Renewables Integration – Market and Product Review, Phase 2
Comments of Beacon Power Corporation on Market Vision & Roadmap
October 21st, 2011

Beacon Power Corporation (Beacon) appreciates the opportunity to comment on the CAISO's October 11th **"Market Vision & Roadmap"** ("Proposal") and the discussion on the October 18th stakeholder conference call about the Proposal.

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 Proposal is part of the CAISO's Renewables Integration - Market and Product Review, Phase 2 ("RI-MPR2") initiative. The Proposal has been revamped to focus mainly on specific "mid-term" (2013-2015) initiatives. One of these initiatives is "Pay for Performance [PFP] Regulation."

CAISO studies have identified the need for significantly more Regulation and ramping capability to manage higher levels of Variable Energy Resources (VERs). The CAISO is already planning to implement Regulation Energy Management (REM) in Spring 2012, which will enable the participation of new fast-response storage technologies in CAISO's Regulation markets. REM is identified in the Proposal as a "short-term" (now through 2013) initiative; it would use the five-minute Imbalance Energy market to replenish LESRs and enable them to offer continuous Regulation service.

While the Regulation Energy Management ("REM") mechanism 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 to enter the market. In order to attract new fast-ramping regulation technologies to help with VER integration, the CAISO must change its regulation compensation structure to incentivize and compensate for performance, through implementation of PFP Regulation.

PFP Regulation would implement this change, continuing the removal of barriers to LESR participation in CAISO Regulation markets. It would pay Regulation resources based on the extent of their response to the Regulation Automatic Generation Control (AGC) signal from the CAISO's Energy Management System (EMS). 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;

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

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 does not contain any details about the content or schedule of this initiative. It stated only that the CAISO would defer action until receipt of FERC guidance in a ruling on a February 17th Notice of Proposed Rulemaking (NOPR) (Docket Nos. RM11-7-000 and AD10-11-000).

FERC issued that order (Order No. 755) on October 20th. The Order finds that the current ISO/RTO payment structures for Regulation are "unduly discriminatory and preferential" and that changes are required for them to become just and reasonable. Specifically, RTOs and ISOs must compensate Regulation resources "based on the actual service provided", including:

- **A capacity payment** (uniform for all resources providing the service) that includes the marginal unit's opportunity costs, intended to cover the costs to "[keep] a resource's capacity in reserve" to provide Regulation. (Order at pp. 3 and 107); and
- **A performance payment** ("market-based") that reflects: (1) the quantity of Regulation provided by a resource in response to the dispatch signal ("mileage"); and (2) the accuracy with which each resource responds to the Regulation dispatch signal. (Order at pp. 3 and 108)

The order is effective 60 days from the issuance date. Compliance filings are due 120 days from the Effective Date and implementation must take place no later than 180 days later.

Thus, the CAISO must implement the Order within one year, i.e., in October 2012 (i.e., in the CAISO's regular Fall 2012 software release), which effectively converts this initiative into a short-term initiative. Beacon strongly supports this timing, because 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.

Thus, the next version of the CAISO Proposal should include a plan to fully develop, file, and implement PFP Regulation within the required timeframe. Beacon has provided the CAISO with considerable information in its comments in this initiative on how a two-part Regulation payment framework could be structured, and we urge the CAISO to review this material in crafting its design, compliance filing, and eventual tariff filing.

Beacon recommends that the CAISO also take this opportunity to also consider implementing changes to the Regulation signal to send faster signals to fast-ramping resources that fully take advantage of their capabilities, e.g., through the "ACE Smoothing" method discussed in the Appendix of our last comment submittal (and, for the convenience of the reader, repeated in the Appendix of this document).

APPENDIX A

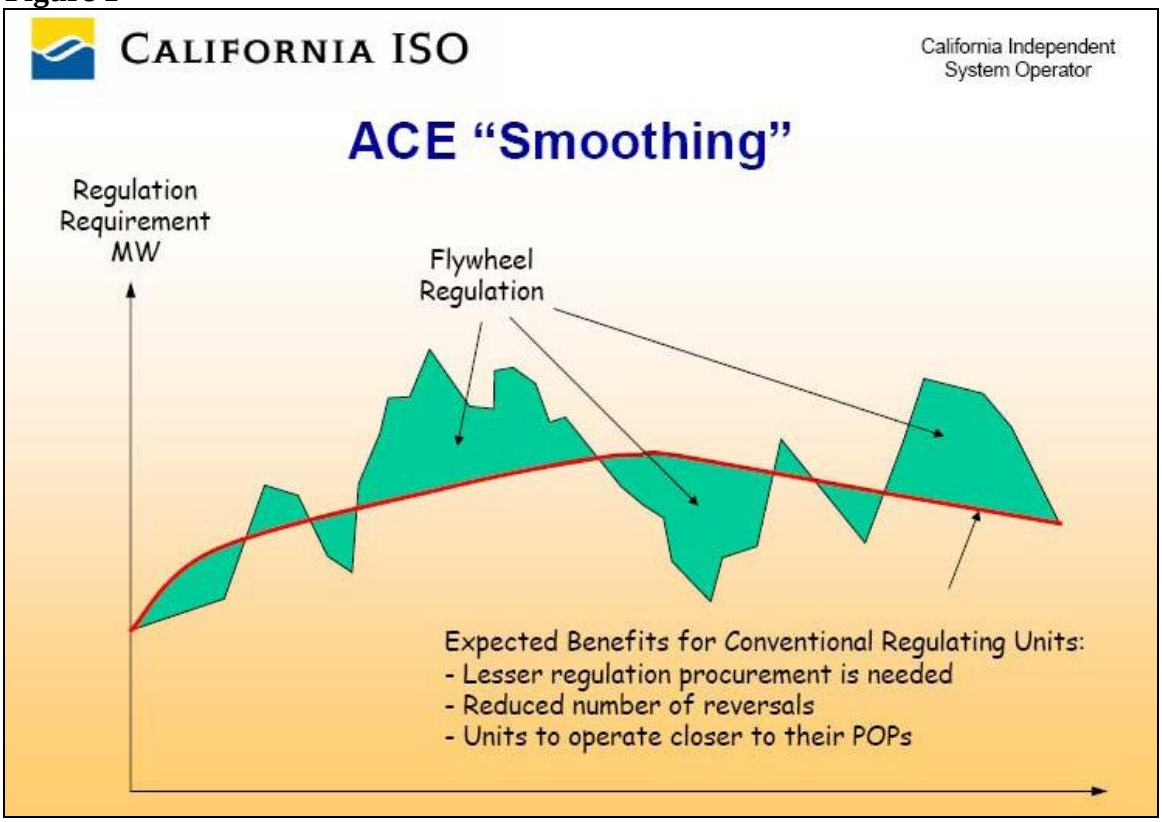
CAISO ACE Smoothing Dispatch (repeat of submittal with last Beacon comments)

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 rate[1] 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

$ACE_m\ = 10\ minute\ rolling\ average\ of\ ACE$

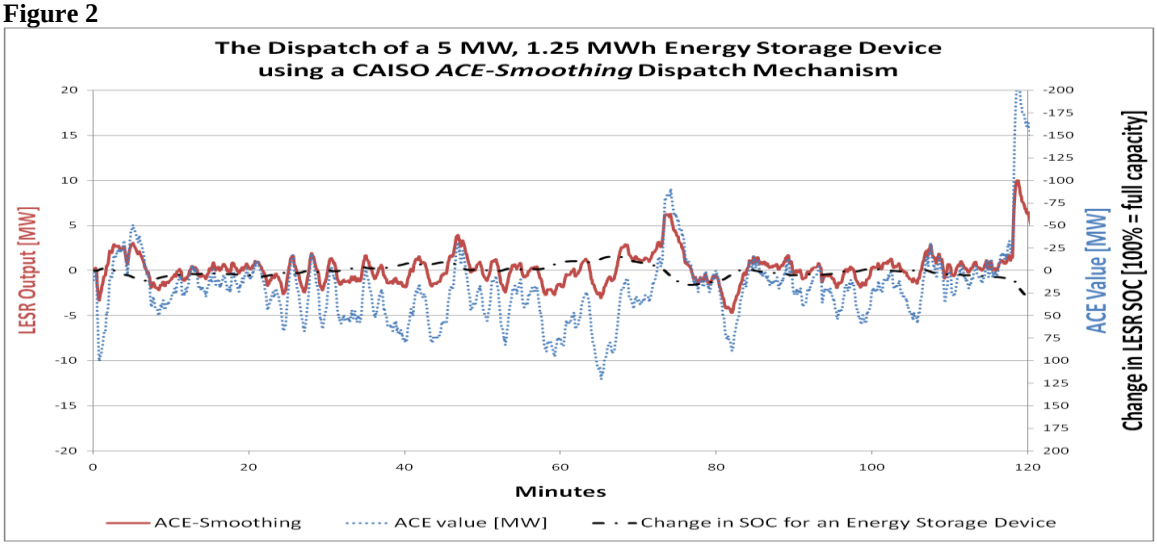
$ACE\ =\ Instantaneous\ Area\ Control\ Error$

$MW_{capacity_i}\ =$ 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



[1] 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 results[2] 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

[2] 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