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Remunerating Primary Frequency Response even when it's Mandated

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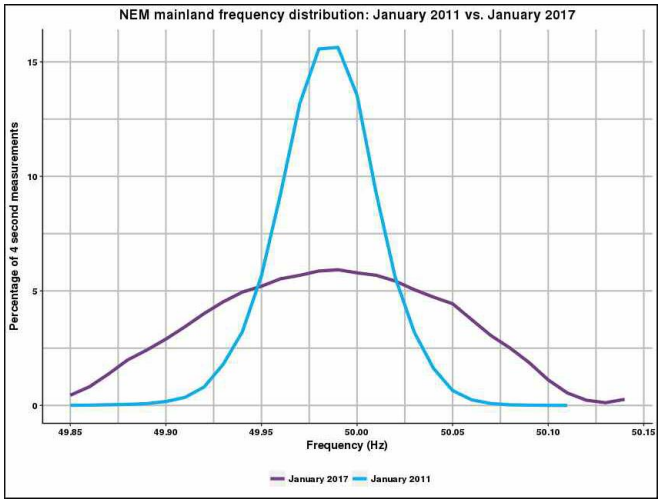
Where we have come from

It has now been more than 5 years since deterioration in frequency control has been evident. Since then AEMO has commissioned a range of reports examining the issue and undertaken many trials to try to persuade the system to behave better. Below is a chart where the deterioration is starkly shown.

Figure 1: Frequency Distribution Profile NEM mainland: Jan 2011 – Jan 2017



Source: AEMC analysis of 4 second frequency data provided by AEMO.

At the same time AEMC has produced numerus reports examining the issue as well setting out and evaluating options to improve performance[1]. A core finding is that the primary cause is withdrawal of Primary Frequency Response (PFR) from normal operations, largely because of narrow definitions of conformance during dispatch, but also because the service is not paid for.

Looking to the future, the AEMC has also canvassed pricing mechanisms. One such pricing mechanism has in fact been on the table for 20 years[2]. Current AEMO staff are aware of it but AEMO for some reason has failed to take it up. Over this time, traditional governor response, unrewarded has, unsurprisingly, withdrawn from the market, as will unrewarded inertia in due course.

Yet AEMO seemed surprised when, on 25 August 2018, following a "non-credible" transmission failure, the traditional governor action of synchronous plant that electricity systems have long relied upon to help stabilise the system simply went missing when and where it counted, and the system fell apart. This failure could not be ascribed to renewable energy or even to lack of inertia.

Since that time AEMO has been laser-focussed on mandating a primary frequency response capability in all generators as matter of urgency. Generators pleaded for time to do something better but left their run too late. AEMC has now acceded to AEMO's rule change request, but with a strong caveat that the current mandate will expire in three years AEMO may not have been pleased with this outcome, given its arguments in favour of a mandated, unpaid service.

AEMO is also pursuing related rule changes, chief of which is to recognise that generators that leave their strict energy

[1] AEMC, Frequency control frameworks review, Final report, 26 July 2018.

[2] Intelligent Energy Systems, Who Should Pay for Ancillary Services? A Project commissioned by the NEMMCO Ancillary Services Reference Group: Final Report (with Appendices). Available from: http://www.iesys.com/Content/ProjectDocuments/AS%20Who%20Pays%20Appendices%20Final.pdf

targets to improve frequency performance should be lauded rather than punished. That is a major concession to reality. Until recently, AEMO and AER have been fixated on strict adherence to linear ramping.

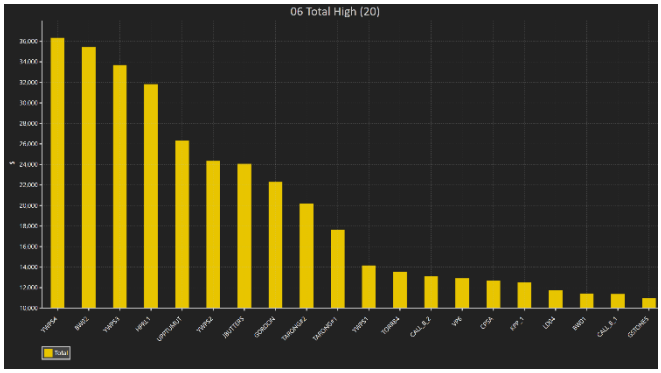
Where to from here?

Setting aside the wild card of the ESB 2025 market design, it seems that the AEMC likes the idea of deviation pricing for frequency control but has never clearly defined what it would look like in any detail. It cannot because the supporting research and development has not yet been published and scrutinised.

To its credit, CS Energy has sponsored IES to develop and demonstrate cut-down version of deviation pricing to address the immediate problem with PFR, with or without mandatory provision. Double-sided Causer Pays for PFR is tailored to look like regulation Causer Pays because that is a familiar concept. Under the hood, though, it is deviation pricing tailored to existing technology (NEM SCADA) and to a response time in the order of 4 to 10 seconds and longer.

IES is making the results of this work available, including access to near real time analysis and settlement results for scheduled generators and other participants. This will be done through providing access to Neopoint to market participants and other parties who request it. We will also provide one-on-one Skype (or alternative) guidance through the set of charts on request. A charting example is the "leaderboard" of PFR service providers is shown below. Note that behaviours will change when such a system begins to operate.

Figure 1: Histogram of Accumulated PFR Performance Factors for Month of March 2020



IES is also seeking financial and technical support to refine and publish the results of its research into deviation pricing, with the aim of being able to propose a coherent and comprehensive rule change within the next 18 months covering frequency control from inertia and Fast Frequency Response (FFR) though to 5 minutes and beyond.

Following is brief description of Double-sided Causer Pays for PFR. At the end we give details on how to access the near real time results and the further research that IES seeks to do to further the deviation pricing concept.

Double-sided Causer Pays for PFR

The logic of the proposal is as follows.

1. Initially, devices actively participating would be those who are measured with 4 second SCADA for the purpose of scheduling and dispatch in the wholesale energy spot market. Other unmeasured parties would be passive participants under this arrangement.
2. We estimate a MW requirement at any moment as proportional to the negative frequency deviation at that 4-second interval. This is a simplification of the quantity ACEReg used in AGC regulation and AGC Regulation Causer Pays. We will retain this nomenclature for PFR.
3. We distinguish Raise and Lower services according to whether the system needs more or less power at any given 4-second interval, as measured by the sign of ACEReg, to bring it back into balance.
4. We define a base trajectory for each participating device as the linear, ramped trajectory determined each 5 minutes in the energy market scheduling and dispatch process.
5. We define provision as power that helps bring the system back into balance and cause as power that tends to drive the system away from balance.
6. We define a performance factors as the product of system deviation and power deviation from the energy power trajectory. This form has a justification in control and economic theory. Based on the distinctions made in (3) and (5) above, there are four "buckets" that a factor at any 4 second interval could be placed in:
    a. Raise provision
    b. Raise cause

c. Lower provision

d. Lower cause

7. For convenience only, we accumulate these 4-second values into four pots of 5-minute values. We also define a residual so that the sum of both energy and performance factors equals zero. We can break down the residual into forecast error and load relief.

8. We estimate a suitable cost of provision for each of Raise and Lower in each 5-minute interval. There are a several ways that this can be done, depending on one's objective. See the following policy discussion.

9. We pay the providers (of Raise or Lower separately) in this 5-minutes a share of this estimated cost, allocated in proportion to their performance factors.

10. We then allocate this cost to the causers and residual in proportion to their performance factors.

11. Each of the four buckets accumulated in each 5 minutes is summed over the settlement period for payment purposes. The amount paid or received is the net of the dollar amounts in each of the four buckets.

Additional Design Issues

A rule change to implement double-sided causer pays for PFR would need to address some additional issues of a policy nature.

1. What cost formula should be used? The prototype IES as implemented with CS Energy is based on a typical coal-fired generator operating in a region of high reserve - a typical potential provider in the near and intermediate term. This is an attempt to mimic the current "cheapest in system" philosophy the applies to most FCAS right now. An alternative is to weight the performance measure by the relevant regional energy price, perhaps at a somewhat higher cost but in a way that could meet current AEMO preferences for a wide geographic dispersion of providers.

2. In its final report of the Frequency Control Frameworks Review, the AEMC canvassed its concern that any incentive payment to provide a PFR service should avoid double counting with respect to AGC regulation enablement and, presumably, contingency services when they apply[3]. We would argue that this line of thinking is misguided. There is no theoretical or practical reason why well defined "usage" services cannot overlap.

3. A related policy is is whether costs will increase if services can overlap and both are paid for. The answer is that prices will adjust when a PFR service is introduced. The key question is: will the package of services be delivered more effectively than efficiently than before? Well-structured pricing arrangements deliver such an outcome.

4. AEMC has finalised an AEMO-proposed rule change mandating a requirement to provide primary frequency response capability outside a tight deadband. Is an incentive mechanism along the lines proposed here still relevant, given that the service is now mandated? We argue that mandating the service does not negate the desirability and effectiveness of efficient pricing. Such pricing also helps resolve many issues affecting non-synchronous units that would otherwise have to be resolved through a bureaucratic process within AEMO. Further, a market mechanism is required when the mandated requirement expires in 3 years.

Prototype Implementation

CS Energy has sponsored IES to develop a prototype of the above double-sided causer pays logic for PFR. The aim is to make live charts of the calculation process and outcomes available to a wider audience. We have implemented the charts in NEOpoint and published a page on our IES website www.iesys.com that contains access to:

- a more detailed description of the calculation process and reporting;
- the IES reports on the topic sponsored by CS Energy;
- access to most of the live charts reporting on the calculation process and results down to the unit level.

[3] Frequency Control Frameworks Review p100

- ongoing information relating to the measures being taken by the industry to improve primary frequency response

This page does not yet provide access to the theoretical and simulation work that IES has done on the more widely applicable concept of deviation pricing. Such a regime when fully implemented requires more sophisticated metering that IES is currently working on prototyping. Although the deviation pricing concept has been recognised as worthy of consideration in AEMC reports on the frequency control issue, it has yet to gain industry acceptance. IES is seeking industry support to further this research. An outline of the proposed research is included as an attachment to this article.

An Example of PFR as Measured by the Proposed Mechanism

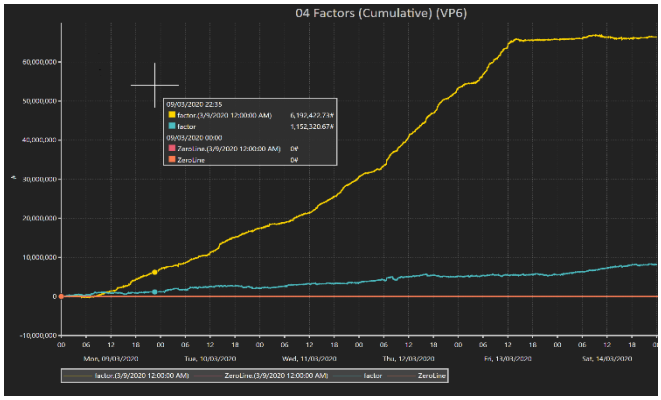
While undertaking this work, IES became aware of a trial being undertaken by Delta Electricity to progressively narrow the deadband of the governor on its VP5 unit over a period of several days. The schedule followed is tabulated below:

Table 1: Testing Schedule for VP5

Start Date & Time	Test Description	End Date & Time (see Note 1)
9/3/20 09:00	Modify FCAS controller deadband from 140mHz to 80mHz via the DCS Engineering Workstation	11/3/20 09:00
11/3/20 09:00	Modify FCAS controller deadband from 80mHz to 60mHz via the DCS Engineering Workstation	12/3/20 09:00
12/3/20 09:00	Modify FCAS controller deadband from 60mHz to 50mHz via the DCS Engineering Workstation	13/3/20 15:00
13/3/20 15:00	Modify FCAS controller deadband from 50mHz to 140mHz via the DCS Engineering Workstation	Trial Completed

A plot of accumulated double-sided causer pays factors for VP5 (yellow) and the similar VP6 unit (blue) whose deadband was not changed is shown in the figure below.

Figure 2: Performance of VP5 & VP6 over the Trial Period



The chart clearly shows the start of the trial and the abrupt change to a flat profile (no positive performance) at the end of the trial. Further, the generally convex shape of the VP5 curve reflects the progressive tightening of the dead band over the trial period.

The chart shows accumulated factors. There are several ways that 5-minute factors could be weighted to give a final cost (depending on secondary policy objectives such as desired geographic spread), but the trend is clear.

IES wished to thank Delta to for supporting the publication of this material.

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To request access to the live Double-sided Causer Pays for PFR live reports and one-on-one-advice, go to the link below:

http://www.iesys.com/Projects/dscp

Alternatively, you can also contact Jabez Wilson at jwilson@iesys.com

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Appendix

An R&D project to submit to ARENA with industry support and participation could cover the following topics.

1. A clear outline of the deviation pricing concept and how it would fit in with current arrangements including mandatory provision of PFR capability and the FCAS enablement markets.
2. Control and economic theory and practice supporting the concept
3. What is the appropriate form of the pricing function and why? Under what condition would you modify it?
4. Is there any sound basis for having concerns about double counting?
5. What is the relationship between enablement and a performance-based service? Are they alternatives or complementary?
6. Develop a simulation to illustrate the effectiveness of deviation pricing, distinguishing where possible the cases with and without mandatory provision.
7. Develop a prototype deviation pricing meter (including use of SCADA as an initial approach but ultimately intended to scan all timescales from a few cycles upwards) as well settlement logic, covering:
    a. meter accuracy; resolution, scaling and offsets;
    b. metering reliability;
    c. visibility to AEMO and production of useful data for ex post analysis; and
    d. additional analysis that would benefit AEMO in its role of ensuring system security
8. Design and conduct of a trial of the double sided causer pays concept
9. Assessment of trial performance and materiality and efficiency gain with mandatory provision and also when mandatory provision lapses.
10. Draft a proposed rule change.
11. Report and recommendations from the research
12. Promulgation of the results