Opportunity Cost of Flexible Ramping Constraint

Issue Paper & Straw Proposal

June 24, 2011

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Table of Contents

1 Introduction

The ISO proposes to implement a new flexible ramping constraint in the market optimization for the Residual Unit Commitment (RUC), 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 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 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 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 is proposing that the costs of the flexible ramping constraint will be allocated to measured demand.

2 Plan for Stakeholder Engagement

Item	Date
Post Issue Paper & Straw Proposal	June 24, 2011
Stakeholder Conference Call	July 1, 2011
Stakeholder Comments Due	July 8, 2011
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

3 Overview

The ISO proposes to implement a new flexible ramping constraint in the market optimization for the Residual Unit Commitment (RUC), 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 the 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 and downward ramping 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, based capacity not designated to provide regulation or contingency reserves (spinning and non-spinning reserves) and the upward capacity not utilized to meet the load forecast.

4 Operational Need

IFM, 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 IFM and 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 IFM and RTPD. The IFM, especially in the peaks and valleys, can optimize resources to meet the average load forecast for the hour, but these resources may not necessarily meet the imbalance for every five minutes within that hour. RTPD does the same thing 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 the 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
- 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.

5 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 and downward interval based ramping capability and affects the RUC/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.

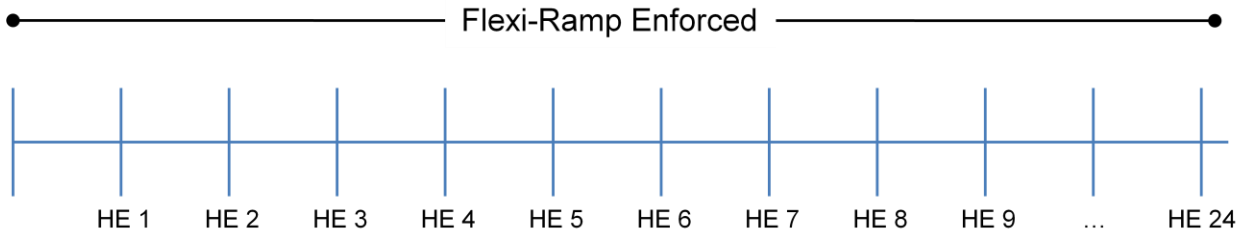
The flexible ramping constraint will provide the online dispatch flexibility to follow net load variation efficiently in the event the actual load is higher or lower than forecast or supply is not responding as expected or instructed. In addition, the use of the flexible ramping constraint will reduce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

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 and downward needs used in the constraint for each relevant market process (i.e., RUC, RTPD and RTD).

6 RUC Opportunity Cost and Compensation

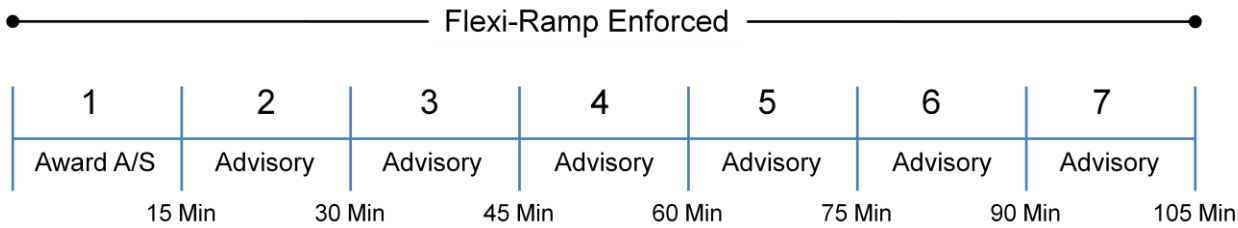
Figure 1 – RUC Flexible Ramping Constraint Enforcement Horizon



During RUC, incremental capacity is awarded to meet the ISO forecast of demand. Since resources are not de-committed during RUC, an opportunity cost cannot arise because the IFM schedule is not changed. If incremental capacity is awarded in RUC, resource adequacy (RA) resources have a must-offer obligation with a zero bid price. For non-RA resources that are awarded incremental capacity, the resource is compensated based upon their RUC bid. The enforcement of the flexible ramping constraint in RUC does not require changes to the settlement of the resource or cost allocation methodology.

7 RTPD Opportunity Cost and Compensation

Figure 2 - RTPD Flexible Ramping Constraint Enforcement Horizon



In RTPD (including the 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 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 ancillary services.

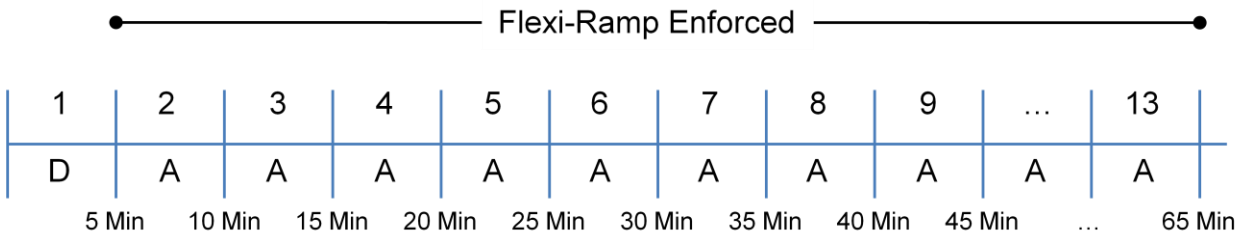
The ISO proposes to compensate resources at the flexible ramping shadow price when the constraint is binding in the first interval. The flexible ramping shadow price is the resource specific opportunity cost of the marginal unit that resolves the constraint. Since RTPD co-optimizes ancillary services and energy, 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. The resource will be compensated for its lost opportunity based on the RTPD shadow price in the binding 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.

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.

8 RTD Opportunity Cost and Compensation

Figure 3 - RTD Flexible Ramping Constraint Enforcement Horizon



D = Dispatch, A = Advisory

The enforcement of the flexible ramping constraint in RTD allows the ISO to maintain sufficient flexible ramping capacity due to changes between the 15 minute RTPD run and the 5 minute RTD run. The majority of flexible ramping capability will be procured in the RTPD runs. 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.

In RTD, energy is dispatched in the first 5 minute interval to meet forecasted load and the energy is settled at the binding LMP for the first 5 minute interval resulting from the RTD market optimization over the horizon. The remaining intervals across the 65 minute horizon are advisory and may become binding in subsequent RTD runs which occur every 5 minutes. The flexible ramping constraint is not enforced in the first 5 minute interval to allow resources that resolved the flexible ramping constraint in RTPD to be dispatched. The RTD market optimization over the horizon can impact the dispatch in the binding 5 minute interval with or without the flexible ramping constraint binding. In the RTD binding interval all the services are released for use and are compensated at the going RTD energy price just as is done currently. Therefore there is not a unique resource specific opportunity cost resulting from enforcement of the flexible ramping constraint in RTD that is not already reflected in the LMP.

9 Next Steps

The ISO will discuss the Issue Paper and Straw Proposal with stakeholders during a teleconference to be held on July 1, 2011. The ISO is seeking comments on the proposal compensate resources based upon the resource's opportunity cost when the flexible ramping constraint in binding in RTPD or RTD. Stakeholders should submit written comments by July 8, 2011 to Flexi-Ramp@caiso.com.