP participation in the FCAS market. AEMO cannot present itself as a facilitator of grid modernisation and DER enablement if it actively thwarts industry being able to learn and progress solutions.

Even the arrangements for the VPP demonstration program still represent a hefty barrier to entry for new participants. AEMO can readily see this by comparing the large number of interested parties focused on the VPP demonstration program versus the comparatively small number of participants, and the time required to become operational. Allowing new participants to the VPP demonstration program / interim arrangements, especially with a cap on fleet size, will not result in sufficient volume of DER-based FCAS providers entering the market to cause issues - that is assuming that there even would be any issues presented, an assumption that Evergen has challenged in the preceding sections of this submission.

7.4 APIs for operational telemetry

As part of the VPP demonstration program, AEMO required participants to integrate with AEMO via API for provision of de-identified 5 minute telemetry at both the device and fleet aggregate level. This is similar to API-based telemetry requirements in place for government DER funding initiatives, such as the NextGen program in the ACT.

Although there is an upfront cost associated with establishing an API integration and teething issues, both of these can be mitigated to an extent with improved documentation and a functional testing platform. Both AEMO and industry would get better at this... with experience. Once up and running, API-based automated telemetry provision to AEMO represents a low running cost and an incredibly valuable data stream, offering insight both on the site level (e.g., of grid voltage), and of behind the meter telemetry. These APIs represented a mature, 21st century approach to visibility, monitoring and data.

Under the VPP demonstration program, AEMO was privy to this data at no charge to AEMO. It would normally be reasonable that such an extensive, near real time data set would fetch a significant price for access. Even DNSPs lack this level of fine-grained visibility over site-level voltage on their own networks.

Given this, it is a concern that AEMO elected to decommission these APIs. Doing so suggests that AEMO did not devote sufficient resources to taking advantage of these valuable data streams. If they did so, the insights and fine-grained visibility delivered would outweigh any internal expense in maintaining the APIs and performing data analysis, especially when some degree of data analysis could be automated.

AEMO will need to constantly build on a solid capability for data ingestion and analysis, routinely handling huge volumes of data, to inform decision making. That the world is moving towards a big data and data science mindset is not a new idea.

That AEMO performs FCAS verification by having participants email files which AEMO then runs through a spreadsheet should be a source of concern to AEMO and incumbent participants more broadly, more befitting small business accounting processes than operation of the National Electricity Market.

Decommissioning the APIs implies that in practice AEMO is still hampered by an outdated mindset, and is shying away from developing even its own internal capabilities. To match its own rhetoric, AEMO must work to operate in the contemporary context of big data, real time data streams, automated data analysis and machine learning. It is an unambiguous backwards step for AEMO to decommission these APIs.

Evergen recommends that AEMO reinstates the VPP demonstration program APIs and makes API integration a condition of entry for new VPP participants against the interim arrangements. This will ultimately benefit AEMO and contribute to the ongoing learning that needs to occur for both AEMO and industry to progress against AEMO's publicly stated aims of facilitating active consumers in the electricity market, and prosumer-based DER provision of grid services.

8. Conclusion

Evergen strongly requests that AEMO reconsider this draft determination, and seeks a path that nurtures the excellent collaboration and data gathering that has occurred to date, rather than one that extinguishes it.

We feel that accepting the draft determination as it currently stands:

- is unnecessary on the basis of the technical reasons stated (measurement time resolution, location measurement point and system security);
- represents a bad outcome for energy consumers by removing a route for their participation in the market;
- represents a bad outcome for network operators by reducing visibility to DER;
- represents a bad outcome for industry collaboration by pushing a whole disruptive and innovative section of the industry to one side indefinitely; and
- represents a bad outcome for Australian leadership and innovation in the energy space.

Evergen presents this proposal in the spirit of open collaboration, and a genuine desire to continue innovating and accelerating the energy transition with the Australian energy industry for the benefit of all Australians.

References

Mancarella, P., Zhang, L., and Wang, H. (2021). *Fast FCAS sampling verification in support of market ancillary services specification (MASS) consultation*. Prepared for AEMO by University of Melbourne. Downloaded from: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/second-stage/aemo-fcas-verification-uom.pdf

Market ancillary services specification and FCAS verification tool, AEMO (2021). Downloaded from: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/market-ancillary-services-specification-and-fcas-verification-tool

About Evergen

Evergen is leading the charge using software to enable decentralised energy systems of the future. Founded in collaboration between AMP Capital and the CSIRO in 2015, Evergen has invested in some of the smartest, curious and most capable minds across the industry. Evergen now works with many retailers and network operators in Australia, in Europe, and Latin America. Evergen's mission is to kill a coal-fired power station in 10 countries by powering the transition to a resilient, renewable, decentralised energy system of the future.

For more information, visit https://evergen.energy/

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Appendix A - additional calculations relating to verification error

FCAS verification

Here we only discuss the assessment window methodology. The assessment window considered here is notionally a period of 6s beginning at the frequency disturbance time, t0-actual. Estimation t0-actual is determined locally via measurement of local frequency.

AEMO's current methodology is to take the timestamp of the first recorded sample after frequency leaves the normal operating frequency band (NOFB) as t0-estimate, and uses this as the start of the 6s assessment window. For example, if the actual frequency disturbance time (t0-actual) is at 3.6s and the first recorded sample is at 4.5s (t0-estimate), then the true 6-second window is between 3.6s and 9.6s while the assessed window will be between 4.5s and 10.5s, as shown in Fig. 5.

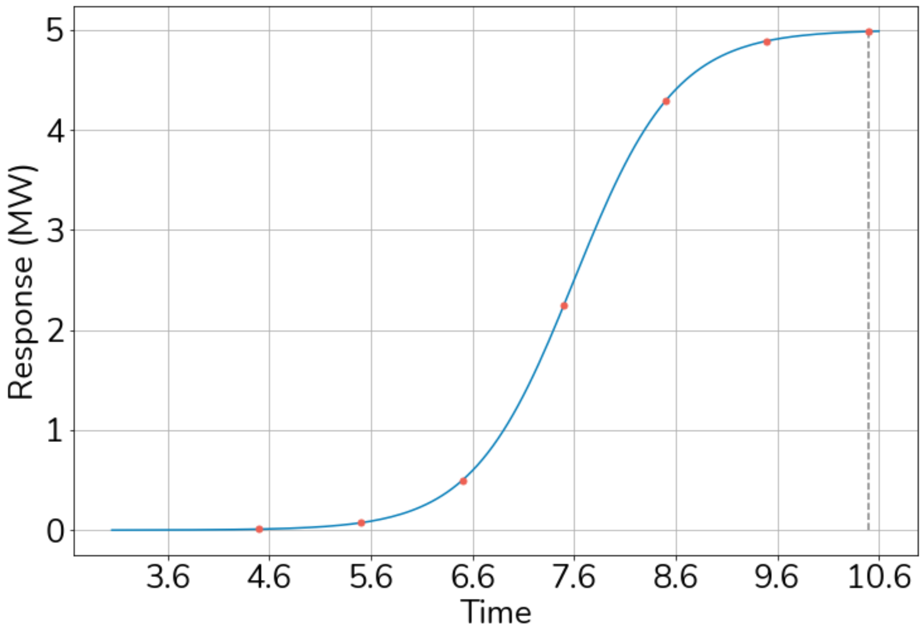

Fig. 5. Example assessment window with actual frequency disturbance time being 3.6s, and the first sample after this taken at 4.5s (1s sampling rate)

The closer the first sample is to t0-actual, the more accurate is the assessed window, and hence the more accurate is the estimated delivered energy. However, the current way of determining the 6-second window *always* overestimates the delivered energy.

Evergen conducted a simulation of data sampling, assuming t0-actual = 3.6s, and with the first sampled point being at $3.6 + k * 0.05$, where k is randomly selected from the range $[0, 1, \cdots, 19]$. The response curve we used was a simple sigmoid function which roughly approximated how a battery may respond to a frequency disturbance, and is similar to the analysis conducted in Mancarella et al. (2021).

The selection of $k$is repeated 1000 times. Fig. 6 shows the error percentage compared with the true value (the area under the curve between 3.6s and 9.6s). It is approximately uniformly distributed, and it supports the Mancarella et al. finding that the current assessment method always overestimates the assessed FCAS delivery.

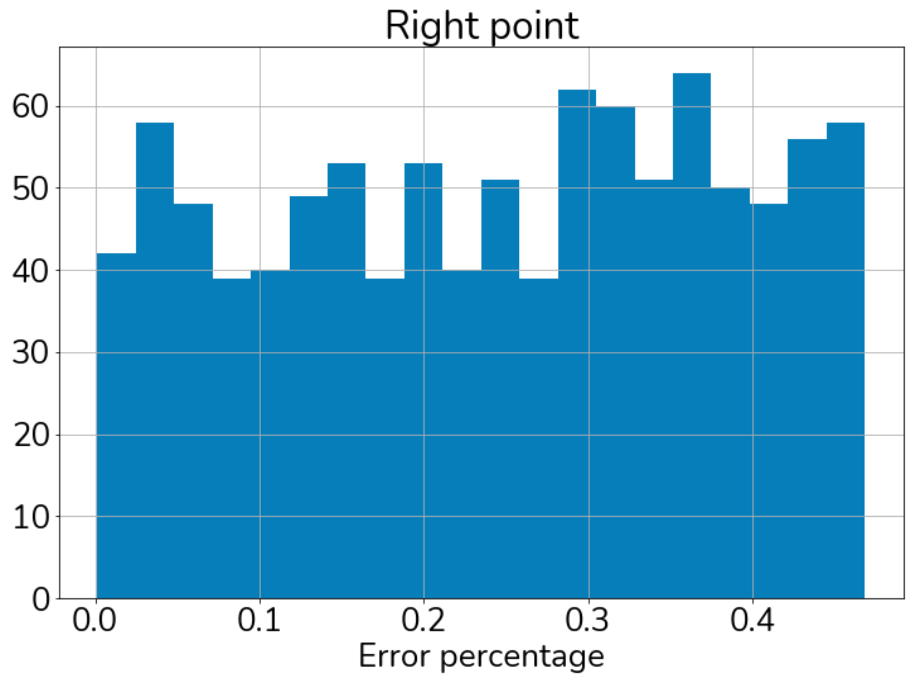

Fig. 6. Distribution of error percentage across 1000 different 1s sampling series, using AEMO's current method for determining t0-estimate.

If Instead of choosing the first point *after* the frequency leaves the NOFB, we were to use the timestamp of the last point before the frequency leaves the NOFB as t0-estimate, then the calculated delivered energy would instead be always underestimated.

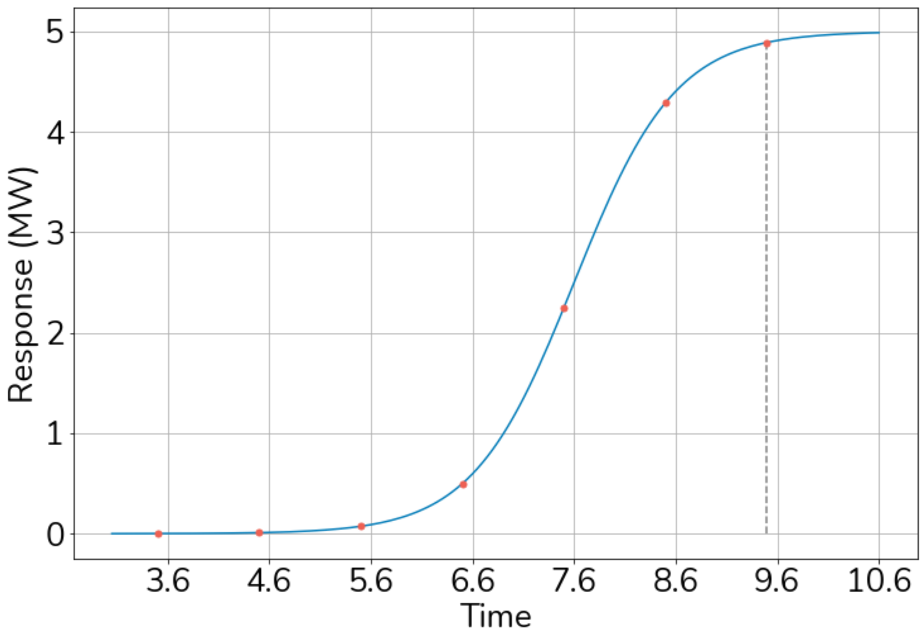

Fig. 7: Example assessment window with actual frequency disturbance time being 3.6s, and the first sample prior to this taken at 3.5s (1s sampling rate)

If we were to average these two estimates, the resulting error may be an overestimate or an underestimate, instead of always one or the other.

Evergen also calculated the error of the average of these two estimation methods for 1000 simulations using a similar method to that discussed above. The new distribution of percentage errors is shown in Fig. 8. It is also approximately uniformly distributed, but is now centred (x axis) on a mean error of approximately 0.

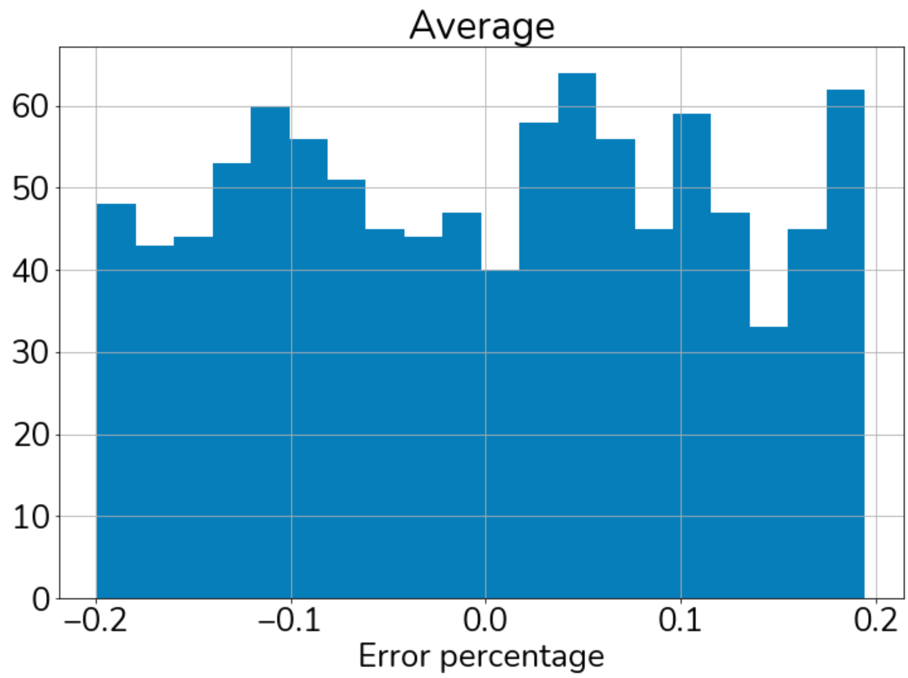

Fig. 8: Distribution of error percentage using new approach to t0 estimation

In the next section, it is proved that, with this alternative method, the total estimation error for a fleet could be far lower than the required threshold, as long as the fleet size is large enough.

Verification error assessment for a fleet

Assume that there are n identical devices in the fleet, the true energy delivered by each device is C, and the assessment error for each device is normally distributed $U(-\ pC, pC)$, where p in $[0,\ 1]$. We can assume the error is distributed in this way if we were to use an unbiased approach to selecting t0-estimate (i.e., not AEMO's current method).

For the assessment error, we have

$$\mu\ =\ 0,\ \sigma^2\ =\frac{1}{12}\,(2pC)^2\ =\frac{1}{3}p^2C^2$$

Then for the error of the total energy of the fleet, we have

$$\mu^*\ =\ 0,\ \sigma^{*2}\ =\frac{n}{3}p^2C^2$$

By the central limit theorem, we know that the error of the fleet's energy estimate follows (approximately) the normal distribution $N(\mu^*, \sigma^*)$. The 95% confidence interval of the error percentage of the total energy is

$0 \pm \sqrt{\frac{2}{3n}}p.$

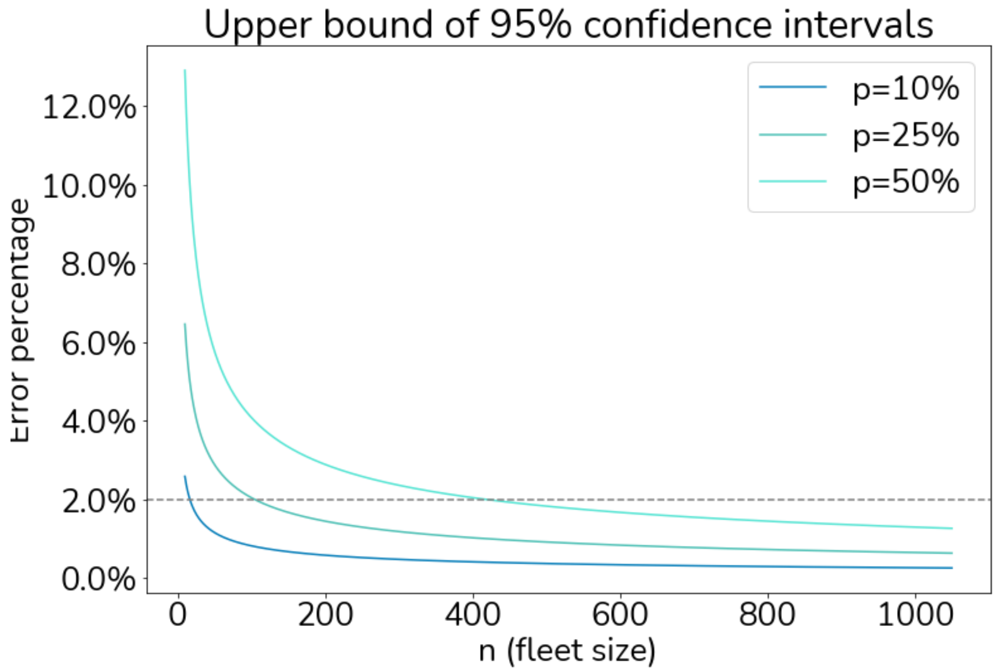

Fig. 9: Upper bounds of 95% confidence intervals for different p values

The smallest fleet sizes are calculated for different values of p and are shown in the following table.

Table 4: The minimum fleet size to achieve the desired accuracy with a given assessment error percentage for a 95% confidence level

	2% error (fleet)	1.4% error (fleet)	1% error (fleet)
10% error (device)	17	35	67
25% error (device)	105	213	417
50% error (device)	417	851	1667

Measurement error assessment for a single device at 50ms sampling rate

Neither AEMO nor Mancarella et al. calculated the error in the assessed FCAS delivery of a single device sampled at 50ms. We do so here.

Assume that the device has a capacity of 5MW and the measurement error of each sampled point is within $\pm$ 2%of the true value (in accordance with the MASS requirement) and is normally distributed. Let's denote the measured values are

$y_i\ ,\ i\ =\ 0, 1,...,120$

the true values are

$y_i^*,\ i\ =\ 0, 1,...,120$

There are 121 points sampled in a 6-second window with a 50ms sampling rate.

Each measured value follows a normal distribution

$U((1\ -\ 2\%)y_i^*,\ (1\ +\ 2\%)y_i^*),$

with

$\mu_i = y_i^*,\ \sigma_i^2 = \frac{(0.02)^2}{3} y_i^{*2}$

The Trapezoidal sum for the estimated energy delivered equals

$\frac{h}{2}[y_0 + \sum_{i=1}^{119} y_i + y_{120}]$

By the central limit theorem, the sum follows a normal distribution, with

$\mu\ = \frac{h}{2}[y_0^* + \sum_{i=1}^{119} y_i^* + y_{120}^*]$

$\sigma^2\ = \frac{h}{2}[\sigma_0^2 + \sum_{i=1}^{119} \sigma_i^2 + \sigma_{120}^2] = \frac{(0.02)^2}{3} \frac{h}{2}[y_0^{*2}\ \ + \sum_{i=1}^{119} y_i^{*2} + y_{120}^{*2}]$

The 95% confidence interval of the error percentage is

$0\ \pm \frac{2\sigma}{\mu}$

For the sigmoid function in Figure 1

$f\ = \frac{5}{1+e^{-0.002\times(x-4000)}}$

the 95% confidence interval is

$0\ \pm\ 1.4\%$

Thus, for a 5MW battery (or fleet) with each device responding with a profile as in Fig. 7, the error of energy assessment with the 50ms sampling rate will have a 95% confidence interval $0 \pm 1.4\%$if there is 2% measurement error for each point.

Comparing to a VPP consisting of 1000x 5kW DER, each sampled at 1s

Based on the analysis above, if the fleet contains 1000x 5kW batteries, the overall assessment error will be much smaller than 1% even if the error for each battery is as high as 25% with the 1s sampling rate. Therefore a reasonably sized fleet will be able to afford a more accurate verification of FCAS delivery if each DER is sampled at 1s than what is achievable with a single 5MW device sampled at 50ms, given 2% measurement error for each measurement.