IES
Intelligent Energy Systems

6 December 2022

Project Manager
Consultation on Frequency Contribution Factors Procedure (FCFP)
Australian Energy Market Operator (AEMO)
Melbourne VIC 3000

Dear Sir/Madam

IES SUBMISSION ON AEMO FCFP CONSULTATION PAPER

I am pleased to submit our response to AEMO's consultation paper published on 31 October 2022. I would be pleased to discuss and answer questions on the content of the submission.

Yours sincerely

Hugh Bannister
CEO

Intelligent Energy Systems ACN 002 572 090 ABN 51 002 572 090

Head Office – Sydney Level 2 10-12 Clarke Street Crows Nest NSW 2065 Australia PO Box 931 Crows Nest NSW 1585
Telephone 61 2 9436 2555 **Facsimile** 61 2 9436 1218 **Email** ies@iesys.com **Web** www.iesys.com
Melbourne Level 1 2 Main Street Point Cook VIC 3030 Australia
Telephone 61 3 9037 0956 **Mobile** 61 438 226 384 **Email** ies@iesys.com **Web** www.iesys.com

1 Frequency measure and criteria for appropriate metering

1.1 Overview

The default metering available to AEMO is that available through the SCADA system. However, there is some scope to use local measurements which the consultation paper dismisses as likely too complex to implement and probably not necessary. However, this possibility is worth exploring. To do so, we first need to be clear on what we intend a frequency measurement to mean when different metering options have different resolutions. Finally, an approach to the practical use of such metering will be outlined.

1.2 Estimating the frequency measures used for performance factors

It is possible and commonplace to measure frequency and load or generation at different resolutions, for example to as little as 50ms for high resolution instruments, ranging to around a second or fraction of a second for local control, to 4 or 8 seconds used for mainland and Tasmanian SCADA, respectively. Clearly, a 50mS frequency measurement is not the same as a 4-second measurement. One could, as AEMO does in its consultation paper, base frequency measures on a moving average over some duration of window, or a combination of such measurements. However, more natural measures (based on the usual assumption of linear system dynamics around a base operating point) would use low pass filters of different time constants. A digital low pass filter has the following simple form[1]:

$$filtered\_frequency_{TC,t} = (1 - a_{TC}) \times filtered\_frequency_{TC,t-1} + a_{TC} \times measured\_frequency_t$$

Where

t	is the time a measurement is made
Δt	is interval between raw measurements (resolution)
TC	is time constant of desired filtered frequency measure
$a_{TC} = \frac{\Delta t}{TC + \Delta t}$	is the low pass filter parameter

Note the Δt in the numerator of the expression above. Suppose we have 4 second measurements and we set TC = 0; this gives us $a_{TC} = 1$ and

$$filtered\_frequency_{0,t} = measured\_frequency_t$$

Cleary, this direct relationship to raw frequency measurements cannot apply for different measurement intervals. Instead, we define a filtered frequency according to a filtering time constant and apply the filtered frequency formula with the appropriate measurement interval. for example, the time constant of the fast response component of PFR might be taken as the approximate time constant of 6 seconds used for contingency FCAS. In this case, for 4 second metering we get:

$$filtered\_frequency_{6,t} = (1 - {}^{4}/_{(6+4)}) \times filtered\_frequency_{6,t-1} + {}^{4}/_{(6+4)} \times measured\_frequency_t$$

But if we have a local 1 second set of measurements, the formula would be:

$$filtered\_frequency_{6,t} = (1 - {}^{1}/_{(6+1)}) \times filtered\_frequency_{6,t-1} + {}^{1}/_{(6+1)} \times measured\_frequency_t$$

The 1 second resolution estimate of a 6-second time constant filtered frequency would be a more accurate than a 4-second estimate. However we would not expect any systematic error from using one

[1] See the Discrete-time realization section at https://en.wikipedia.org/wiki/Low-pass_filter

version relative to the other unless other issues such as time lags come into play. In that case the local measurement would likely lead to more accurate factor, and a higher factor in the case of a provider. Of course reducing such effects is a key motivation for making local measurements.

The IES report to AEMC suggested an incentive based on a combined metric with fast and slow-moving components. There is merit in setting the slow-moving component as closely as possible to the AGC value to ensure the enabled and non-enabled units operate reasonably consistently. A time constant of 30 seconds seems to give a good fit, giving the filter formula for 4 second resolution as:

$$filtered\_frequency_{30,t} = (1 - {}^{4}/_{(30+4)}) \times filtered\_frequency_{30,t-1} + {}^{1}/_{(30+4)} \times measured\_frequency_{t}$$

However, for 1-second interval measurements the filter formula would be:

$$filtered\_frequency_{30,t} = (1 - {}^{1}/_{(30+1)}) \times filtered\_frequency_{30,t-1} + {}^{1}/_{(30+1)} \times measured\_frequency_{t}$$

We note that it would be possible to define additional components such as:

- a 5-minute(300 second) time constant component to assist with ramping;
- an internal time correction element, similar to but simpler and not directly linked to the AGC correction (to minimise incentives that may work against each other).
- with improved metering and at some time in the future, shorter time constants to reward good PFR performance, for example.

These different components would reflect the different dynamic elements at play in the system and their weightings will change over time as the draft procedure anticipates.

1.3 Criteria for appropriate metering – an option for local measurement

Given that the components of the performance metric can be estimated for any measurement interval, there is scope to allow sites that can locally measure frequency and real power flow to measure, calculate and provide AEMO with data to use in settlement. These data could be raw, or already processed into 5-minute factors (in the form of means rather than totals, to eliminate any need to adjust any further for measurement interval at AEMO's end). This process could operate as follows.

- A site seeks accreditation from AEMO if it seeks to use its own local measurements.
- The site should provide to AEMO, each day and in a standard format, 5-minute values of data already processed into mean, non-normalised factors using the same logic as used by AEMO.
- AEMO compares these values to its own SCADA values as a cross check, before normalising and using them in settlement. Where there is significant disagreement, SCADA and local calculations, AEMO will use the version that it considers the most accurate.
- AEMO may require routine accuracy checks (such as providing each day a compete data set for one dispatch interval in addition to the processed data, to allow for a check calculation for one period) as well as require annual audits of the site's calculation system.
- Sites will be required to implement parameter changes as published by AEMO in a timely manner.

We *recommend* that AEMO consider allowing for pre-processed performance factors from sites that wish to use local measurements in its system design. The full procedure need not prioritised unless the industry thinks it worthwhile.

1.4 Should Raise and Lower be determined separately for each performance factor component?

The Rule requires Raise and Lower incentives be separated, but there is a potential choice in implementation; the boundary between Raise and Lower could be assessed on the basis of:

- the sign of a combined frequency metric; or
- the sign of each component individually

We argue for the second approach because of potentially perverse incentives inherent in the first. Note that a fast response requirement (such as fast governor action from steam turbines) will often be of a different sign to a slow response requirement (along the lines of the AGC response). This can happen as AGC corrects for forecast error, but there is then a short-term disturbance requiring correction. Now consider a unit that can respond quickly but which cannot sustain a response. If the combined factor is showing raise but a short-term lower is required, the combined raise incentive would seem to point in the wrong direction. Conversely, if a unit can sustain a long period of raise and a fast Lower is required, it may not be inclined to respond because the fast incentive for Lower has been removed.

This issue should be investigated further by the TWG as it could affect outcomes negatively and it does affect the design of AEMO's software systems.

1.5 Response to AEMO Questions

- Are there any alternatives to the proposal that would provide demonstrably greater net benefit to the market than regional measurement?

  We have suggested above that local measurement and initial processing could be advantageous to specific sites and provision should be made to support the option in the design of AEMO's software system. However, development of a complete protocol need not be a current priority.

- What process should AEMO follow to change the weighting of parameters for the frequency measure?

  Broadly, the process should work as follows.

  - AEMO assesses the likely need for one or more parameter changes and publishes the proposal for consultation
  - When a determination is made it sets a date to implement the proposed change. Typically, this would be a month or two ahead.
  - Short term, emergency changes should be avoided if the parameter settings are "near enough".

- How should AEMO assess the efficacy of the frequency measure and weightings?

  This may be difficult. However, the thinking on this could be along the following lines

  - The objective is to maintain frequency control to within the required standard
  - The parameters should be set to give the desired technical performance, bearing in mind that the short-term outcome must be stable and the long term outcome should tend to encourage the maintenance of PFR capability.

2 Calculation and application of contribution factors and default contribution factors

Response to AEMO Questions

- Feedback is sought on the proposed formulation for determining contribution factors in the FCFP. Do you see any issues with the proposal?

The broad description in the consultation paper makes sense, although it will need more detail at some point. With more than one component and with a requirement for separated Raise and Lower, how does the procedure then look? Bearing in mind the issues discussed in Section 1.4, there will be more steps involved.

AEMO is assessing possible timeframes for determining average performance for historical default contribution factors. This could be, for example, an eligible unit's average raise or lower performance for a period of a week, or as in the draft FCFP, a certain number of trading intervals for which there is valid raise or lower performance values. What principles should AEMO have regard to in determining this?

Response

There are likely to be different views on this, but we see merit in defining a sufficiently long period, say a full settlement period over which to average a performance factor. In this way the long term performance would be used to allocate this cost, rather than a potentially more volatile shorter-term measure.

- In determining default contribution factors should AEMO exclude good performance or, as in the draft FCFP, should it be a simple average of all performance.

Response

If only negative values are used, one might ask about he arbitrariness of setting 5-minute boundaries. Using only negative values bring in generally good performers or often trivial amounts, for little benefit. Our suggestion would be to choose a relatively long measurement period, say a settlement cycle and use the performance factors (price weighted?) summed over that period. Such an approach will clearly delineate the good and the bad.

- What specific circumstances are there where default contribution factors should apply automatically that should be explicitly captured in section 5.3 of the draft FCFP? Where should AEMO have discretion to apply default contribution factors?

Response

Default factors will need to be used where there is some data failure and a calculation cannot otherwise be done. However, we agree with the comment in the draft procedure that such exceptions should be minimised or eliminated. Specifically, there is no basis replacing measured factors with defaults where there has been a contingency. The (modest) negative spike that the failed generator would incur is not an unreasonable outcome, and the positive incentive provided over the one or two dispatch intervals would assist the recovery.

- How should offline units contribute to the cost of regulation FCAS? Are there circumstances (such as being offline for an extended period of time) in which a unit should cease being liable and be given a default contribution factor of zero? If so, how should AEMO determine a unit to be offline?

Response

It would seem unreasonable to charge units that are not online by giving them default factors. Unfortunately, if they pay when online, it will influence their decision on whether to commit or not. This is one of several unfortunate by-products of the approach taken to regulation FCAS cost recovery.

3 Formulation of RCR

3.1 The Consultation Paper approach and a more robust alternative

The settlement formula for a unit in a dispatch interval is given by:

$$Settlement\_amount = Contributon\_factor \times Price \times RCR$$

Where for Raise the RCR is the maximum gross deviation when the frequency deviation is negative and correspondingly for Lower.

Where RCR is calculated as the maximum (or minimum) gross deviation when the performance measure is on the Raise (or Lower) side. This approach has the following characteristics:

- As illustrated in Figure 3 of the Draft Procedure, gross deviation tends to be relatively stable over a dispatch interval, albeit with some spikes.
- When this relatively stable volume is combined with the current reg price, we get a relatively stable settlement amount to be distributed.
- However, this amount remains the same regardless of whether the service (Raise or Lower) is used a lot, a little or not at all (hence the need for default factors in the last case). This observation remains substantially valid even though gross deviation can vary significantly over time, but usually quite slowly.

In summary, inherent in the proposed approach is a relatively large implicit cost weighting given to small frequency deviations and relatively low weighting given to large deviations. The case of zero deviations (in a particular direction) is an extreme case of a larger problem. This situation can be corrected by deriving a slightly modified formula using the broad approach set out in Appendix A of the IES report to AEMC. Without going into the details, the revised settlement formula is:

$$\begin{aligned} Settlement\_amount \\ &= Contributon\_factor \times Price \\ &\times \left(\left(\frac{Measured\_frequency_{rms}}{Target\_frequency_{rms}} \right) \times Gross\_deviation_{rms} \right) \end{aligned}$$

The last term in brackets is the suggested alternative RCR.

The rms values are taken to be in the relevant direction – Raise or Lower. They are the one-sided versions of standard deviation in a symmetrical system The rms of the target frequency will be set by the reliability standard, currently it is measured at around 25mHz.

Rms values are easily calculated and are more robust and less volatile measures then maxima or minima. Further, these measures are relatively independent of measurement interval (i.e. any differences are not likely to be systematic; this can be checked with real data.

3.2 Response to AEMO Questions

- Should the requirement for corrective response be capped in certain circumstances? What should those circumstances be?

  Response

  As noted above, the following formula, derived from the approach in Appendix A of the IES report to the AEMC, resolves the problem posed by small or zero frequency excursions in either Raise or Lower. This could be capped at some value but there would seem little point in doing so as it would dilute incentives, especially after a contingency.

$$RCR = \left(\frac{Measured\_frequency_{rms}}{Target\_frequency_{rms}} \right) \times Gross\_deviation_{rms}$$

- Is the use of a simple maximum value in MW for a 4-second period within a trading interval ideal? What other options are there that meet the rule requirement, and how should AEMO evaluate them?

  Response

  See above.

- Should minimum thresholds apply to the calculation (for example, a minimum number of consecutive raise or lower 4-second intervals before a 4-second interval can be used to potentially determine RCR, or a minimum frequency deviation required to set RCR?)

  Response

  See above

- Should some types of variable generation be aggregated for the purpose of calculating RCR?

  Response

  Choice of the gross deviation measure inevitably leads to some arbitrariness in dispatch interval outcome depending on how units are grouped, but such differences should wash our over a settlement period. Excepting some type of plant would seem to increase that level of arbitrariness. Measurement at the connection point is the simplest approach. Other ways of calculating the RCR (e.g. some extended form of rms calculation operating at the unit as well as time level) might sidestep this issue.

- How should RCR be calculated for global requirements when there are two AGC areas (e.g. Tasmania and Mainland)?

  Response

  We understand that Basslink and Marinus when operating will have their own frequency management arrangements between AGC areas. Inflows and outputs to and from these areas should be treated as pseudo generators and loads and the RCR in each AGC area calculated independently.

4 Formulation of Usage of Reg FCAS

- Are there any preferable alternatives to the draft FCFP formulation of usage?
- Referring to section 7.3 of the draft FCFP, are there any circumstances in which usage should be defined as being equal to zero, for which the requirement for corrective response should not also be zero? In other words, are there any scenarios in which frequency performance payments would not be made, but for which regulation FCAS costs should still be allocated in part to eligible units on the basis of measured frequency performance during that trading interval?

  Response

  No comment on either of these questions.

5 Determination of reference trajectory (within the confines of the rule that requires it to be based on target-to-target)

- There is a lag between the start of the trading interval and when AEMO sends out a dispatch instruction. If this impact is deemed to have a material impact on contribution factors, what are the options to address it?

Response

The impact on contribution factors would need to be systemic to warrant special consideration. The errors from the absence of a clear target in in the relatively few seconds after the start of the dispatch interval should be small.

- Should units that are enabled to provide Regulation FCAS be treated differently? If so, how?

Response

Including regulation FCAS-enabled units in the performance incentive arrangements is the simplest approach which removes any issues of determining a boundary between what is provided under enablement and what is provided as an "extra". If the incentive arrangement is substantially (not necessarily completely) aligned with the AGC performance requirement, enabled units should earn a fair return for good performance. The perceived risk of "double payment" should be reduced as the extra incentive to get paid for both enablement and performance makes bidding for regulation enablement more attractive.

6 Determination of the Residual, both for global and local requirements

- Are there any complications with this approach that have not been raised?

Response

The proposed approach is simple and robust. The concept of a scheduled and physical energy balance applies around any close boundary around all or part of the system, s drawing a boundary at an interconnector is valid.

- Would it be preferable for the impact of interconnector deviations to be borne entirely by the local residual for local requirements? This would enable the framework to have good and bad performance for appropriately metered units to offset (since the link between deviations and cost would remain intact).

Response

This option is unclear. An interconnector is essentially just another metered unit and should be treated as such.

- Should contribution factors for the Residual be capped at zero? (noting that default contribution factors for eligible units that are appropriately metered are capped at zero).

Response

The residual can be regarded as just another metered unit (with many meters) and so contribution factors should be treated the same way. For normal factors, there is no merit in any capping, the residual factor can be positive or negative although it is usually negative. For default factors, choice of a suitably long reference period (say a full settlement period) should clearly delineate good and bad performers, so no capping should be required.

7 Estimating Contribution factors in the predisptach timeframe

- Do you see value in AEMO publishing estimated aggregate values in the predispatch timeframe?

Response

What would those aggregate values be?

- What other data do you consider worthwhile for AEMO to publish

Response

  - 4-second data each 5 minutes, at least for individual units
  - Draft performance factors each 5 minutes