

Renewables Integration – Market and Product Review, Phase 2
Comments of Beacon Power Corporation on Revised Straw Proposal
September 12th, 2011

Beacon Power Corporation (Beacon) — appreciates the opportunity to comment on the CAISO’s August 29th “*Revised Straw Proposal – Market Vision & Roadmap/Day-of-Market*” (“Proposal”) and the discussion at the September 12th stakeholder meeting about the Proposal.

The Proposal is part of the CAISO’s Renewables Integration - Market and Product Review, Phase 2 (“RI-MPR2”) initiative and contains: (1) proposed enhancements to the CAISO Market; and (2) a stated intention to develop a longer-term “vision” and “roadmap” for forward-market enhancements in the future.

Beacon is a manufacturer and merchant developer of flywheel energy storage plants that provide fast and accurate Regulation Service. These flywheels, and other types of Limited Energy Storage Resources (“LESRs”) like batteries, provide Regulation by rapidly injecting into and withdrawing power from the grid to follow moment-by-moment demand and frequency changes. They can respond with full up or down power less than four seconds after receiving a CAISO control signal; by comparison, generators in the CAISO’s current Ancillary Services (“A/S”) markets (including the Regulation market) can take up to 10 minutes (600 seconds) to ramp to full power.

The prior Proposal contained both significant Regulation-market reforms to take advantage of fast LESR capability and a proposed new Real Time Imbalance Service (RTIS) to help address 1-5 minute ramping needs. It assumed that faster resources would gravitate to a reformed Regulation market and that slower resources would gravitate to RTIS. Both services would have included “pay-for-performance features,” to encourage all resources to perform faster and more accurately than the allowable 10-minute ramp time.

Beacon’s comments supported this dual-market approach to managing expected increased future system variability. We further encouraged the CAISO to take advantage of faster-ramping LESR capability by improving the quality of its Regulation dispatch signal to more closely follow second-by-second system needs, instead of the current damped signal designed for slower-ramping resources.

The current Proposal version replaces the RTIS proposal with a new Flexiramp Product, described extensively. Similar to its comments on the earlier RTIS service, Beacon supports creation of the Flexiramp Product for slower-moving resources. However, Beacon is concerned about the lack of focus in the new Proposal on the Regulation market. CAISO studies of system operations at both 20% and 33% Renewable Portfolio Standard (RPS) levels have identified the need for large increases in both Regulation and ramping capability to integrate Variable Energy Resources (VERs), but Regulation is barely mentioned in the new Proposal. Furthermore, of most concern, there is no longer any mention in the Proposal of “pay-for-performance” regulation compensation.

While Beacon was pleased that the CAISO clarified at the stakeholder meeting that Regulation “pay-for-performance” features were still included in the RI-MPR2 initiative, this important element must be included in the Roadmap & Vision document. We therefore highly recommend the CAISO include this feature in its next version of the Proposal.

“Pay-for-performance” features

The Proposal states: “The ISO’s integration studies have provided important insights into the operational requirements to maintain reliability with high levels of participation by wind and solar resources, and recent market product enhancements have provided the means for new technology types to participate in the ISO’s spot markets. *Yet more work remains to be done.*” Beacon strongly agrees. While the Regulation Energy Management (“REM”) mechanism which is scheduled to be implemented in the Spring 2012 is a necessary market enhancement to remove barriers to fast-ramping limited energy resources providing Regulation, it will not in itself send sufficient price signals to encourage fast-ramping Regulation resources into the market.

The CAISO has identified significant need for more Regulation and ramping capability. In order to attract new fast-ramping regulation technologies into the market the CAISO must change its regulation compensation structure. Beacon Power *strongly* supports the proposed payment structure in the prior Proposal to compensate Regulation resources based on capacity, mileage, and an accuracy adjustment.¹ This type of payment structure would compensate resources commensurate with the amount of service they perform for the system operator. Performance-based payments would also promote improved market performance, i.e.:

- **Encourage all resources to increase their ramping capabilities** and the speed and accuracy of their response; 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 capacity that must be procured to integrate VERs, with cost savings to consumers. (The Proposal clearly states, at p.15, that CAISO expects Regulation procurement targets to increase with additional VERs.) Furthermore, structuring payments into two-components (capacity and mileage) will better reflect supplier costs, i.e.:

- **Capacity costs**, the opportunity cost of making capacity available to provide Regulation—primarily, the lost revenue for not using the capacity for a different product and the additional fuel cost of operating the unit at a lower operating set-point; and
- **Mileage costs**, the additional fuel cost of operating the unit at a lower operating set-point and moving up/down in response to a Regulation signal – increased fuel costs of operating in a non-steady state condition, increased O&M due to additional ‘wear and tear’ on the equipment, and potentially the cost of decreased cycle life.

At the September 12th meeting, the CAISO seemed reluctant to move forward with such Regulation market reforms pending receipt of further guidance from the current FERC NOPR. Instead, the CAISO should proceed with the redesign of the Regulation payment structure and dispatch signal, regardless of the outcome of the FERC NOPR.

These are common-sense reforms needed for CAISO management of increased VER penetration that have been approved by FERC for other systems. Even if not required by FERC, the CAISO should pursue these changes under the flexibility afforded under “independent entity” FERC rules.

¹ Compensating Regulation resources based on capacity, mileage, and an accuracy adjustment was proposed by FERC in *Order on Notice of Proposed Rulemaking re Frequency Regulation Compensation in the Organized Wholesale Power Markets*, Docket Nos. RM11-7-000; AD10-11-000, 134 FERC ¶ 61,124 (October 2011) (“Frequency Regulation NOPR”).

Beacon strongly urges the CAISO not to allow the NOPR to slow down the CAISO reform process. The CAISO should proceed with Regulation compensation reform in 2012 and (in parallel with its Flexiramp Product effort) implement appropriate market changes later in the year or, at the latest, very early in 2013.

It is not necessary to wait for a ruling from FERC on this NOPR, as PJM has demonstrated. PJM has already begun to move forward with a proposal similar to the CAISO's Initial Straw Proposal. The PJM proposal was developed in its Regulation Performance Senior Task Force meetings that have been convening since April 7th, 2011, and has already been presented to the PJM Markets and Reliability Committee (MRC)².

PJM's proposal, like the CAISO's initial proposal, includes a Capacity payment, Mileage Payment, and Accuracy adjustment³. The PJM proposal also incorporates resource performance into the resource Regulation qualification, market clearing and settlements processes. Beacon Power highly recommends that CAISO review PJM's proposal as guidance for its own pay-for-performance market design.

Additional comments on Regulation changes and new Flexiramp Product

Creation of new Flexiramp Product: As noted before with respect to RTIS, Regulation is better suited for fast-ramping units, and the Flexiramp Product is better suited for slower-ramping units, especially if the market change is accompanied by a faster-moving Regulation signal that utilizes the capabilities of LESRs and other fast-ramping resources (see below). A separate service for slower-ramping resources will benefit both types of resources and, more importantly, result in operational efficiencies for the grid.

As with the initial RTIS service proposal, the CAISO should operate the Flexiramp Product to set Regulation resources back to their "null point," even if it procures separate Flexiramp Up and Flexiramp Down products. This would result in a Regulation dispatch that would tend to be energy-neutral, making the reformed Regulation service well-suited for many storage and demand response technologies and thus likely broadening the mix of resources participating in the Regulation market.

Bi-directional Regulation product: In its prior Proposal, the CAISO proposed to change Regulation to a bi-directional service. Beacon Power supports either a bi-directional or single directional regulation market.

Regulation dispatch signal: As noted in our prior comments, the current CAISO Regulation dispatch signal does not take advantage of LESR and other fast-response resource capabilities, because it: (1) damps the rapidly moving, instantaneous ACE to minimize generator movement and directional change; and (2) further slows overall response by "allocating" the dispatch instruction pro rata (based on MWs of Regulation capacity) to all the generators providing the service, regardless of their response speed, instead of prioritizing the dispatch to resources that can respond the fastest (as is done in other markets, such as ISO-NE).

² <http://www.pjm.com/~media/committees-groups/committees/mrc/20110915/20110915-item-13-rpstf-update-presentation.ashx>

³ <http://www.pjm.com/~media/committees-groups/task-forces/rpstf/20110902/20110902-item-02-rpstf-performance-plan-phase-1-and-2.ashx>

Beacon Power continues to recommend that the CAISO dispatch fast-ramping storage resources to take advantage of their near instantaneous ability to respond to a control signal. Utilizing the fast response capability will provide the greatest cost and reliability benefits to the grid. (Please see Appendix A.)

Proposed schedule and timeline

Beacon applauds the CAISO's stated intent to fully utilize the capability of fast-ramping technologies and to implement pay-for-performance. However, we continue to be concerned about the length of time to implement these changes (i.e., 2013-2015 timeframe).

As discussed above, the CAISO 20% RPS study showed significant need for additional Regulation capacity and ramp-rate to integrate 20% and 33% renewable resources. For example, the maximum Regulation Up requirements estimated for summer 2006, 2012, and 2020 were 278 MW, 455 MW, and 1444 MW, respectively. Similarly, the maximum Regulation Up ramp-rates estimated for summer 2006, 2012, and 2020 were 75 MW/min, 118 MW/min, and 528 MW/min, respectively.

To encourage faster ramping capability in the market – through improvements to the Regulation response of existing resources and/or entry by new, fast Regulation resources – the CAISO should not postpone all Regulation reform efforts until after the FERC issues an order in the NOPR. Instead, the CAISO should proceed with the design of the proposed new Regulation payment structure and dispatch signal as soon as possible, make any adjustments that seem warranted after a decision in the FERC NOPR. This least-regrets action would do the following:

- ***Send the necessary market signals*** to encourage investment in new storage resources that can provide critically needed renewable integration services.
- ***Reduce or eliminate the need for increased CAISO Regulation procurement*** due to higher VER penetration, thereby lowering the cost to ratepayers to attain 20% and 33% renewables on the California grid.

Postponing design and implementation of the new Regulation design until 2013-2015 will significantly delay investment in new storage technologies that are “grid-ready” and operating in other regions of the country today.

Other potential products and issues

Automatic Unit Response: Beacon Power supports the earlier CAISO proposal to create a product for Inertia and Frequency Response. The Energy, Ancillary Services, and Unit Commitment markets may not provide enough natural Frequency Response and Inertia to accommodate the integration of variable energy resources. Moreover, it may be difficult and/or costly for VERs to acquire the ability to provide primary frequency response.

The primary source of frequency response today is generation. However, generation-based frequency response can only be provided by a subset of the generation fleet, and only when the generation is operating and below its maximum output.

A new market product would allow the CAISO to procure Inertia and Frequency response from other resources, such as flywheel energy storage, that can provide synthetic inertia and primary frequency control. Storage provides a very fast and proportionate response and could always be

available because it does not require an underlying amount of generation or load.⁴ This would greatly expand the pool of resources available for this critical reliability function.

Long-term ramping product: The current Proposal raises the possibility that the CAISO might establish a forward market for capacity-resource (ramping) procurement through long-term contracts. The CAISO said that “a design solution must be finalized and vetted by 2012/2013” to allow for implementation in the 2015-2020 timeframe; thus, it plans to initiate later this year a separate effort to consider and design this element, with a framework finalized in 2012.

It is difficult to comment on this proposal without more details. However, the CAISO should ensure that any new market product for this service is technology-neutral, i.e., open to all supply- and demand-side technologies that could provide it.

⁴ Flywheels’ capability to provide frequency response was proven as part of the Beacon Power’s demonstration program conducted within the New York ISO in 2006.

APPENDIX A

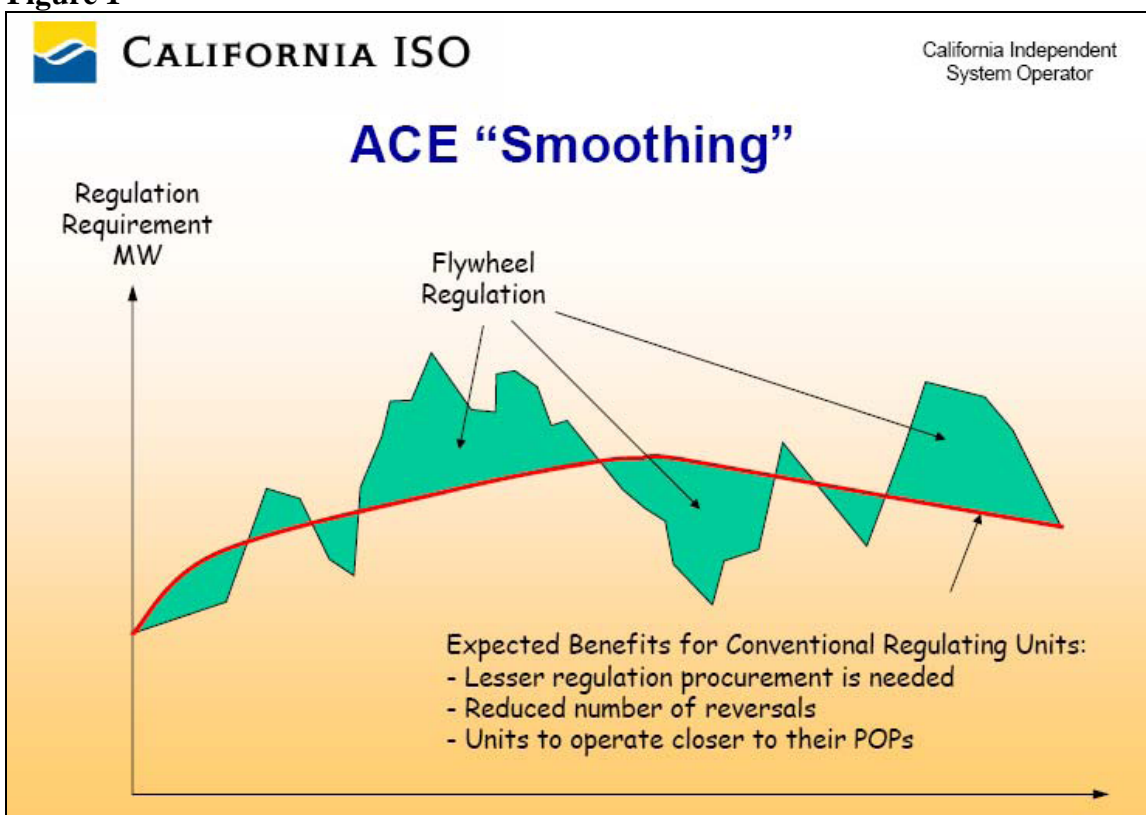
CAISO ACE Smoothing Dispatch

In 2005, in conjunction with Beacon Power and the California Energy Commission (CEC), the CAISO developed a new dispatch algorithm to take advantage of flywheels' fast response capability.

Most regulation dispatching algorithms intentionally damp the rapidly moving instantaneous ACE, so the participating generators movement and directional changes are minimized. During the flywheel technology demonstration project, the CAISO developed a new algorithm, called ACE Smoothing, to maximize the benefit of these fast moving resources to the ISO.

The ACE Smoothing dispatch mechanism divides the work of correcting the ACE into two distinct roles: 1) conventional generation (ramping in the 5-10 MW/min range) provides the corrective action necessary to correct imbalances that occur over tens of minutes; and 2) fast responding resources (ramping in the 100's MW/min range) provide the corrective actions required to react to instantaneous changes in ACE. Figure 1, taken from a February 2005 CAISO presentation to the CEC, shows graphically the goal of correcting the majority of the ACE with fast-responding resources and leaving an easier task of following the slower signal to the slow responding resources.

Figure 1



The signal given to the slower ramping units is derived from a rolling average of the ACE (Equation 1). This slower signal is easier to follow and cycles less frequently, so those generators could run at a lower heat rate⁵ and incur lower operating and maintenance costs. When a slow-ramping unit follows a fast signal and does not control accurately, that inaccurate control creates the need for even more control actions. This is known as over-control. Allowing slow-ramping units to react to the slow portion, or smoothed portion, of the ACE limits the amount of over-control, allows for the system to be more effective and uses less Regulation to provide the same level of reliability.

Equation 1:

$$ACE\ Smoothing\ Slow\ Signal = ACE_m \times MW_{capacity_i} / MW_{capacity_{total}}$$

Where

ACE_m = 10 minute rolling average of ACE

$MW_{capacity_i}$ = the Regulation capacity of the conventional regulation resource i

$MW_{capacity_{total}}$ = the total Regulation capacity of all the conventional regulation resources

The signal to the faster ramping units is the difference between the instantaneous ACE and the rolling average (Equation 2). This part of the signal changes direction very often, taking advantage of those resources' ability to ramp quickly and limiting the amount of energy necessary to provide this service. The fast signal also tends to be energy-neutral, because it does not contain any of the ACE long-term trends. All these properties combined make the fast portion of ACE Smoothing ideal for Energy Storage, V2G, or SmartGrid applications.

Equation 2:

$$ACE\ Smoothing\ Fast\ Signal = (ACE_m - ACE) \times MW_{capacity_i} / MW_{capacity_{total}}$$

Where

ACE_m = 10 minute rolling average of ACE

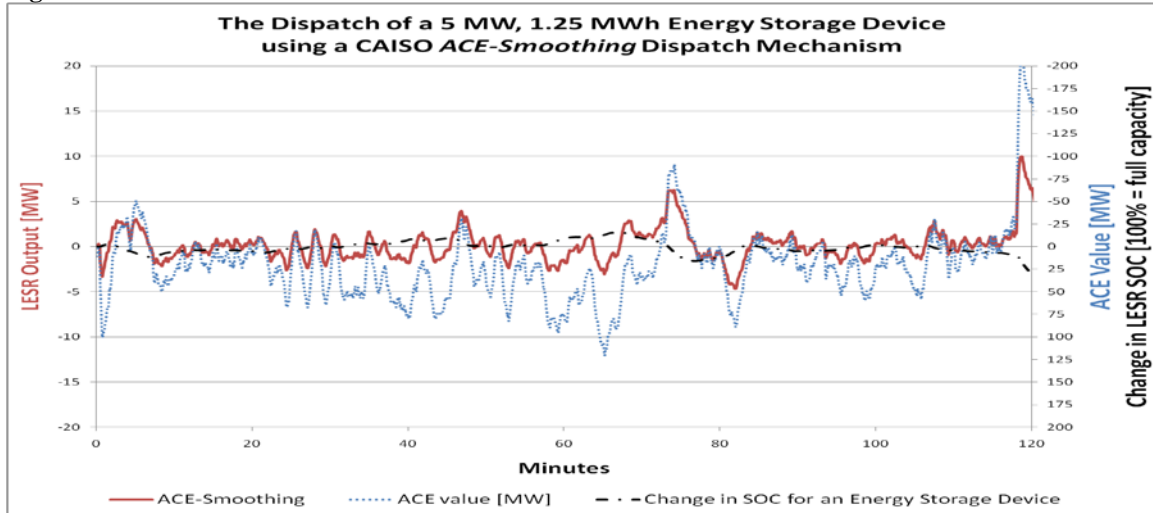
ACE = Instantaneous Area Control Error

$MW_{capacity_i}$ = the Regulation capacity of the fast responding resource i

$MW_{capacity_{total}}$ = the total Regulation capacity of all the fast responding resources

Figure 2 shows ACE data, the resulting fast signal from the ACE Smoothing dispatch method, and the change in LESR SOC responding to the dispatch. Note that the change in SOC is less than 25%, i.e., the resource has more than sufficient energy storage capacity to provide this service. The signal is well-matched to this resource's characteristics with respect to ramp rate and energy duration.

Figure 2



⁵ Heat rate is the number of British Thermal Units of Fuel that is used to produce one kWh of electricity

Our CAISO demonstration also developed an easy solution to the current problem of inability to send a negative signal to participants. This problem was resolved by CAISO sending raw signal data to Beacon that was scaled on a 0 to 65000 counts basis, where 0 to 32500 counts equaled minus full scale output to zero output, and 32500 to 65000 counts equaled zero output to full scale output.

The final results⁶ produced by the CAISO suggested that combined approach of the ACE Smoothing algorithm provided twice the regulation benefit of traditional AGC resources driven by traditional dispatching algorithms.

ACE Smoothing Advantages for the Grid

- Less Regulation Procurement
- More effective and tighter control – reduces amount of over-control
- Fewer emissions associated with Regulation

ACE Smoothing Advantages for Energy Storage, V2G, SmartGrid

- Takes advantage of the ramp capabilities
- Energy neutral signal increase utilization of the resource's capacity

ACE Smoothing Advantages for Ramp-Limited Resources

- Allows generation to cycle less frequently and operate closer to their preferred operating point
- Less O&M for Generators

⁶ California Energy Commission. (2007, January 10th). *News Releases*. Retrieved February 2nd, 2009, from California Energy Commission: http://www.energy.ca.gov/releases/2007_releases/2007-01-10_Beacon_Power.html