Opportunity Cost of Flexible Ramping Constraint

Draft Final Proposal

July 20, 2011

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1 Introduction

The ISO will be implementing a new flexible ramping constraint in the market optimization for the real-time unit commitment or pre-dispatch process (RTPD), and the real time dispatch (RTD) process. This constraint is necessary to address certain reliability and operational issues observed in the ISO's operation of the grid. The ISO has observed that in certain situations reserves and regulation service procured in the real-time and units committed for energy in the fifteen unit commitment process (RTPD) lack sufficient ramping capability and flexibility to meet conditions in the five minute market interval during which conditions may have changed from the assumptions made during the prior procurement procedures.

The enforcement of the flexible ramping constraint in the RTPD can give rise to opportunity costs for resources that are committed to resolve the flexible ramping constraint. In RTPD, a resource specific opportunity cost can result if the resource is not awarded incremental ancillary services or committed incremental energy. The ISO proposes to compensate all resources that resolve the flexible ramping constraint at the shadow price of the constraint. The flexible ramping constraint shadow price is the marginal unit's resource specific opportunity cost. The ISO further proposes that the costs of the flexible ramping constraint be allocated to measured demand, which consists of metered load and exports.

2 Changes from Straw Proposal

The ISO no longer proposes to implement the flexible ramping constraint in the market optimization for the Residual Unit Commitment (RUC) in the day-ahead market. Many stakeholders questioned the need to include the constraint in RUC given that the primary objective of the flexible ramping constraint is to ensure sufficient flexibility between RTPD and RTD.

3 Plan for Stakeholder Engagement

Item	Date
Post Draft Final Proposal	July 20, 2011
Stakeholder Conference Call	July 27, 2011
Stakeholder Comments Due	August 3, 2011
Board Meeting	August 24-25, 2011

4 Overview

The ISO will be implementing a new flexible ramping constraint in the market optimization for the real-time unit commitment or pre-dispatch process (RTPD), and the real time dispatch (RTD) process. This new constraint is necessary to address certain reliability and operational issues observed in the ISO's operation of the grid. The ISO has observed that in certain situations reserves and regulation service procured in the real-time (RTPD and HASP) and units committed for energy in the fifteen unit commitment process (RTPD) lack sufficient ramping capability and flexibility to meet conditions in the five minute market interval during which conditions may have changed from the assumptions made during the prior procurement procedures. While the flexible ramping constraint can also be enforced to ensure sufficient downward ramping capability of dispatchable resources, the ISO plans to only implement the constraint to ensure sufficient upward ramping capability at this time.

The ISO's real-time procedures are designed to ensure sufficient capacity is committed to allow for efficient and economic load following during each five minute interval. A fundamental goal of the ISO is to commit resources through its market and produce awards, commitments and dispatches that are feasible and reasonably mitigate for unexpected outcomes. As discussed below, the ISO has observed numerous instances in which awards and commitments are rendered infeasible due to load forecast error, generation variability, and intertie changes. These instances pose reliability concerns because to the degree the ISO must re-dispatch resources in the real-time and there is insufficient committed resource flexibility, the ISO may be drawing on operating reserves, regulation, or on the interconnection. This issue can be addressed in part by the adoption of the flexible ramping constraint, which is designed to ensure that sufficient upward capability of dispatchable resources is committed to enable the real-time dispatch (RTD) to follow load efficiently and reliably over an estimated range of potential variability of net load around the load forecast.

Under the flexible ramping constraint, unit commitment and dispatch will ensure the availability of a pre-specified quantity of upward five-minute dispatch capability. This capability will be provided by committed flexible resources not designated to provide regulation or contingency reserves (spinning and non-spinning reserves) and whose upward capacity is not committed for load forecast needs.

5 Operational Need

RTPD and RTD optimize resources based on a single imbalance energy forecast amount for an entire interval (hour, 15 minute or 5 minute period, respectively), assuming a perfect load forecast, generation acting in accordance with their dispatch, and constant conditions over the interval. There are times when RTPD optimize resources so efficiently across the horizon that there is little or no additional on-line and available unscheduled capacity for RTD to dispatch for any variation from the constant conditions assumed in RTPD. RTPD can optimize resources to meet the average load forecast for the 15 minute period by committing or de-committing resources sufficient to meet the load forecast at the time RTPD is run for a single load forecast but not necessarily sufficient for RTD to meet changes between the time RTPD ran and the time RTD runs. In addition, RTPD is dispatching units to meet the average imbalance energy needs for each 15 minute interval but not necessarily sufficient to meet the imbalance energy needs for every 5 minute interval within the 15 minute interval. This issue is more prominent when the load is increasing in the morning and evening ramps.

Changes in the imbalance energy needs for RTD after RTPD runs are many and could trigger imbalance shortages especially at peaks and valleys due to short term ramping shortages in RTD. Observed reasons for changes in imbalance energy needs between HASP/RTPD and RTD include:

- Changes in load conditions from forecast
- Differences between average 15 minute imbalance energy needs and 5 minute imbalance energy needs within the 15 minute interval
- Resources shutting down without sufficient notice
- Variable energy resources delivering more or less than forecast, including sudden changes in expected deliveries
- Contingency events
- High hydro run-off decreasing resource flexibility
- Interties tagging and delivering less than awarded in HASP
- Interchange ramp in and out between hours

When these real-time imbalance energy changes occur and available dispatch ramping capability is exhausted, leaning on regulation or the interconnection, biasing the load and/or exceptional dispatch are the only tools left for the operator to deal with this issue. Shortages of ramping capability are an existing operational issue as more intermittent renewable resources are integrated into the ISO system.

The lack of sufficient operational flexibility to respond to the imbalance variability and the uncertain magnitude of differences between expected conditions in RTPD and RTD results in both operational and market impacts. During conditions of real-time imbalance flexibility shortages, the ISO will automatically begin leaning on regulation capacity and available operating reserves that have not been flagged for use only in case of a contingency. If an imbalance shortage persists or is larger than what can be satisfied by available regulation and non-contingency reserves, the ISO may either begin leaning on other Balancing Authority Areas in the interconnection, and/or be forced to dispatch and potentially deplete its operating reserves. If this leaning becomes excessive or the ISO is not able to maintain its operating reserves, the ISO could jeopardize its ability to meet NERC operating criteria and could incur penalties. In the most extreme circumstances, imbalance shortages can result in the ISO being forced to consider firm load curtailment and/or be subject to reliability compliance actions from WECC/NERC. Therefore it is necessary to ensure that the ISO is prepared for varying and uncertain imbalance conditions to operate the grid consistent with prudent utility practice.

6 The Flexible Ramping Constraint

The ISO has already implemented several measures to reduce the uncertainty of imbalance conditions expected between HASP and RTD. These measures include: 1) improving consistency between the HASP and RTD forecasts, 2) accounting for hourly intertie ramp when scheduling hourly intertie energy in HASP, 3) improving the real-time load forecasting tools, and 4) providing improved guidance to the operators regarding HASP and real-time load adjustment practices. Although these measures have yielded improvements, alone they do not ensure there is sufficient operational flexibility committed to meet the variability and uncertainty of real-time imbalance conditions.

The flexible ramping constraint utilizes an operator-specified quantity of upward interval based ramping capability and affects the RTPD unit commitment and the RTD dispatch for intervals beyond the binding dispatch interval so as to provide for the availability of this capacity for dispatch in the RTD. This constraint only applies to the generation resources and does not apply to static import or export in our market. The flexible dispatch capability constrained to be available as a result of this constraint in RTPD will come from capacity that is not designated to provide regulation or contingency reserve (*i.e.*, spinning or non-spinning reserve), and will not offset the required procurement of those reserves. Rather, this capacity will be available for five-minute dispatch instructions from the RTD, and if dispatched above minimum load will be eligible to set real-time LMP prices subject to other eligibility provisions established in the ISO tariff section 34.19.2.3.

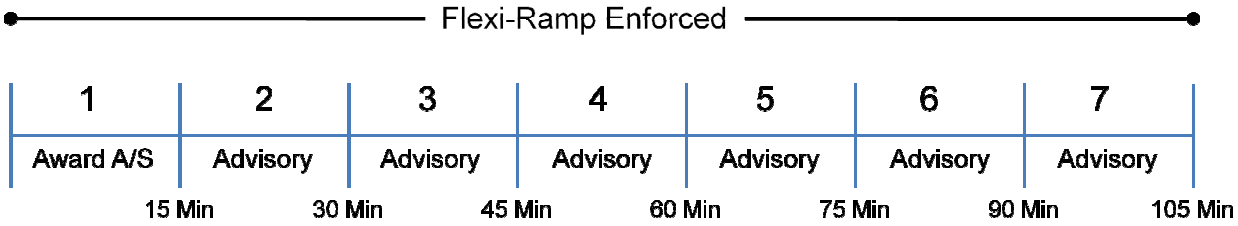
The flexible ramping constraint will provide the online dispatch flexibility to follow net load variation efficiently in the event the actual load is higher or lower than forecast or supply is not responding as expected or instructed. In addition, the use of the flexible ramping constraint will reduce the need to bias the ISO forecast in HASP.

The quantity of the flexible dispatch capability will be determined by operators using tools that will estimate: 1) the expected level of imbalance variability, and 2) the uncertainty due to forecast error, and 3) the differences between the hourly, 15 minute average and actual 5 minute load levels. The expected level of historical imbalance variability will consider the

statistical pattern of supply variation including expected variation due to scheduled changes in interchange ramp. Uncertainty due to forecast error will also factor in the historical differences between the hour ahead forecast level and the actual load. The ISO will publish the quantity of upward needs used in the constraint for each relevant market process (i.e., RTPD and RTD).

7 RTPD Opportunity Cost and Compensation

Figure 1 - RTPD Flexible Ramping Constraint Enforcement Horizon



In RTPD (including HASP run), incremental ancillary services are awarded for the first 15 minute interval and the awarded ancillary services are settled at the ancillary service marginal price (ASMP) from the first 15 minute interval resulting from the RTPD market optimization over the horizon. All remaining intervals are advisory for ancillary services and may become binding in subsequent RTPD runs which occur every 15 minutes. RTPD also commits or de-commits resources to meet forecasted load, but this does not result in binding energy settlement. Therefore, an opportunity cost can arise in RTPD if a resource was not awarded ancillary services in the binding 15 minute interval in order to reserve sufficient upward ramping capability in any interval across the RTPD horizon. The resource specific opportunity cost attributed to ancillary services can be calculated as the difference between the ASMP and the resource's ancillary services bid price.

For example, assume the spinning reserves ASMP was $5.00, if the resource had a $3.00 bid for spinning reserves, but was not awarded incremental spinning reserves in order to resolve the flexible ramping constraint over the horizon, the resource incurred an opportunity cost of $2.00. However, if the resource had a $7.00 bid for spinning reserves, even though the upward ramping capability of the resource resolved the flexible ramping constraint over the horizon, the resource did not incur an opportunity cost because the resource would not be economically awarded incremental spinning reserves. It is assumed that the bid price represents the price at which the resource is indifferent to being awarded a specific ancillary service, in this example spinning reserve. The example above illustrates that an opportunity cost only arises when awards are financially binding; however, since the market co-optimizes energy and ancillary services across the horizon, the implementation of a pure opportunity cost compensation mechanism cannot be easily implemented.

Since it is difficult to decompose the shadow price to only the ancillary services portion which is financially binding in RTPD, the ISO proposes to compensate resources at the flexible ramping shadow price when the constraint is binding in the first interval. The flexible ramping shadow price is the resource specific cost of the marginal unit that resolves the constraint. Since RTPD co-optimizes ancillary services and energy across the entire horizon, the shadow price will be based on the ancillary services opportunity cost and reductions in energy committed even though the energy price is not binding for settlement purposes.

The ISO proposes to compensate for flexible ramping in RTPD as this is the clear market where opportunity cost exists due to interplay with other services. All resources resolving the constraint will be compensated based on the RTPD shadow price in the binding ancillary services interval only. The compensation will equal the product of the ramping MW quantity of

capacity that the resource has been awarded and the flexible ramping constraint shadow price. All resources used to meet the flexible ramping constraint will be compensated even if a specific resource does not have a resource specific opportunity cost. This is because the shadow price reflects the marginal unit's opportunity cost, similar to how the LMP is based upon the marginal unit and not an individual resource's bid.

In the technical bulletin[1] for the flexible ramping constraint more detailed information was shown to illustrate the calculation of the flexible ramping constraint shadow price. The calculation of the flexible ramping constraint shadow price was shown for three scenarios: (1) energy component only, (2) ancillary services component and energy component, and (3) ancillary services component only. In scenario 1, the compensation for the flexible ramping constraint is the shadow price of $20.00. In scenario 2, the compensation would be $22.00. In scenario 3, the compensation would be $4.00.

In stakeholder comments, many highlighted that the flexible ramping constraint is very similar to non-contingent spin. As a result, the ISO could address the operational need through the procurement of additional spinning reserves which would compensate resources at the spinning reserve price. The ISO procures 100% of its spinning reserve requirements in the day-ahead market. The current market design does not differentiate between non-contingent spin and contingent-only spin procured in the day-ahead market. Contingent-only spin can only be dispatched for energy if a contingency event occurs. When the ISO procures incremental spinning reserves in RTPD the spinning reserves is contingent-only, non-contingent spin cannot be procured in RTPD. Also, if the resource providing the incremental spinning reserves in RTPD also was awarded spinning reserves in day-ahead, the total quantity of spinning reserves from this resource is considered contingent-only even if the day-ahead award was previously identified as non-contingent. A new constraint would be required to ensure sufficient non-contingent spinning reserves were procured. This constraint, if binding, would result in price divergence between non-contingent and contingent-only spinning reserves and would look very much like two separate products. The intent of the flexible ramping constraint is to meet the operational need in the interim without creating a new product. The new product and allocation methodology are being evaluated in the Renewable Integration Market and Product Review Phase 2 stakeholder initiative[2].

The ISO will create a single charge code to track the costs associated with the flexible ramping constraint binding. The costs will be allocated to measured demand. The proposal to allocate to measured demand it aligns with the existing allocation of ancillary services and simplifies implementation of the compensation mechanism.

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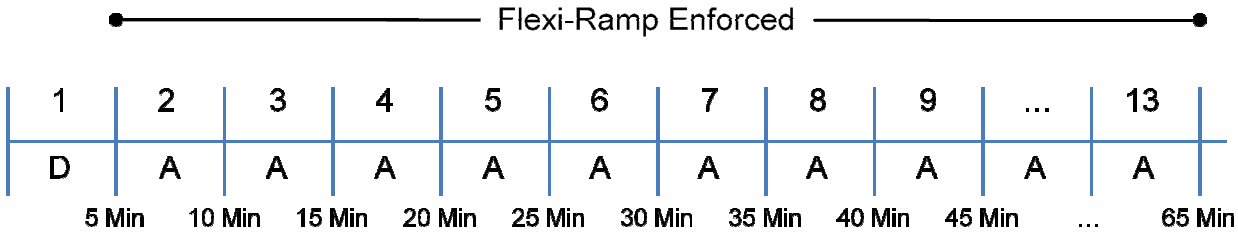
1 See Appendix 1. The technical bulletin is available at http://www.caiso.com/Documents/TechnicalBulletin-FlexibleRampingConstraint_UpdatedApr19_2011.pdf

2 See page 18 of the Renewable Integration: Market and Product Review Phase 2 for discussion of the Real Time Imbalance Service. The document is available at http://www.caiso.com/2bb3/2bb3e594394f0.pdf.

8 RTD Opportunity Cost and Compensation

Figure 2 - RTD Flexible Ramping Constraint Enforcement Horizon



D = Dispatch, A = Advisory

The enforcement of the flexible ramping constraint in RTD allows the ISO to manage the flexible ramping capacity provided for in RTPD due to changes between the 15 minute RTPD run and the 5 minute RTD run. The flexible ramping capacity requirement in RTD will not increase but may decrease from the RTPD requirement depending on which interval in the RTD horizon. In addition, the resources which resolve the flexible ramping constraint in RTD will only come from the resources which resolved the constraint in RTPD. Therefore no opportunity cost can arise for resources in RTD which were not previously compensated through the RTPD shadow price. Since the RTPD flexible ramping shadow price includes opportunity costs for energy even though the RTPD commitment (de-commitment) of energy is not binding for settlement purposes, resources that resolve the flexible ramping constraint are compensated for anticipated opportunity costs due to energy.

9 Next Steps

The ISO will discuss the Draft Final Proposal with stakeholders during a teleconference to be held on July 27, 2011. The ISO is seeking comments on the proposal compensate resources based upon the flexible ramping constraint shadow price resulting from the flexible ramping constraint binding in RTPD. Stakeholders should submit written comments by August 3, 2011 to Flexi-Ramp@caiso.com.