DETERMINING REGULATION RESERVE CAUSER CONTRIBUTION

A causer pays approach to regulation reserves cost recovery

CAUSER CONTRIBUTION BASED APPROACHES TO REGULATION RESERVE COST RECOVERY

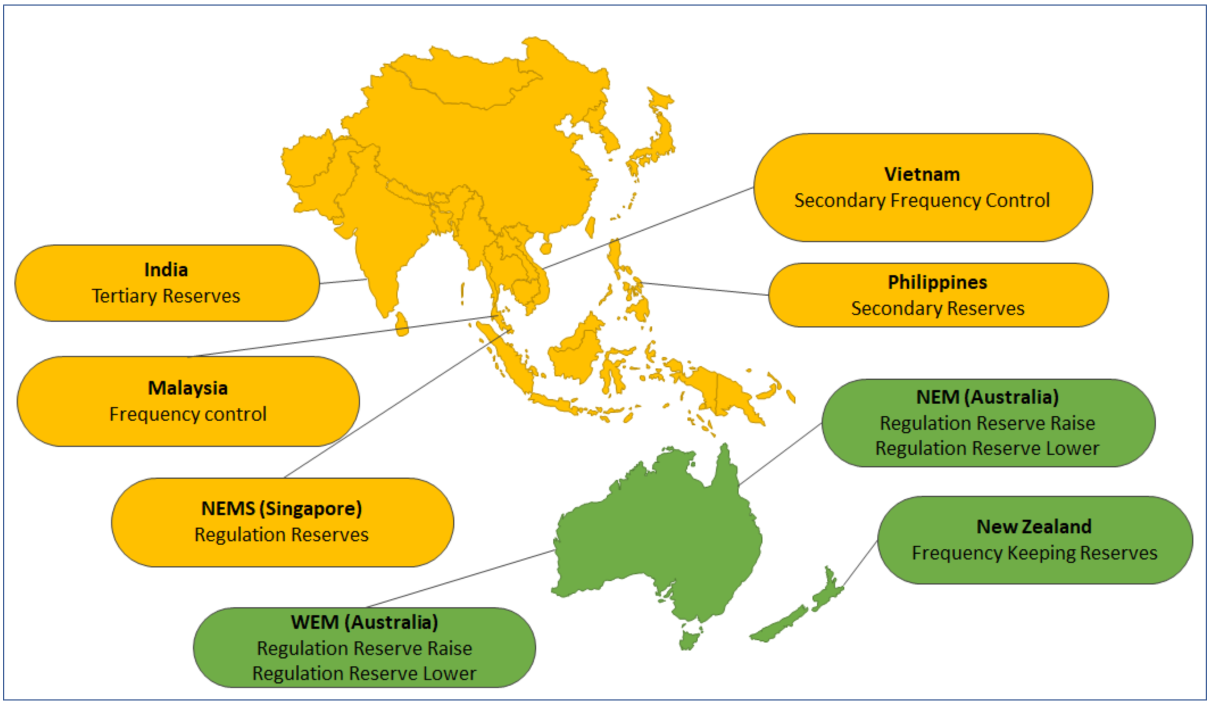
WHAT ARE REGULATION RESERVES

Regulation reserves are procured to maintain power system frequency at regulated levels by offsetting minor mismatches between electricity supply and demand on short time frames (within each dispatch interval). Regulation providers respond to frequency deviations by following the load up or down, either in direct response to local system frequency, or via automatic generator control by the system operator.

The need for regulation reserves is driven by volatility and variation in demand, or by deviation from dispatch generation targets or forecasts in the case of intermittent generators.

Regulation reserves are also referred to as load-following or frequency-keeping reserves.

Figure 1: Regulation Reserve products in selected markets



WHY CAUSER-PAYS?

Traditionally, loads have been the primary driver of power system volatility, so regulation reserve costs have been allocated to them using a simple postage stamp approach where costs are smeared across loads in proportion to consumption. With the Energy Transition, we are seeing increasing penetration of both Variable Renewable Energy (VRE) resources as well as distributed Photo-Voltaic (PV) systems or rooftop PV. Increasing levels of intermittent generation on a power system are likely to increase regulation reserve requirements. Retaining a postage stamp approach in a world with high levels of intermittent generation (including rooftop PV) does not incentivise the causers of variation to modify their behaviour to reduce the variation as reducing consumption does not necessarily reduce volatility.

Causer pays approaches to allocating regulation reserve costs can incentivise the causers of variation to minimise their variation. For example:

- An intermittent generator can invest in more accurate forecasting systems to minimise their exposure to regulation reserves costs.
- Large (e.g., industrial) loads can institute measures to minimise variation in energy consumption.

If causers act in this way, less regulation reserve is needed, and market costs reduce accordingly.

To implement a causer pays approach to allocating regulation reserve costs, a causer's contribution to the regulation requirement needs to be measured (i.e., contribution factors need to be determined for each causer). This can be challenging. In fact, causer-pays approaches to regulation cost allocation are used only in Australia.

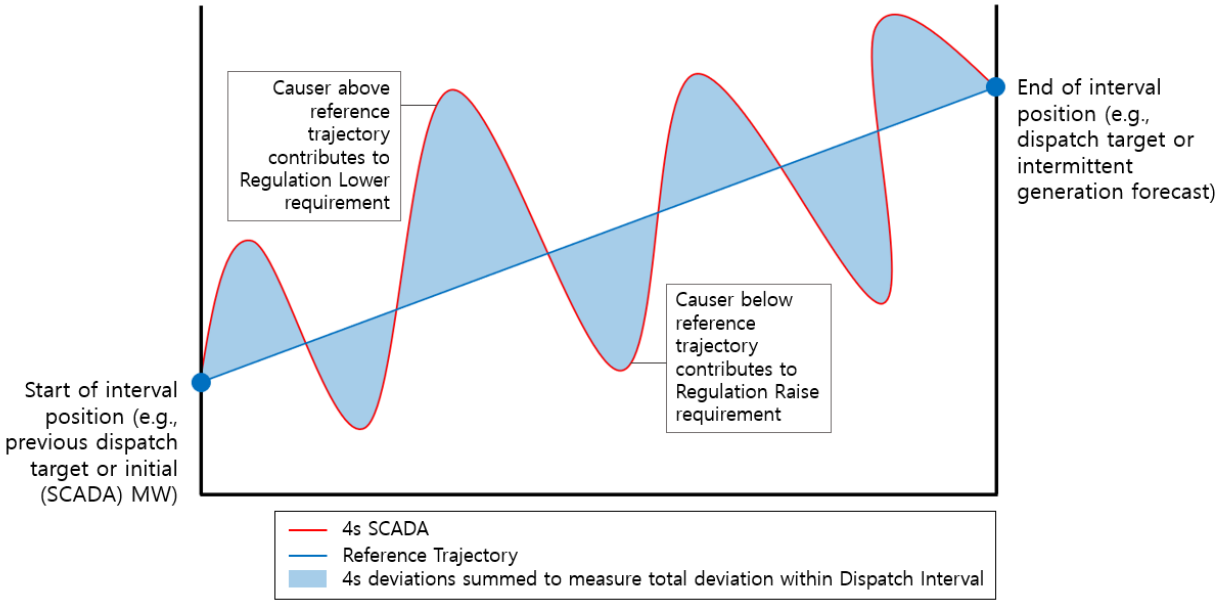
In this article, we:

- Provide a brief overview of what contribution factor-based cost allocation methodologies for regulation reserves look like.
- Discuss the features of the Australian contribution-factor methodologies
- Discuss some insights from the Australian experience.

SIMPLIFIED OVERVIEW OF CONTRIBUTION-BASED METHOD

Contribution factor-based methods calculate contribution factors for 'causers' (e.g., dispatchable and non-dispatchable generators and loads) based on the extent to which they have deviated from expected output or consumption (a hypothetical "reference trajectory") during a dispatch interval (five minutes in most mature markets). Each causer's injection or withdrawal is measured at a very granular level (e.g., 4 seconds) using SCADA data (where available). The reference trajectory represents a linear ramp from a causer's start of dispatch interval position (e.g., previous dispatch target or initial MW measured by SCADA) to its end of dispatch interval positions (e.g., current dispatch target or end of interval dispatch forecast or end of interval MW measured by SCADA).

Figure 2: Reference trajectory and actual (SCADA measured) intra-interval output of a hypothetical generator.

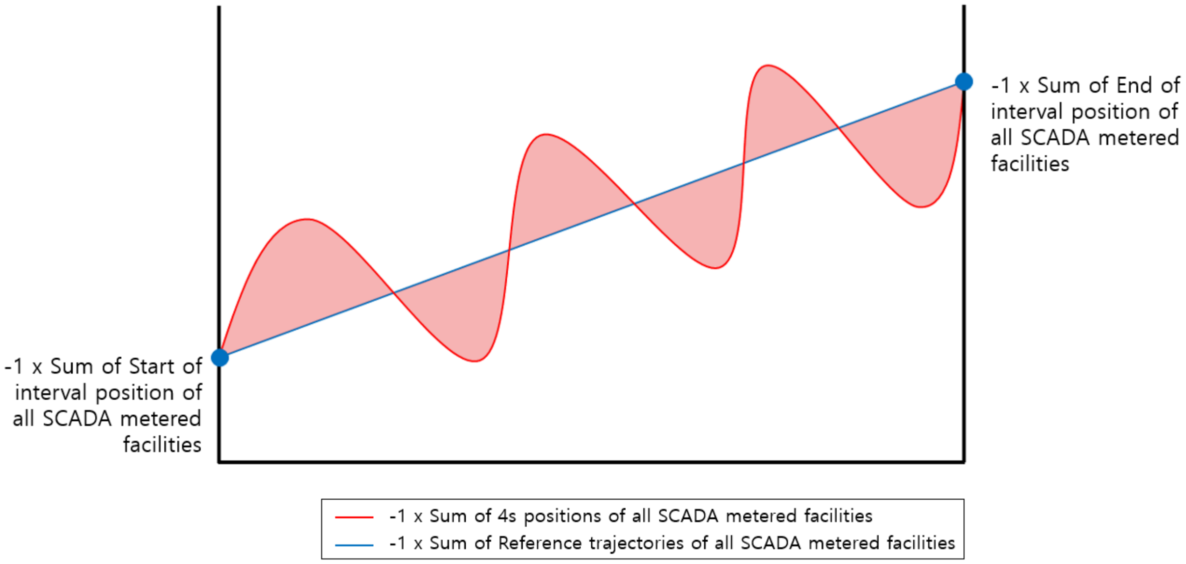


The diagram above shows the reference trajectory and actual output (as measured by SCADA every 4 seconds) of a hypothetical generator. The generator's deviations are represented by the shaded area; the 4 second deviations are summed over the dispatch-interval to measure the generator's deviation over the dispatch-interval. The deviations of generators providing regulation reserves are adjusted to ensure they are not penalised for deviating from their reference trajectories when they are providing a regulation response (i.e., moving up or down in response to the Automatic Generation Control (AGC) signal).

One of the largest contributors to intra-interval volatility are small loads that do not have SCADA monitoring. This means that the performance of these loads cannot be directly measured. However, with a balanced frequency, total generation should equal total load, so we can infer the behaviour of all loads (and generators) that do not have SCADA metering as the residual of the SCADA measured facilities. That is, the deviations of the "residual" group of non-metered loads and generators (facilities) can be determined as follows (see Figure 3):

- The 4 second position of all non-metered facilities can be estimated by multiplying the sum of the 4 second positions of all SCADA metered facilities by negative one.
- The reference trajectory of all non-metered facilities can be estimated by multiplying the sum of the reference trajectories of all SCADA metered facilities by negative one.

Figure 3: Inferred reference trajectory and intra-interval consumption of "residual" group comprising loads without SCADA metering



Five-minute deviations are therefore calculated individually for all SCADA metered facilities and inferred for the residual group (which comprises multiple loads and generators).

Contribution factors are calculated by normalising the five-minute deviations (so that contributions of all SCADA metered facilities and the residual group sum to one). Regulation reserve costs are then allocated to these groups in proportion to their contribution factors. The cost allocated to the residual group is allocated to the retailers who serve the loads in the residual group in proportion to their consumption.

The rationale behind the above methodology is that linking cost allocation to deviation from a hypothetical linear ramp will incentivize causers to maintain output or consumption as close to their reference trajectories as possible – thereby alleviating the need to activate regulation reserves.

VARIANTS OF CONTRIBUTION BASED METHOD

Only two markets use causer-pays approaches to recovering regulation reserve costs. Both markets are in Australia which has been at the forefront of the Energy Transition.

While both approaches use the concept of intra-interval variation to measure contribution to the regulation reserve requirements, there are some interesting differences.

National Electricity Market (NEM, Eastern Australia)

The NEM has a contribution-based approach to allocating regulation reserves costs which has recently been amended to address perceived flaws in the original approach.

Key features of the new NEM approach include the following:

- Contribution factors are weighted by the total deviation from 50Hz for each 4 second sub-interval within a dispatch-interval. This means that facilities that deviate from their reference trajectories during periods of high deviation end up with higher contribution factors.
- Regulation reserves costs are divided into two buckets:
    - Regulation reserves that were enabled and activated to respond to frequency deviations. These costs are allocated in proportion to contribution factors calculated using causer deviations in the dispatch interval in which the regulation reserves were activated. This directly links the use of regulation reserves to the deviations that occurred during the dispatch interval.
    - Regulation reserves that were enabled but not used. These costs are allocated in proportion to contribution factors calculated using deviations over a historical period.
- The NEM approach is "double-sided". To incentivize participants to "help" system frequency, participants with positive factors (i.e. deviations are in the same direction as the regulation requirement) are paid an incentive payment that is be recovered from participants with negative factors (i.e. deviations are in the opposite direction to the regulation requirement).

Wholesale Electricity Market (WEM, Western Australia)

The WEM currently uses a non-causer pays approach to allocating regulation reserves costs where costs are allocated only to intermittent generators, non-scheduled generators and loads in proportion to their metered generation or consumption. This cost-share does not accurately reflect each causer's contribution to the requirement. The only way for a participant to reduce its cost share is to reduce generation or consumption which will not necessarily affect the quantity of regulation reserves enabled or activated.

For this reason, the WEM is implementing an enhanced contribution-based approach to allocating regulation reserves costs from October 2025.

The WEM approach is significantly less complex than the NEM approach (noting that the WEM is a much smaller market that is not interconnected with other states). Particularly:

- The WEM approach is one-sided and allocates the total cost of regulation reserves (enabled) to all causers (i.e., all generators and loads) in proportion to contribution factors calculated using deviations in the dispatch interval in which the regulation reserves were enabled.
- Individual deviations are not weighted by total frequency deviations.
- Reference trajectories are adjusted to take into account droop response of generators to ensure that generators are not penalised for deviations attributable to droop response.

LESSONS FROM THE AUSTRALIAN EXPERIENCE

Method must enable causer to infer behaviour needed to reduce cost share

As previously noted, contribution factor methods for allocating regulation reserves can be highly complex. At the same time, the method must enable a causer to infer what behaviour is needed for them to reduce their cost share.

Under the previous NEM contribution factor-based method, monthly contribution factors were calculated historically (for the previous month) and applied to regulation reserve costs in the current month. This means that a causer's historical performance was used to allocate costs in the current month which weakens the link between the causer's real-time actions and their effect on regulation reserves dispatch. The new double-sided method addresses this issue by using five-minute factors calculated using causer deviations in the dispatch interval in which the regulation reserves were activated.

The allocation of costs to smaller loads is not strictly causer-based

One of the drawbacks of the WEM and NEM approach is that even though the allocation of costs to the "residual" group comprising small loads without SCADA metering is causer-based, the allocation of costs to the causers within that residual group is not causer-based (as the residual cost is allocated in proportion to metered consumption or generation). A potential alternative could be to allocate costs to the residual causers in proportion to their inter-interval variation in metered consumption or generation (as a proxy measure for volatility).

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Extensive testing needed to tailor approach to individual market

Extensive testing is needed on power system and market data to tailor such an approach to an individual market. Such testing will inform decisions such as:

- The formation of reference trajectories including what the start and end-of-interval positions should be and whether and how trajectories should be adjusted to account for droop.
- Whether less granular contribution factors (e.g., 1 minute, 30 second or 15 second vs 4 seconds) will suffice (as this will reduce the computational intensity of the approach).
- How interconnectors should be treated (in markets with interconnecting regions like the NEM).
- How the approach to allocating costs to the "residual" group (that contributes materially to system volatility) can be made more causer-based.

If you need more information on cost recovery approaches to ancillary services, we'd be happy to help. Please get in touch.

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