Renewables Integration – Market and Product Review, Phase 2

Comments of Beacon Power Corporation on Discussion/Scoping Paper

April 29th, 2011

Beacon Power Corporation (Beacon), a manufacturer and merchant developer of flywheel energy storage plants that provide fast and accurate Regulation Service, appreciates the opportunity to comment on both the April 5th document, ***Discussion and Scoping Paper on Renewable Integration Phase 2*** (Paper), and the April 12th stakeholder meeting about the Proposal.

Beacon Power's flywheels, and other types of Limited Energy Storage Resources (LESRs) like batteries, provide Regulation by rapidly injecting and withdrawing power from the grid to follow moment-by-moment demand and frequency changes. Beacon's flywheel technology can respond with full up or down power less than four seconds after receiving a CAISO control signal. By comparison, the CAISO allows generators in its Ancillary Services (A/S) markets, including the Regulation market, up to 10 minutes (600 seconds) to ramp to full power.

Beacon has strongly supported CAISO efforts to remove barriers that limit the full participation of flywheels and other LESRs in the Regulation markets, including the recent approval by the CAISO Board to establish the Regulation Energy Management (REM) mechanism.[1] The REM will enable LESRs, which can typically hold a charge that can produce energy continuously in one direction for less than an hour, to provide Regulation for an entire hour, and virtually indefinitely, by regular replenishment using the CAISO 5-minute real-time energy market. In addition, in the stakeholder process leading up to Board approval of the REM, Beacon consistently supported revision of the Regulation payment structure to incorporate a "mileage" payment, i.e. a performance payment, based on a resources speed and accuracy of response to the CAISO control signal.

Revising the Regulation compensation structure to include a performance payment will enable the CAISO to procure the resource capabilities it will need in order to integrate significantly greater levels of renewable resources. The CAISO 20% Renewable Portfolio Standard study showed significant need for additional Regulation capacity *and* ramp-rate in order to integrate 20% and 33% renewable resources. As the saying goes, "you get what you pay for". The current Regulation compensation structure does not send market signals to encourage or reward resources for performance that is faster or more accurate than the CAISO's allowable ramp time of 10 minutes. In order to encourage faster ramping capability into the market – through improvements to the Regulation response of existing resources and/or entry by new, fast Regulation resources – the CAISO should structure its Regulation payments to pay for that capability.

Therefore, Beacon Power strongly supports FERC's proposed rules that will require all ISOs/RTOs to adopt a Regulation compensation formula that pays resources based on two components: (1) a uniform capacity payment that includes the marginal regulating resource's opportunity costs (*i.e.*, the amount of megawatts that a resource makes available to provide Regulation); and (2) a performance payment based on the amount of up-and-down movement, in megawatts, the resource accurately provides in response to a control signal. A two-part payment structure will ensure that resources will be compensated commensurate with the amount of service they perform for the system operator. Performance-based payments would also:

[1] Decision on Regulation Energy Management – Motion, 2/3/2011, http://www.caiso.com/2b1a/2b1acd6d20610.pdf

- Encourage all resources to increase the speed and accuracy of their Regulation response and ramping capabilities; and

- Encourage market entry of new, faster-ramping technologies capable of responding nearly instantaneously with precise accuracy to a control signal.

By improving the performance of the Regulation fleet, this structure should reduce the amount of Regulation that must be procured to integrate more intermittent renewable resources, thereby yielding cost savings for consumers.

Thus, Beacon is extremely pleased to see that the CAISO has included Regulation performance-payment provisions in the scope of this latest effort. Beacon continues to strongly support such performance elements in the Regulation payment structure, and our comments below focus on responding to the CAISO's questions in the Paper ("Issues to Consider") related to this topic.

Responses to CAISO questions – capacity payment

- ***Is there a minimum required amount of stored energy for a given interval of time for a storage device to qualify to provide Regulation service?***

  No. This issue was addressed in great detail during the stakeholder process that led to the development of REM, and there is no reason to rehash that issue now.

  REM will allow new storage technologies to provide Regulation energy over a sustained period. The CAISO maintains the resource's state of charge by balancing the energy dispatched from the resource, providing Regulation service with offsetting dispatches through the real-time energy market in subsequent periods.

  By meeting the energy offset through the real-time energy market, the CAISO will ensure that the resource provides the Regulation capacity the CAISO procured over the hour. As long as the resource can provide continuous Regulation service over the hour (e.g., through either its energy storage capacity or participation in REM), the resource should qualify. The existing CAISO "No-Pay" provision will adequately address situations where resources are unable to provide the service for the full hour in real time.

- ***In real-time, should resources awarded to provide Regulation in subsequent intervals be disqualified from providing Regulation in subsequent intervals if the resource's stored energy falls below a minimum energy threshold due to energy releases in previous intervals?***

  No - see above. The resource should be allowed to provide Regulation service as long as the 5-minute energy market can provide replenishment in real time, with No-Pay addressing situations where the resource is unable to provide Regulation in real time, for any reason. Again, this topic was discussed and resolved in the stakeholder process for REM.

Responses to CAISO questions – performance payment with accuracy adjustment

- ***Does the fact that the CAISO procures Regulation up and Regulation down as separate services have an impact on how the CAISO would implement a performance payment?***

  No. Speed and accuracy can still be measured with the CAISO Regulation market structure, by:

- Applying the total MW movements (mileage) in response to the Regulation Up control signal to the Regulation Up mileage payment; and
- Applying the total MW movements in response to the Regulation Down control signal to the Regulation Down mileage payment.

Furthermore, the CAISO can implement an accuracy metric which measures how accurately a resource is hitting its dispatch signal within a tolerance band. If a resource is determined by the accuracy metric to not be following its signal, the CAISO would rescind a portion of the mileage payment received by that resource.

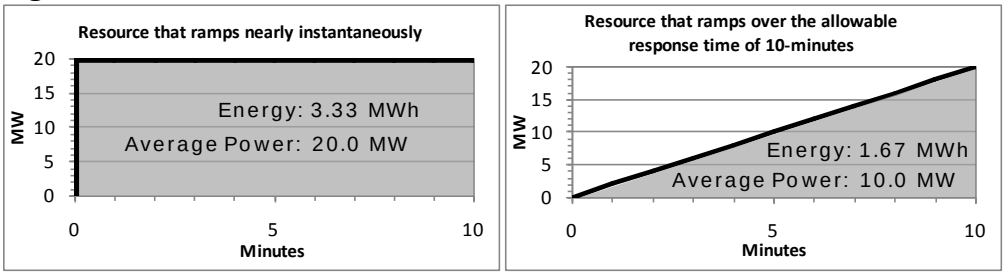
- ***Are there minimum threshold performance standards to be eligible to receive a performance payment?***

No. A properly designed performance component would automatically correct for low performance by reducing the performance payment commensurately.

- ***Is there a correlation between fast ramping and accuracy? For instance, can a single fast ramping regulating resource be more accurate in satisfying ACE correction than several slower ramping regulating resources?***

Faster-ramping resources are capable of providing a greater amount of ACE correction per MW of Regulation capacity than slower-ramping resources, because they can move more quickly to their dispatch target and in turn provide more ACE Correction in real-time. For example, a resource that responds instantaneously and accurately with its full output provides twice the amount of energy over 10 minutes than a resource that takes the allowable 10 minutes to respond. (See Figure 1)

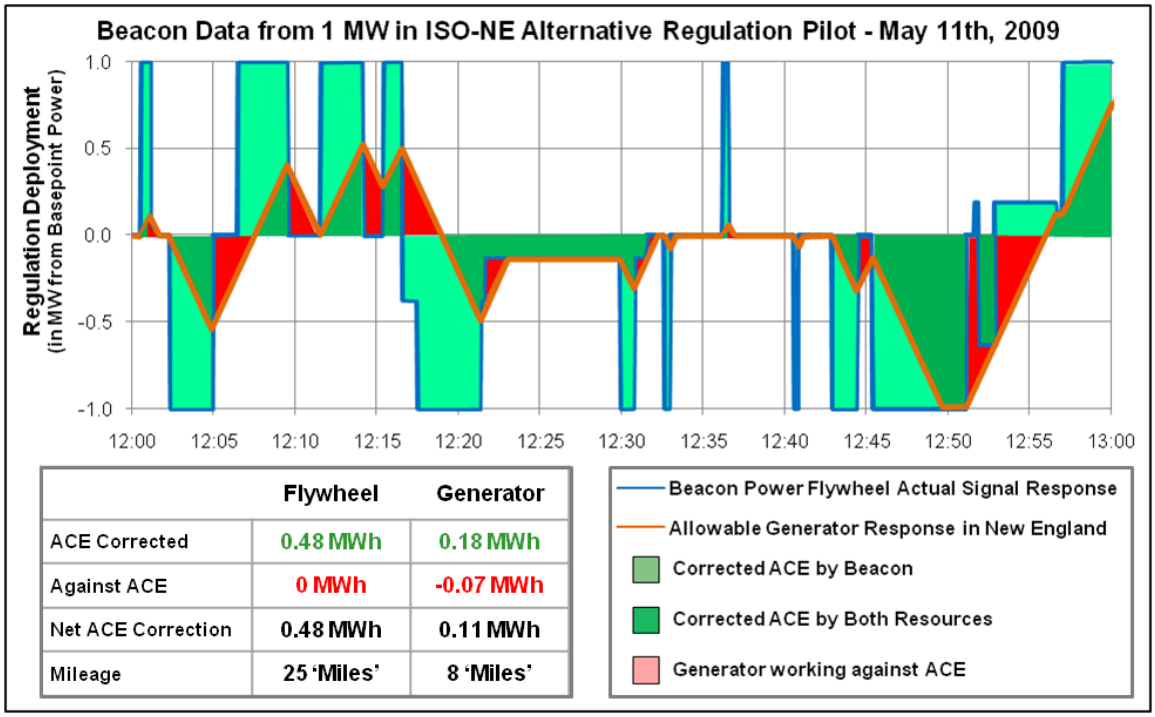
Figure 1



Because the amount of energy that can be provided by fast Regulation resources to correct ACE is much greater per MW of procured capacity than that provided by slower ramping resources, the ISO/RTO can procure less Regulation when using fast-responding Regulation resources to regulate the grid.

Actual data from Beacon Power's operating experience using flywheels to regulate the grid in ISO-NE illustrates the potential reduction in total Regulation procurement that can be achieved by utilizing fast-ramping resources that are capable of rapidly delivering their full power output versus utilizing slow-ramping resources. For example, **Figure 2** below compares the ACE Correction of Beacon Power's 1MW flywheel plant responding nearly instantaneously to ISO-NE control signal sent by ISO-NE with the response that would have been provided by 1 MW of Regulation provided by a resource with a ramp time of 5 minutes, the allowable response time in ISO-NE. Beacon Power's flywheels are capable of delivering their full 1 MW capacity in one four-second AGC cycle.

Figure 2



As demonstrated in Figure 2, while both the flywheel and the slow-ramping resources provide ISO-NE with the same amount of Regulation capacity (*i.e.*, 1 MW), the fast-responding flywheel provided four times as much Regulation value to the grid per MW capacity as the slow resource. Specifically, the data demonstrate that the flywheel provided 0.48 MWh of net ACE correction in this hour, while the slow-ramping resource provided just 0.11 MWh of net ACE correction.

Therefore, if 0.48 MWh of net ACE correction in this hour were desired, the ISO/RTO must procure 4 MW of Regulation capacity from slower-ramping generation resources, compared to just 1 MW of Regulation capacity using fast-ramping flywheels. Thus, in general, using fast-response flywheel storage resources would reduce the amount of Regulation capacity procured to provide a specific amount of ACE correction.

The fast-ramping flywheel is also able to provide more accurate ACE correction, for two reasons:

- **The flywheel can deliver its full Regulation power output within seconds**, while the slow resource takes 5 minutes to deliver the same quantity of power. The flywheel provides more total energy to correct the ACE.
- **The flywheel is always contributing to correcting ACE**, because it can switch directions nearly instantaneously upon receiving a control signal. Conversely, the slow-ramping resource cannot switch directions quickly and thus often provides Regulation in a direction that is counterproductive to the needs of the grid. As a result, the slow-ramping resource actually adds to the ACE, requiring another resource to be dispatched to re-balance the grid. As shown in Figure 2, the slow-ramping resource provided 0.18 MWh of energy in response to the control signal; however, because of its slow-ramping time, 0.07 MWh of this energy worked against the ACE correction.

The fast-ramping resource provided the grid with more Regulation value per MW of Regulation capacity, because it corrected significantly more ACE than the slower ramping resource. This evidence demonstrates that 1 MW of Regulation capacity from a fast-ramping resource can displace more than 1 MW of Regulation capacity from a slow-ramping resource for the same level of system ACE correction.

Thus, the ISO/RTO can procure less Regulation using fast-ramping Regulation resources, which in turn benefits ratepayers. The greater speed and accuracy of response also provides more value to the electric system through improved flexibility to respond to variability on the system.

- ***How would stakeholders define accuracy? Should physical constraints of certain resource types be considered in an accuracy adjustment? For example, a hydro generator, after CAISO issues a "raise" MW command, will lower MW output before moving up to the target level. This is a characteristic of a hydro generator.***

The performance payment for all resources should take the form of a credit for each MW, up or down, provided by the resource in response to the system operator's dispatch signal. Basing the performance payment on the sum of the absolute value of a resource's MW movement up or down in response to a Regulation signal ensures that the payment received by a resource equates to the Regulation value it provided because:

- Resources that can move more quickly to their dispatch target in turn provide more energy to correct ACE;
- Resources that reach their dispatch target faster will be ready for re-dispatch more often, and thus will be ready to provide further Regulation service more quickly,

Resources that can ramp faster are better able to switch directions when ACE reverses direction or system needs change; they thus provide Regulation less often in a direction that is counterproductive to the needs of the grid. The faster a resource can ramp up or down, the more accurately it can respond to the control signal and avoid overshooting ACE correction or system needs. When a resource ramps too slowly, its ramp limitations may cause it to work against system needs, so the system operator must commit additional Regulation resources to compensate. Payments to all resources based on MW movements, up and down, will encourage them to offer as much ramp-rate capability as possible, because they will be compensated for the additional movement (and additional costs incurred) to provide superior performance.

To calculate the performance payment, each resource should be paid a price-per MW movement multiplied by their actual amount of MW movement, up and down, performed over the course of each hour. The price paid for performance should be market-based. Market-based pricing will encourage resources with the lowest costs to provide Regulation movement (ramp-rate) to enter the market and ensure that rate-payers receive the benefit of new low-cost resources competing in the market.

Specifically, CAISO should have a two-part bid structure to select and pay resources to provide Regulation as follows:

- Capacity: The amount of Capacity (MW) it is offering and a price per MW of capacity ($/MW). [In addition, the CAISO would calculate the resource's lost opportunity cost to include in determining the marginal resource's total cost.]
- Performance: The ramp rate in MW/min and a price for each MW of movement ($/MW-movement).

A two-part bid makes, because the underlying costs for making capacity available to provide frequency regulation are different from the cost of moving up and down in response to a regulation signal. The cost of making capacity available is primarily tied to the lost opportunity cost of not using the capacity for a different product and the additional fuel cost of operating the unit at a lower operating set-point. The cost for ramping up and down in response to an ISO/RTO control signal is the increased fuel costs of operating in a non-steady state condition, the increased costs of operations and maintenance due to additional 'wear and tear' on the equipment, and potentially the cost of decreased cycle life.

Using each resource's bid-in ramp-rate and total capacity offered, the CAISO can determine, based on its dispatch method, how much movement each resource could provide relative to its capacity offered. (For example, it could determine that a 20 MW resource bidding a 4 MW/min ramp-rate could provide 200 MW of movement that hour, while a 20 MW resource bidding a 300 MW/min ramp rate could provide 900 MW of movement.) Thus, a two-part bid structure will allow the ISO/RTO to assess the additional value that a faster-ramping resource can provide versus a slower-ramping resource per amount of capacity offered, and use that data in its selection algorithm to determine the least-cost set of resources to provide Regulation.

This method of bidding, selecting and compensating resources should also allow the CAISO to send the right market signals for resources to offer a higher amount of capacity and ramp-rate. Since frequency is a function of both the amount of MWs of imbalance there is on the grid *and* the speed in which the imbalance is corrected, it is appropriate to select and compensate Regulation providers based on both the amount of MWs capacity it makes available *and* how quickly it can deliver that capacity in response to a CAISO control signal.

Alternatively, the CAISO could use a single bid to set the price for both the capacity and performance payment, as is done in ISO-NE today, as long as it pays resources commensurate with the service they provide. ISO-NE already has a performance payment mechanism in place today that pays resources based on the amount of MW movement, up and down, that each resource provides in response to control signal, but using a single bid approach ($/MW) to set the clearing-price for both the capacity and performance payment.

The Regulation performance credit is the product of the $/MW clearing price, the unit's Regulation Service megawatts (the sum of the absolute value of up and down movement in response to the ISO's control signal) and the Capacity-to-Service Ratio set at 0.1 (a value calculated by the ISO to based on their finding that the average regulation resource in their market provides 10 MW of movement per 1 MW of capacity). This structure ensures that:

- A resource dispatched to provide an average amount of Regulation movement in the market will have a 50/50 split between its capacity and performance payment;
- A resource dispatched to provide more work (MW-movement) will be paid more than average; and
- A resource dispatched to provide less work (MW-movement) will be paid less than average.

The ISO-NE Regulation market design does not enable it to optimize in real-time between the amount of capacity and amount of performance to select the least-cost portfolio of resources like a two-bid market. However, it clearly sends the right market signals for resources to bid in as high a ramp-rate as possible, because if resources are deployed more to provide regulation they will be compensated for it.

Over time, ISO-NE has been able to administratively lower its average regulation capacity procurement as a percentage of average system load. ISO-NE procured 120 MW of Regulation capacity (0.8% of load) in 2008, 94 MW of Regulation capacity (0.66% of load) in 2009, and 70 MW of Regulation capacity (0.47% of load) in 2010. Moreover, in all three years, ISO-NE procured the least amount of Regulation per average system MW of load than all other ISOs.

Compensating resources to ramp quickly to correct ACE deviations will result in grid operators needing to procure less total Regulation which in turn results in lower market costs for ratepayers. Therefore, the relatively simpler ISO-NE methodology, which uses a single market-clearing price for capacity and performance ,along with an administratively determined capacity-to-service ratio, is clearly a successful methodology for paying for performance.

- ***How might the CAISO apply an accuracy adjustment?***

An accuracy metric should be coupled with a mileage payment, not established in lieu of the mileage payment. This will ensure that compensation for all resources is tied to how well it actually responded to the CAISO's control signal while also ensuring that an accurate, fast resource is appropriately being valued more than an accurate, slow resource.

For example, in Figure 2 above, both the fast and slow resource were accurately following their control signal. However the fast resources provided 25 MW of movement and 0.48 MWh of ACE correction, while the slow resource provided just 8 MW of movement and 0.11 MWh of ACE correction.

Slow resources that respond accurately to slow signals are not as valuable to the grid as are fast resources that respond accurately to fast signals. However, under a compensation model that only differentiates payments to resources based on accuracy, the ISO/RTO would pay the more valuable faster resource the same as the slower resource, thus failing to send an efficient market signal.

In fact, an accuracy-based mechanism only works if an accurate fast resource would be paid more than an accurate slow resource. Therefore, the best approach is to couple a mileage payment with an accuracy performance metric. This will encourage a resource to respond both fast and accurately to a CAISO signal.

An accuracy metric in the performance payment that measures how well a resource hits its dispatch target within a tolerance band will encourage resources to accurately respond to the CAISO control signal, and thus ensure that the mileage payment is truly tied to the actual service provided. If a resource is determined by the accuracy metric to not be following its signal, the CAISO could rescind a portion of the mileage payment received by that resource.

NYISO's performance index[2] is a good example of an accuracy metric that could be coupled with a mileage payment. The accuracy metric measures how well a resource hits its dispatch target within a tolerance band every 30 seconds and then calculates a percentage accuracy every 5 minutes which is applied to the resources Regulation compensation. The performance index provides that resources performing at greater than 90% of their expected response not receive a accuracy adjustment less than 100%.

[2] New York Independent System Operator Accounting and Billing Manual , Manual 14, Revision Date 12/17/2010, Version 2.0, http://www.nyiso.com/public/webdocs/documents/manuals/administrative/acctbillmnl.pdf

However, the 30-second snapshot of accuracy is too slow to capture the accuracy of a fast-ramping storage resource that can dramatically change its output each 4-second AGC cycle. Any accuracy metric must be capable of measuring performance each AGC dispatch cycle and account for any latency in the CAISO's dispatch software.

Response to the CAISO questions – Net Energy:

Both net-energy and performance payments are necessary components of an appropriate Regulation compensation structure. Regulation resources should be paid for both their capacity and performance (using the market design approach recommended above) *and* should either be paid (or pay) for the net Energy they inject or withdraw at the wholesale LMP. Regulation is a separate market product from Energy. This issue was heavily discussed during the REM initiative, and the CAISO should retain the energy settlement rules approved in the REM initiative.

Energy settlements also provide desirable incentives for efficiency – a storage device with low conversion losses would pay less for net energy than a device with high losses. Therefore, Beacon Power respectfully recommends maintaining separate Energy settlements and Regulation payments.

Payment for Performance is a High Priority Topic:

The CAISO should consider the revision of its Regulation compensation to include a capacity payment and performance payment as a high priority for the RI-MPR Phase II initiative.

As discussed above, the CAISO 20% Renewable Portfolio Standard study showed **significant** need for additional Regulation capacity *and* ramp-rate in order to integrate 20% and 33% renewable resources. For example the maximum Regulation Up requirement for summer in 2006, 2012, and 2020 is expected to be 278 MW, 455 MW, and 1444 MW, respectively. Similarly, the maximum Regulation Up ramp-rate for summer in 2006, 2012, and 2020 is expected to be 75 MW/min, 118 MW/min, and 528 MW/min, respectively.

In order to encourage faster ramping capability into the market – through improvements to the Regulation response of existing resources and/or entry by new, fast Regulation resources – then it should structure its Regulation payments to pay for that capability. Improving the performance of the Regulation fleet, should reduce or eliminate the need for the CAISO to increase the ancillary service procurement targets due to intermittent renewable resource penetration, thereby lowering the cost to ratepayers for attaining 20% and 33% renewables on the California grid.