July 6, 2012

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: California Independent System Operator Corporation
Docket No. ER12-1630-000

Order 755 Compliance Filing – Frequency Regulation Compensation in the Organized Wholesale Power Markets

Dear Secretary Bose:

On April 27, 2012, the California Independent System Operator Corporation (ISO) submitted a tariff amendment in compliance with the Commission's final rule concerning compensation for frequency regulation in organized wholesale power markets.[1] The ISO's proposal complies with the Commission's directives to establish a two-part compensation methodology for frequency regulation service, which includes a capacity payment and a performance payment based on mileage bids for resources providing regulation service. On June 8, 2012, the Commission's Office of Energy Market Regulation issued a letter requesting additional information concerning the ISO's tariff amendment.[2]

The ISO provides responses to each of the questions in the June 8 letter below. The ISO also provides a further description of its proposal in the background section of this response to ensure that the Commission has an adequate record to support an order accepting the ISO's proposed tariff revisions.[3]

---

1 *Frequency Regulation Compensation in the Organized Wholesale Power Markets,* 137 FERC ¶ 61,064 (October 2011) (*Order 755*); *rehearing denied* 138 FERC ¶ 61,123 (February 2012) (*Order 755-A*).

2 The Office of Energy Market Regulation's letter states that the ISO should provide a copy of its response to all parties that have either requested or been granted intervention in this proceeding and that, pending receipt of the response, a filing date will not be assigned to the filing.

3 As reflected in its April 27, 2012 transmittal letter in Docket No. ER12-1630, the ISO requests an order accepting its tariff amendment by September 2012 and an effective date of

I. Background

In October 2011, the Commission issued *Order 755*, which adopted a final rule for compensation of frequency regulation in organized wholesale power markets. The Commission determined that current compensation methods for regulation service in organized markets fail to acknowledge the inherently greater amount of regulation service provided by faster-ramping resources and that certain practices result in economically inefficient dispatch of resources providing regulation service. To remedy these issues, the Commission's final rule requires organized markets to compensate regulation resources based on the actual service provided, including a capacity payment that reflects the marginal unit's opportunity costs and a performance payment that reflects the quantity of regulation service actually provided by a resource when the resource accurately follows a dispatch signal. *Order 755* requires the use of a market-based rather than administrative price on which to base performance payments.[4]

Using a two-part bid structure for regulation capacity and performance payments, the ISO is proposing to accept separate capacity and mileage bids for resources bidding to provide regulation service. Under the ISO's proposal, resources that receive regulation capacity awards must also receive a mileage award and vice versa. The ISO, accordingly, must consider both capacity and mileage bids in determining the marginal clearing price for both attributes of regulation service. In addition, since a performance payment reflects resources' actual movement in response to a control signal, the ISO must establish some level of expected performance in selecting which resources are awarded regulation capacity and/or regulation mileage.

To establish a market clearing price for regulation capacity and for mileage, the ISO identified two options in its stakeholder process. The first option establishes two separate market clearing prices for regulation capacity and mileage. The second option establishes a single price for regulation capacity and mileage, but then disaggregates the single price into individual prices for capacity and mileage for purposes of settlement.

After discussions with stakeholders, the ISO selected the first option. The proposal follows two guiding principles: (1) avoid disruptions to the current

---

April 9, 2013, subject to the ISO providing two weeks prior notice to the Commission as to the actual effective date. This effective date coincides with the ISO's planned release of market enhancements for the spring of 2013, and will permit the ISO and market participants to deploy and test market systems to implement *Order 755*. The ISO has requested that the Commission waive the requirement of 18 C.F.R. § 35.3 that a rate schedule be filed not more than 120 days from the effective date. The ISO continues to request an order by September 2012 and an April 9, 2013 effective date.

[4] *Order 755* at P 128.

ancillary service market design, including allowing regulation up service to substitute for spinning reserve and non-spinning reserve when it is economic to do so;[5] and (2) determine a market-based marginal clearing price for mileage that takes into consideration expected performance even though the ISO will only compensate resources for actual performance. In the proposed design, the ISO added measures to address regulation capacity and mileage bidding practices, such as submitting a low capacity bid price to obtain a capacity award and a high mileage bid to obtain a high ex-post settlement for performance. For example, the ISO requires each resource with a regulation capacity award to receive a mileage award that is no less than its MW quantity of awarded capacity.[6] Because the ISO will consider a resource's capacity and mileage bid in making awards for both, the market clearing price for mileage may in some cases be lower than the marginal resource's mileage bid price. The ISO, accordingly, proposes to expand bid cost recovery rules to cover regulation mileage. Bid cost recovery will consider revenue and costs of all products, including energy, ancillary services awards and regulation mileage for a 24-hour period.

Overall, the ISO considers its adopted approach more efficient than using a single constraint for capacity and mileage under the design of other ISO markets because it preserves existing ancillary services substitution rules for regulation up capacity and allows the ISO to optimize regulation capacity bids and mileage bids based on price and expected performance.

II. Responses to Questions

Question 1

Please provide step-by-step numerical examples of the entire frequency regulation compensation process outlined in the compliance filing, starting with bids for capacity and mileage and ending with the settlement statement.

a. The examples should show all steps in the entire frequency regulation compensation process, including, but not limited to, resource bids (including opportunity costs), the co-optimization/market clearing process, which resources are awarded capacity, the calculation of mileage multipliers for the system and individual resources, accuracy adjustments, and the settlement process. Enough detail should be included to provide Commission staff with a thorough understanding of the entire frequency regulation compensation process.

---

[5] The ISO markets procure the following ancillary services: regulation up, regulation down, spinning reserve and non-spinning reserve.

[6] This measure is represented by constraint (5) in Figure 1 included in the ISO's response to question 1 herein.

i. Please include any and all functions used in the methodology to establish the marginal clearing prices for mileage and capacity.
ii. If a bid that includes inter-temporal opportunity costs is the marginal bid, please explain whether the marginal price paid to suppliers will include the inter-temporal element.

Answer

Exhibit A, attached hereto, contains numerical examples reflecting the steps of the regulation compensation process outlined in the ISO's April 27, 2012 compliance filing. The examples start with the calculation of resource-specific mileage multipliers and end with settling transactions in which resources provide regulation capacity and respond to the ISO's control signal. The examples include a description of how the ISO will adjust a resource's performance payment based on the accuracy with which the resource responded to the ISO's control signal and how the ISO will adjust a resource's historical performance to assess future regulation capacity awards.[7]

For purposes of establishing marginal clearing prices for capacity and mileage, the ISO will adopt a methodology that clears self-provided and bid-in capacity and mileage against the requirements for each component of regulation service. Figure 1 reflects separate constraints in the co-optimization to meet the requirements for regulation capacity and mileage. The shadow prices of the capacity requirement constraint and the mileage requirement constraint represent the market-based clearing prices for each attribute of regulation service. The ISO's optimization also models known transmission and resource constraints as part of the day-ahead and real-time residual unit commitment market runs.

[7] The ISO's Business Requirements Specification contains business and software requirements for implementing the ISO's *Order 755* compliance filing. A copy of the ISO's Business Requirements Specification is available at the following link on the ISO's web site: http://www.caiso.com/Documents/BusinessRequirementsSpecification-Pay-Performance.pdf. This document describes the input data processing, the algorithm, and the formulae used in the market clearing and settlement of a two-part compensation methodology for regulation service. The numerical examples in Exhibit A employ these formulae.

Figure 1

$$\min\left(\sum_i (BCP_i \times Reg_i + BMP_i \times Mile_i) + \text{cost of energy and other AS}\right)$$

$$s.t. \quad \sum_i Reg_i \geq Req_{Reg} \tag{1}$$

$$\sum_i Reg_i + \sum_j Spin_j \geq Req_{Reg} + Req_{Spin} \tag{2}$$

$$\sum_i Mile_i \geq \min(Req_{Mile,t-1}, m \times Req_{Reg}, \sum_i m_i \times BCC_i) \tag{3}$$

$$m_i \times Reg_i - Mile_i \geq 0 \tag{4}$$

$$-Reg_i + Mile_i \geq 0 \tag{5}$$

$$0 \leq Reg_i \leq BCC_i \tag{6}$$

$$\text{and other constraints} \tag{7}$$

where

BCP_i, BCC_i – bid price and MW for regulation capacity

BMP_i – bid price for regulation mileage

Reg_i, $Mile_i$ – regulation capacity and mileage awards

Req_{Reg}, Req_{Spin} – regulation and spin requirements

$Req_{Mile,t-1}$ – regulation mileage requirement of previous day

m, m_i – system and resources – specific mileage multiplier

As shown in Figure 1, the objective of the optimization is to minimize the total bid-in cost of regulation capacity and mileage, as well as other costs, including the cost of energy, ancillary services, and resource startups. Constraint (1) is the regulation capacity requirement for the ISO system. The sum of regulation capacity awards to all resources must be greater than or equal to the regulation capacity requirement. Constraint (2) is the regulation capacity and spinning reserve total requirement for the ISO system. This constraint allows regulation up capacity to satisfy the ISO's spinning reserve requirement when the ISO market can procure additional regulation up capacity at bid prices lower than bid prices for spinning reserves. Regulation up capacity that satisfies spinning reserve requirements does not result in awarding additional mileage beyond the mileage constraint. Constraint (3) is the regulation mileage requirement for the ISO system. For each resource, its mileage award cannot exceed the product of the resource's regulation capacity award and resource-specific mileage multiplier, which is enforced by constraint (4). If a resource has a regulation capacity award, its mileage award may not be less than the MW of its capacity award. This measure is represented by constraint (5). Through constraint (6),

the optimization determines a regulation capacity award for a resource in the range between 0 and its bid-in MW. Apart from these constraints, the optimization recognizes other constraints to determine energy schedules and ancillary services awards, including, for example, transmission flow limits and ramping capability limits. Constraint (7) is a reference to other general constraints in the ISO optimization not specifically related to the ISO's *Order 755* compliance filing.

The market co-optimization determines the most efficient solution to meet the ISO systems' energy, ancillary services, and regulation mileage requirements. The co-optimization also enforces a minimum and maximum mileage award constraint for each of the resources with self-provided or submitted bids to provide regulation service. A resource must receive a regulation mileage award no less than its regulation capacity award and its mileage award may not exceed the product of the resource-specific mileage multiplier and awarded regulation capacity. These constraints establish a link between individual resource's mileage awards and capacity awards, but still allow for resources to set marginal prices for mileage and capacity separately. This design is consistent with the principle of establishing a uniform clearing price for mileage that takes into consideration expected resource performance.

With respect to the question of whether the marginal price paid to suppliers will include an inter-temporal element, the ISO proposes to allow scheduling coordinators to submit regulation capacity bids that include inter-temporal opportunity costs.[8] If the marginal resource's capacity bid includes inter-temporal opportunity costs calculated and submitted by the scheduling coordinator for that resource, the capacity price paid to all suppliers will include that inter-temporal element. For clarity's sake, the ISO's current optimization assesses inter-temporal resource constraints and opportunity costs over the market horizon. For example, in the day-ahead market the horizon is 24 hours. Beyond this time horizon, however, the ISO's current optimization does not assess or calculate inter-temporal costs a resource may incur by receiving an award in one interval as opposed to another interval. The ISO's tariff revisions in compliance with *Order 755* will permit scheduling coordinators to calculate and include opportunity costs as part of resource bids.

Question 2

Please explain whether CAISO uses a resource-specific estimate of mileage in the optimization routine? If so, please explain how this estimate is calculated. Indicate whether and how the resource-specific estimate of mileage enters the optimization routine's objective function and any associated constraints in the

[8] *See* ISO April 27, 2012 transmittal letter in Docket No. ER12-1630 at 6 and Appendix B thereto - proposed revisions to ISO tariff section 30.5.2.6.1. *See also*, *Order 755* at P 103.

answer, in addition to the explanation. If the resource-specific estimate of mileage is not used in the optimization routine, please explain why not.

Answer

The ISO proposes to calculate resource-specific mileage multipliers for all resources that bid to provide regulation capacity and mileage. The resource-specific mileage multipliers will reflect resources' historic regulation performance accuracy and certified 10-minute ramp capability. The ISO proposes to calculate resource-specific mileage multipliers as follows:

> (1) Determine the relative ramping speed of the resource by dividing the resource's certified capacity in MW by the resource's ramp rate per minute and then dividing 10 by that number. The ISO will round this value to an integer between 1 and 10.
>
> (2) Determine the relative accuracy of the resource as compared to other resources by dividing the resource-specific accuracy by the system wide accuracy.
>
> (3) Then multiply the relative measures of performance (1) and (2) by the system wide mileage multiplier. The ISO proposes to calculate the system mileage multiplier as the average accuracy measurements of resources that provided regulation in the prior week.

The ISO will use the resource-specific mileage multiplier to estimate the maximum MW of mileage that the resource can provide from each MW of awarded regulation capacity. The product of the resource-specific multiplier and the resource's bid-in MWh for capacity sets the maximum mileage the resource can provide for purposes of the optimization. The resource-specific multiplier shall equal at least 1 because, for purposes of the optimization, the ISO expects that the energy management system will send control signals to resources with awarded capacity.[9]

With respect to the questions concerning the optimization's use of the resource-specific estimate of mileage, the objective function of the optimization seeks to minimize costs subject to the constraints such as the resource-specific mileage multipliers. The optimization will use resource-specific mileage

[9] As part of its answer to comments in this proceeding, the ISO has agreed to adopt a parameter to adjust a resource's awarded mileage to reflect the resource's expected actual mileage in order to ensure the efficient selection of resources to satisfy mileage and regulation capacity requirements.

multipliers as constraints so that awarded regulation capacity and the expected mileage awarded through the optimization are consistent with resources' minimum and maximum resource-specific mileage multipliers.

Question 3

CAISO states that the maximum ancillary service bid price is $250.

a. To establish a maximum mileage bid price, CAISO assumes a mileage multiplier of 5 and divides the maximum ancillary service bid price by the assumed multiplier to arrive at a maximum mileage bid price of $50. Please provide the basis of the assumed multiplier of 5.

b. Please explain the relationship between the mileage bid price and capacity bid price and the ancillary service bid price cap. Include equations, if necessary. Is the ancillary service bid price cap applied to each ancillary service separately, or are the bids combined and together must fall under the cap?

Answer

The ISO selected the multiplier of 5 based on a review of historical operating information. The ISO reviewed system wide performance from July 11, 2010 through July 17, 2010. For both regulation up and regulation down, the ISO summed the hourly system-wide performance of regulation resources and divided the total number of MW moved by the total regulation capacity procured for each hour. The ISO calculated mileage multipliers for regulation up and regulation down separately. The average system wide mileage multiplier over the period reviewed was 4.55. This means that for every MWh of capacity awarded, the average mileage provided in each interval was 4.55 MW. The ISO rounded this number to 5 as an initial value for the system mileage multiplier. The ISO used this initial value as the multiplier to derive the maximum mileage bid price, which reflects the ISO's existing ancillary service maximum bid price ($250 MWh) divided by the system mileage multiplier of 5. In the future, the ISO will calculate the system mileage multiplier dynamically and intends to reassess the design of its proposed maximum mileage bid price after obtaining one year of operational data. The calculation of the system mileage multiplier is described in the answer to question 5.

The maximum ancillary services bid prices for regulation capacity and regulation mileage are independent. The ISO accepts separate bids for each of its ancillary services (regulation up, regulation down, spinning reserve and non-spinning reserve). A resource may submit separate bids for each service up to the price of $250 MWh for each bid.[10] Under the ISO's tariff amendment, the

[10] ISO tariff section 39.6.1.3.

maximum bid price a resource may submit for either regulation up mileage or regulation down mileage is $50/MWh. The proposed maximum mileage bid price will not change the maximum bid prices for regulation up or regulation down capacity.

Question 4

Please explain how the AGC system dispatches resources for regulation up and regulation down service. For example, are faster-ramping resources dispatched first or are resources dispatched pro rata? Additionally, please explain how the AGC system dispatches resources in relationship to how resources are selected in the market clearing process.

Answer

As part of its energy management system, the ISO uses regulation resources on automatic generation control to manage the difference between its scheduled and actual interchange, as well as its share of correcting the frequency of the Western interconnection. Automatic generation control sends signals to resources to minimize Area Control Error. In order to keep Area Control Error within acceptable ranges, resources qualified for regulation respond to a control set point.

The ISO's energy management system receives information on regulation awards from the ISO's market systems every fifteen minutes. Once the energy management system receives updates on self-provided or awarded regulation capacity, the system calculates regulation high and low limits based on resources' dispatch operating targets and real-time availability, which is informed in part by resource and transmission outages and de-rates. The energy management system then issues control set points to resources on automatic generation control within the calculated regulation limits. The ISO's software calculates participation factors for resources with self-provided or awarded regulation capacity based on each resource's pro rata share of regulation awards. For example, if there are ten regulation units, then each unit will have a 10 percent participation factor; the participation factors of all resources providing regulation capacity will sum to 100 percent. If resources are not able to respond to control signals within 8 seconds (the round trip of the ISO's 4 second control signal to and from the resource), then the ISO will move other units to fulfill the ISO's regulation requirements. If resources do not respond accurately, then overall interconnection frequency correction takes longer, and inadvertent interchange occurs with neighboring balancing authority areas. To address these results, the ISO must continue to instruct resources between each 5 minute real time dispatch interval. Failure of resources to respond accurately during a frequency deviation will obviously increase the challenge of returning the market to operating within acceptable limits.

With respect to questions of whether the ISO dispatches faster-ramping resources first, the ISO's energy management system does not include a priority dispatch for resources with faster-ramping capability. The ISO can, however, configure the system to send control signals to faster ramping resources, if the ISO requires a fast response to correct Area Control Error. Resources also receive capacity awards based on their certified ramp rate. Accordingly, compensation for regulation in the ISO market already recognizes performance albeit implicitly. As a result, a fast ramping resource can potentially provide more regulation capacity and thus receive additional automatic generation control signals. Again, this outcome normally results from the resource's ramp rate rather than a pre-defined ISO dispatch priority.

The ISO's energy management system also maintains Area Control Error in several bands or thresholds. These bands vary based on the control performance standard defined by the North American Electric Reliability Corporation, in both normal and disturbance conditions. When possible, the ISO's energy management system attempts to maintain a resource's dispatch operating target when Area Control Error is in a dead band zone. The ISO's energy management system will not move resources for a sustained period of time if there is no reliability reason to do so and if signaling the resource would move it away from its optimum economic operation. On the other hand, the ISO's energy management system may keep resources at their high or low regulation limits, if a sustained need for the service exists.

With respect to the question of whether the energy management system dispatches resources in relationship to how resources are selected in the market clearing process, the ISO's energy management system does not dispatch resources with regulation awards based on bid price.

Question 5

CAISO's proposed tariff language provides that mileage requirements for either regulation up or regulation down will reflect the minimum of: (a) the product of the respective regulation capacity requirement and the system mileage multiplier; (b) the average instructed mileage for the applicable trading hour from the prior calendar week; or (c) the product of a resource's resource-specific mileage multiplier and a resource's self-provided or bid-in regulation capacity, which number is then summed for all resources. Please explain and justify the significance of each of these conditions and CAISO's use of a minimum of these conditions to determine the mileage requirement.

Answer

As reflected in its April 27, 2012 tariff amendment, the ISO has proposed to establish mileage requirements for regulation up and regulation down based on the minimum of three variables. Each variable serves as a proxy for the mileage the ISO expects from the regulation up and regulation down capacity requirements.

The first variable reflects the mileage the ISO expects from resources based on the relationship between historical awards and self-provisions of regulation capacity and mileage. The system mileage multiplier signals this relationship. The ISO currently establishes regulation up and regulation down capacity requirements for each hour of the trading day. The ISO proposes to calculate the hourly system mileage multiplier by summing the total mileage from all resources (both self-supplied and procured in the ISO market) over the prior week for the given hour and dividing that number by the regulation capacity procured for the week in that hour.[11]

The second variable is based on the mileage the ISO actually instructed in the prior calendar week. This variable seeks to capture an approximate requirement based on current system conditions given the time of year.

The third variable is the product of a resource-specific mileage multiplier and a resource's self-provided or bid-in regulation capacity, which number is then summed for all resources. This variable reflects the maximum mileage in either the up or down direction that the ISO expects self-provided and bid-in regulation capacity can provide.

To comply with *Order 755*, the ISO is proposing to establish a market clearing price for mileage to compensate resources for their actual performance in response to a control signal. To establish this price, the ISO will estimate the actual mileage requirement for each operating hour. The first two variables identified by the ISO address this need. The ISO, however, does not want mileage awards (which are not financially binding) to cause a scarcity situation and thereby create an artificial need to increase capacity requirements. In addition, given the connection between regulation capacity and mileage, an artificially high mileage requirement could also increase regulation capacity requirements, thereby potentially distorting the ISO's ancillary service prices and undermine ancillary service substitution. For this reason, the ISO believes the requirement for regulation mileage should not be greater than the maximum total

[11] *See* Pay for Performance Regulation Addendum to final Draft Proposal at 7. http://www.caiso.com/Documents/Addendum-DraftFinalProposal-Pay_PerformanceRegulation.pdf

mileage the self-provided and bid-in regulation capacity can provide. The third variable identified by the ISO reflects the maximum total mileage.

The ISO plans to select the minimum of these variables in part to avoid a scarcity condition for mileage. Additionally, based on operational experience under the ISO's current procurement of regulation capacity, the ISO procures capacity that provides sufficient performance in response to the ISO's control signal. Setting a mileage requirement that reflects the minimum of these variables will establish a mileage requirement sufficient to meet the ISO's operational needs but in the most efficient manner for scheduling coordinators with ancillary services obligations.

Question 6

Please explain whether the bid cost recovery process includes the capacity payment as well as mileage (adjusted for performance). Additionally, please explain in detail how any uplift payments will function under the tariff. This explanation should include, but not be limited to, an explanation of how uplift is paid compared to a resource's offer to sell both regulation capacity and mileage, as well as a description of how the accuracy adjustment and any uplift payment interact with each other.

Answer

As part of its tariff amendment, the ISO is proposing to provide bid cost recovery for resources with regulation capacity bids as well as mileage bids. The ISO's bid cost recovery rules include day-ahead, residual unit commitment and real-time transactions.[12] In each market process, the ISO compares market revenue to bid costs to evaluate a resource's revenue shortfall or surplus. The ISO then nets the shortfall or surplus across all market processes. In the event of a shortfall, the ISO tariff provides for a payment to compensate a resource for the shortfall. The ISO evaluates bid cost recovery for each resource on each trading day.

Bid cost recovery currently includes awards for energy, regulation up, regulation down, spinning reserve, non-spinning reserves, and residual unit commitment that are economically committed or awarded in each ISO market process. In other words, the ISO tariff already provides for bid cost recovery for regulation capacity. As part of the ISO's tariff amendment in this proceeding, bid cost recovery will also apply to mileage.[13] In its answer to comments, the ISO

[12] *See generally* ISO tariff section 11.8.

[13] See ISO April 27, 2012 transmittal letter in Docket No. ER12-1630 at 11 and Appendix B thereto - proposed revisions to ISO tariff sections 11.8.2.1.6 and 11.8.4.1.6.

proposed to calculate bid cost recovery for mileage bids based on instructed mileage as adjusted for accuracy.[14] The ISO proposes to use any accuracy adjustment to calculate revenue from performance payments for purposes of offsetting mileage bid costs. Importantly, the ISO will not isolate bid cost recovery for mileage but instead will consider all product offerings from a resource to calculate any shortfall or surplus for purposes of bid cost recovery. To the extent a resource self-provides regulation capacity and mileage, the ISO will treat this self-provision as a $0 bid, which will cause bid costs to reflect $0.[15] In this case, revenue will exceed bid costs and the resource will not receive regulation bid cost recovery.

To help explain how the ISO's bid cost recovery proposal for regulation capacity and mileage will work, the ISO offers following three numerical examples of calculating uplift payments for regulation capacity bids and regulation mileage bids under the ISO's tariff amendment. Again, the ISO will include these calculations in its overall assessment of a resource's eligibility for bid cost recovery during a trading day based on bid costs and market revenues from all commodities.

Example 1

A resource bids $10.00/MW for regulation up capacity and $6.00 for mileage.[16] The market clearing price for regulation up capacity is $14.00/MW and $4.00 for mileage. The resource receives an award of 50 MW of regulation up capacity. The resource has instructed mileage of 200 MWh, an under-response adjustment of 10 MWh, and accuracy of 90 percent. Assume the resource only provides regulation up capacity and mileage for one hour in the day.

Revenue
Regulation Up Capacity = $14.00 x 50 MW = $700
Mileage Revenue = $4.00 x ((200MWh – 10MWh) x 90%) = $684
Total Revenue = $1384.00

Bid Cost
Regulation Up Capacity = $10.00 x 50 MW = $500
Mileage Cost = $6.00 x ((200MWh – 10MWh) x 90%) = $1026
Total Cost = $1526.00

Since Bid Cost > Revenue, the resource will receive bid cost recovery.

---

14 *See* ISO answer to comments filed on June 4, 2012 in Docket No. ER12-1630 at 4-6.

15 *See* ISO answer to comments filed on June 4, 2012 in Docket No. ER12-1630 at 8-9.

16 Settlement prices for mileage reflect MWh for settlement purposes.

Bid Cost Recovery = $1526.00 - $1384.00 = $142

Example 2

A resource bids $20.00/MW for regulation up capacity and $3.00 for mileage. The market clearing price for regulation up capacity is $14.00/MW and $4.00 for mileage. The resource receives an award of 50 MW of regulation up capacity. The resource has instructed mileage of 200 MWh, an under-response adjustment of 10 MWh, and accuracy of 95 percent. Assume the resource only provides regulation up capacity and mileage for one hour in the day.

Revenue
Regulation Up Capacity = $14.00 x 50 MW = $700
Mileage Revenue = $4.00 x ((200MWh – 10MWh) x 95%) = $722
Total Revenue = $1422

Bid Cost
Regulation Up Capacity = $20.00 x 50 MW = $1000.00
Mileage Cost = $3.00 x ((200MWh – 10MWh) x 95%) = $541.50
Total Cost = $1541.50

Since Bid Cost > Revenue, the resource is eligible for bid cost recovery.

Bid Cost Recovery = $1541.50 - $1422.00 = $119.50

Example 3

A resource bids $15.00/MW for regulation up capacity and $3.00 for mileage. The market clearing price for regulation up capacity is $14.00/MW and $4.00 for mileage. The resource receives an award of 50 MW of regulation up capacity. The resource has instructed mileage of 200 MWh, an under-response adjustment of 10 MWh, and accuracy of 95 percent. Assume the resource only provides regulation up capacity and mileage for one hour in the day.

Revenue
Regulation Up Capacity = $14.00 x 50 MW = $700.00
Mileage Revenue = $4.00 x ((200MWh – 10MWh) x 95%) = $722.00
Total Revenue = $1422.00

Bid Cost
Regulation Up Capacity = $15.00 x 50 MW = $750.00
Mileage Cost = $3.00 x ((200MWh – 10MWh) x 95%) = $541.50
Total Cost = $1291.50

Since Bid Cost < Revenue, the resource is not eligible for bid cost recovery.

Bid Cost Recovery = $0.00

III. Conclusion

The ISO's proposed tariff amendment complies with the requirements of *Order 755* to compensate resources for providing regulation service through a capacity payment and a payment for performance that reflects the quantity of regulation service provided by a resource when the resource accurately follows a control signal. Based on the information provided in the ISO's initial transmittal letter, its answer to comments, as well as this response, the Commission should accept the ISO's tariff revisions subject to the modifications the ISO agreed to make in its answer to comments. The ISO requests an order accepting its tariff amendment by September 2012, and a proposed effective date of April 9, 2013, which coincides with the ISO's planned release of market enhancements for the spring of 2013.

Please contact the undersigned if you have any questions regarding this matter.

Respectfully submitted,

By: */s/ Andrew Ulmer*
Nancy Saracino
General Counsel
Sidney M. Davies
Assistant General Counsel
Andrew Ulmer
Director, Federal Regulatory Affairs
California Independent System Operator Corporation
250 Outcropping Way
Folsom, CA 95630
Tel: (202) 239-3947
Fax: (916) 608-7222
aulmer@caiso.com

Attorneys for the California Independent System Operator Corporation

California ISO
Shaping a Renewed Future

Exhibit A

Numerical Examples Supporting ISO Tariff Amendment in ER12-1630

Step 1: Calculate mileage multipliers based upon historical data

The ISO will calculate resource-specific mileage multipliers to identify the maximum mileage award that a resource can receive through the market optimization. The ISO expects that the energy management system will dispatch resources with regulation capacity awards. For this reason, the ISO has adopted a minimum resource-specific mileage multiplier of 1. This minimum resource-specific multiplier reflects that a resource will move 1 MW for every MW of awarded capacity. The maximum resource-specific mileage multiplier considers the performance of a resource relative to the fleet of resources providing regulation. The resource-specific mileage multiplier will reflect an individual resource's historical performance accuracy and certified ramp capability to determine the maximum resource-specific mileage multiplier.

Under the ISO's proposal, a resource's historical performance accuracy is a 30 day simple average of 15 minute accuracy measurements. In the event that the resource does not provide mileage in a 15 minute interval, the ISO will not include the 15 minute interval in calculating the resource's historic regulation performance accuracy. In the event that a resource has not provided regulation over the prior thirty 30 days, the ISO will use the simple average historic regulation performance accuracy for all resources from the prior 30 days as an initial adjustment factor.

Resources with faster ramp capability may receive greater mileage awards than resources with slower ramp capability. Resources with historic accuracy measurements that are higher than the system wide accuracy may also receive greater mileage awards. For example, if a resource can ramp within one minute to its full regulation capacity it will be awarded ten times the mileage of a resource that requires 10 minutes to reach its full regulation capacity. If resources have similar ramp capability, then a resource with 100 percent accuracy could receive an award that is twice that of a resource with 50 percent accuracy.

<u>Numerical Example</u>

In this example, three different resources with certified regulation capacity each have different historic regulation performance accuracy measurements. Across the entire system, resources historical accuracy performance in responding to the ISO control signal is 85 percent. Each resource has a different ramp rate and a different mileage multiplier. The ISO proposes to calculate the resource-specific mileage multiplier for each resource as follows:

(1) Determine the relative ramping speed of the resource by dividing the resource's certified capacity in MW by the resource's ramp rate per minute and then dividing 10 by that number. The ISO will round this value to an integer between 1 and 10.

(2) Determine the relative accuracy of the resource as compared to other resources by dividing the resource-specific accuracy by the system wide accuracy.

(3) Then multiply the measures of performance in steps (1) and (2) by the system wide mileage multiplier.

For Resource 1, the ISO's proposed calculation follows:
10 / (100/20) = 2
80 / 85 = .94[17]
Hourly system mileage multiplier = 5
2 x .94 x 5 = 9.4

The ISO proposes to calculate an hourly system mileage multiplier by summing the total mileage from all resources (both self-supplied and procured in the ISO market) over the prior week for the given hour and dividing that number by the regulation capacity procured for the week in that hour.

Step 1

	Historical Accuracy	Ramp Rate (MW/Min)	Mileage Multiplier	Capacity MW
Resource 1	80%	20	9.4	100
Resource 2	90%	5	52.9	5
Resource 3	70%	2	4.1	20
System	85%	N/A	5	N/A

Step 2: Determine regulation capacity and mileage requirement

The ISO procures 100 percent of its day-ahead forecasted ancillary services requirements in the day-ahead market. Beginning in October 2009, the ISO added new functionality to vary its regulation capacity requirements in the day-ahead market for different hours of the operating day. The ISO market now procures regulation capacity based on a forecasting tool that reflects varying operational needs throughout the day.[18] This tool calculates the amount of

[17] The ISO has rounded the product of this calculation to .94.

[18] http://www.caiso.com/Documents/TechnicalBulletin-ASProcurement-Regulation.pdf

regulation up and regulation down needed for each hour based on changes in the demand forecast, generation self-schedules, and hourly intertie fluctuation. Based on these variables, the calculation for determining regulation up and regulation down capacity requirements reflects the coincidental 10 minute peak for regulation up and regulation down needs separately for each operating hour. The ISO is not proposing to change how it calculates the regulation capacity requirement in this tariff amendment.

Expected mileage from regulation capacity will determine the mileage requirement that the ISO will establish in the day-ahead market. The ISO proposes to use the minimum of three estimates of expected mileage: The first estimate is the product of the system-wide mileage multiplier and the regulation capacity procurement target. For example, if the regulation capacity procurement target for an operating hour is 350 MW and the system wide mileage multiplier is 5, the mileage procurement target will equal 1750 MW (350 MW x 5). The second estimate will be based on the average actual mileage hour the trading hour from the prior week. The third estimate is the product of a resource-specific mileage multiplier and a resource's self-provided or bid-in regulation capacity, summed for all resources. Under the ISO's proposal, the mileage requirement will not cause the ISO to procure additional regulation capacity.

Numerical Example

In this example, the ISO's existing regulation procurement tool identifies an hourly need for 80 MW of regulation up capacity. The ISO reviews three variables to identify its mileage requirement: (1) product of the system-wide mileage multiplier and the regulation capacity procurement target (5 X 80 MW = 400MW); (2) the average actual mileage from trading hour for the prior week (500 MW); and (3) the product of a resource-specific mileage multiplier and a resource's self-provided or bid-in regulation capacity, summed for all resources (1288 MW). The ISO selects the minimum of these variables as the mileage requirement; in this case, 400 MW.

Step 2

	MW
Regulation Up	80

	Mileage
Prior Week	500
System Multiplier	400
Bid In	1288
Minimum	400

Step 3 – Accept bids and submission to self-provide from market participants; bids include inter-temporal opportunity costs that occur outside of the ISO's market timeframe.

Market participants will submit economic bids and quantities for regulation capacity. Market participants may also submit self-provision of regulation capacity. The market optimization considers cross-product opportunity costs as well as opportunity costs of providing the capacity in one interval as opposed to another across the time horizon of the optimization. The horizon for the day-ahead market is 24 hours. In the real-time unit commitment process, the time horizon is up to 4 hours. Consistent with *Order 755*, the ISO will permit a resource to include additional inter-temporal opportunity costs as part of the resource's capacity bid in either the day-ahead or real-time market.

For mileage, market participants may submit economic bids but no quantities. Market participants may also self-provide mileage, which the ISO will treat as a $0 bid. The quantity of a mileage award that a resource may receive is based upon the minimum and maximum resource-specific mileage multipliers calculated in Step 1. Mileage awarded through the market optimization is not financially binding. Instead, resources are compensated for their actual response to the ISO's control signal at the mileage marginal clearing price, subject to an accuracy adjustment.

Numerical Example

In this example, three resources submit regulation capacity and mileage bids. The capacity bids reflect the volumes identified in the numerical example for Step 1 (Resource 1 bids 100 MW, Resource 2 bids 5 MW, and Resource 3 bids 20 MW). Resource 1 includes an inter-temporal opportunity cost in its regulation capacity bid. The resources bid mileage prices but do not bid mileage quantities.

Step 3

	Regulation Up Bid	Opportunity Cost	Total Reg Up Bid	Mileage Bid
Resource 1	$ 5.00	$ 1.00	$ 6.00	$ 1.50
Resource 2	$ 7.50	$ -	$ 7.50	$ 1.00
Resource 3	$ 10.00	$ -	$ 10.00	$ 1.25

Step 4 – Co-optimize energy, regulation capacity, mileage and ancillary services.

In both the day-ahead and real-time markets, the ISO will co-optimize energy, regulation, mileage and other ancillary services. The ISO's proposed changes to the market optimization follow two guiding principles: (1) avoid disruptions to the

current regulation capacity market design, including allowing regulation up to substitute for spinning reserve and non-spinning reserve when it is economic for the ISO's market optimization to make such substitutions; and (2) determine a uniform clearing price for mileage that takes into consideration expected performance even though the ISO will only compensate resources for actual performance. The ISO's proposed optimization formulation applies two constraints (regulation capacity and mileage) for each resource. This formulation allows a resource to receive an award for regulation capacity, while potentially not being awarded mileage that is in a fixed proportion to the awarded regulation capacity. This approach also ensures that independent shadow prices are calculated for regulation capacity and mileage. If a resource receives a mileage award below its mileage bid the resource will be eligible for bid cost recovery.

Numerical Example

In this example, the resources identified in Step 1 have a submitted energy bids in addition to their regulation up capacity and mileage bids. Resource 1 has also submitted a bid for spinning reserve. The tables below reflect the resources' bid price and MW volumes as well as the requirements for energy, spinning reserve, regulation up capacity and mileage. The ISO's market systems will co-optimize these bids for energy, regulation (capacity and mileage), and spinning reserve.

Step 4

Price	Energy Bid	Spin Bid	Total Reg Up Bid	Mileage Bid
Resource 1	$ 35.00	$ 3.00	$ 6.00	$ 1.50
Resource 2	$ 80.00	N/A	$ 7.50	$ 1.00
Resource 3	$ 30.00	N/A	$ 10.00	$ 1.25

MW	Energy Bid	Spin Bid	Reg Up Bid	Pmax
Resource 1	400	200	100	400
Resource 2	5	0	5	5
Resource 3	300	0	20	300

	Energy	Spin	Reg Up	Mileage
Requirements	500	100	80	400

Step 5 – Issue financially binding energy and ancillary service capacity awards.

Regulation capacity awards from the market optimization in Step 5 are financially binding. All cleared resources receive a capacity payment at the regulation capacity marginal clearing price for each MW of awarded capacity. Unlike capacity awards, the ISO does not pay participants for self-provided capacity. Instead, self-provided regulation capacity reduces a market participant's ancillary services obligation by the value of the self-provided capacity. In the event the market clearing price is below a resource's regulation capacity bid, the resource is eligible for bid cost recovery as outlined in Step 9.

Numerical Example

Based on the economic bids submitted and the ISO's requirements for energy and ancillary services capacity, the market optimization issues the following awards.

Step 5

Awards (MW)	Energy	Spin	Reg Up
Resource 1	200	100	75
Resource 2	0	0	5
Resource 3	300	0	0

	Energy	Spin	Reg Up
Price	$ 35.00	$ 3.00	$ 6.00

Step 6 – Issue non-financially binding mileage awards.

While a resource is awarded mileage in the market optimization, awarded mileage is not financially binding. Instead, the market optimization establishes the uniform marginal clearing price that the ISO will use to compensate resources based on instructed mileage as adjusted for accuracy.

Numerical Example

In this example, Resources 1 and 2 receive mileage awards and Resource 3 does not receive a mileage award. These awards permit the ISO to calculate a marginal clearing price for mileage ($1.50) based on the mileage requirements and the resources' economic bids. Based on its economic bids, Resource 3 does not receive a capacity award and also does not receive a mileage award.

Step 6

Awards	Mileage
Resource 1	136.5
Resource 2	263.5
Resource 3	0

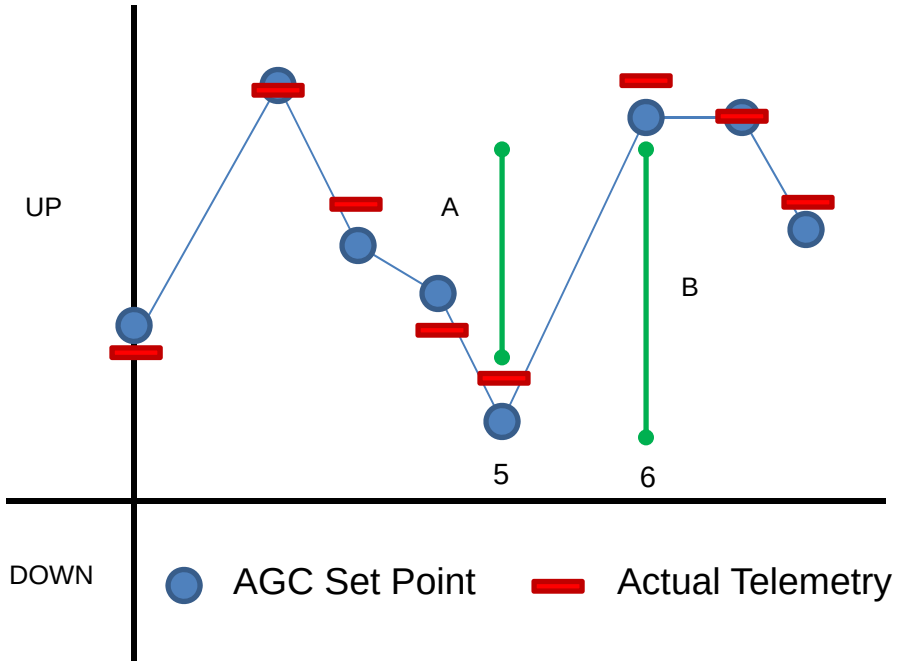
	Mileage
Price	$ 1.50

Step 7 – Calculate instructed mileage, under-response adjustment, and accuracy to determine resource performance

The ISO defines instructed mileage as the absolute change in automatic generation control set points between 4 second intervals. Accuracy is the absolute value of a resource's actual telemetry compared to the resource's automatic generation control set point in a given regulation interval. The ISO considers positive and negative deviations equally in assessing the accuracy of the resource's response to a control signal. Under this proposal, the ISO intends to calculate resource-specific performance based on instructed mileage as adjusted for accuracy. The ISO will measure the accuracy of a resource's response to the ISO's control signal as the absolute value of the difference between the set point and actual telemetry for each 4 second regulation interval. On a 15 minute basis, the ISO will sum a resource's automatic generation control set points for each 4 second regulation interval. The ISO will then sum the total deviations from the set point for each 4 second regulation interval. The sum of the resource's set points less the sum of total deviations bounded by zero will then be divided by the resource's sum of set points. The resulting performance percentage will reflect the accuracy of the resource in responding to the ISO's control signal for each fifteen minute interval. The accuracy percentage value can range from 0 to 100 percent.

Since a resource's mileage is based on changes in automatic generation control set points, the ISO will also adjust a resource's mileage when the resource under-responds in an interval prior to a change in the direction of a control signal. In Figure 2 below, the resource under responds to the control signal in interval 5. Because the direction of the control signal changed, line A reflects the appropriate mileage because the resource achieved its movement toward the set point in interval 6 as a result of under responding to the set point in interval 5. If mileage was calculated simply as the delta between set points as illustrated by line B, the resource would receive an overpayment for mileage.

Figure 2 - Example of Under Response and need to adjust mileage calculation



Numerical Example

In this example, the ISO subtracts the under-response adjustment from the instructed mileage for Resource 1 and Resource 2 to determine that actual mileage to which it will apply the resource's accuracy adjustment, which again reflects the measurement of a resource's actual telemetry compared to the resource's automatic generation control set point in a given regulation interval. The ISO will apply the accuracy percentage to performance payments based upon the instructed mileage less the resource's under-response adjustment.

Step 7

	Instructed Mileage	Under Response	Actual Mileage	Accuracy
Resource 1	80	-5	75	79%
Resource 2	315	-10	305	92%
Resource 3	N/A	N/A	N/A	N/A

Step 8 – Settlement of mileage with a performance adjustment

The ISO will determine an accuracy adjustment for each resource in each 15 minute interval. The ISO will reduce the resource's instructed mileage in the 15 minute interval by the sum of under response adjustments to determine the quantity of mileage, subject to an accuracy adjustment. The ISO will then

calculate the accuracy adjustment as the sum of automatic generation control set points less the 15 minute sum of deviations from the set point, and then divide that number by the sum of the automatic generation control set points. The ISO will apply this percentage to the resource's mileage to calculate a performance payment for the 15 minute interval.

Numerical Example

In this example, the ISO applies the accuracy adjustment to the resources' performance payment based on their instructed mileage less any under-performance adjustment. This is the resources' performance payment for responding to the ISO's control signal.

Step 8

	Mileage
Price	$ 1.50

Payment	Actual Mileage	Pre Adjustment Payment	Accuracy	Payment based upon Performance
Resource 1	75	$ 112.50	79%	$ 88.88
Resource 2	305	$ 457.50	92%	$ 420.90
Resource 3	N/A	N/A	N/A	N/A

Step 9 – Mileage revenue and costs included in bid cost recovery

Since the ISO uses two constraints to establish the market clearing price for mileage, there may be instances in which a resource receives a mileage award when the market clearing price of mileage is below the resource's mileage bid. As a result, the ISO proposes to include mileage revenue and costs as part of bid cost recovery calculations. For each market process, the ISO will include mileage revenue and costs based upon actual compensated mileage (i.e. instructed mileage less the under-response adjustment and multiplied by the resources accuracy adjustment).

Numerical Example

In this example, Resource 1 and Resource 2 have received market revenue associated with energy, spinning reserve and regulation up awards. In this instance, the resources are not eligible for bid cost recovery because their bids were below the market clearing price for these commodities. The ISO has provided numerical examples of cases in which a resource may be eligible for bid cost recovery in the ISO's answer to question 6 in this response.

Step 9

Revenue	Energy	Spin	Reg Up	Mileage	Total
Resource 1	$ 7,000.00	$ 300.00	$ 450.00	$ 88.88	$ 7,838.88
Resource 2	$ -	$ -	$ 30.00	$ 420.90	$ 450.90
Resource 3	$ 10,500.00	$ -	$ -	$ -	$ 10,500.00

Cost	Energy	Spin	Reg Up	Mileage	Total
Resource 1	$ 7,000.00	$ 300.00	$ 450.00	$ 88.88	$ 7,838.88
Resource 2	$ -	$ -	$ 37.50	$ 280.60	$ 318.10
Resource 3	$ 9,000.00	$ -	$ -	$ -	$ 9,000.00

Step 10 – Historical performance tracked for establishing resources specific mileage multipliers in Step 1 and mileage requirement in Step 2.

The ISO proposes to incorporate resources' historical performance into future market optimizations. The ISO will use a historical system-wide mileage multiplier as a variable to determine the mileage procurement target. A resource's accuracy is used to determine the resource's maximum resource-specific mileage multiplier. The use of historical performance information will help the ISO select the optimal portfolio of resources to meet regulation capacity and mileage requirements.

Numerical Example

In this example, the ISO will include resource's performance accuracy for the 15 minute interval as part of the resource's historical performance accuracy, which is calculated as the simple average of performance accuracy for each 15 minute interval over a 30 period. The ISO will not include a 0 accuracy value for Resource 3 because the resource did not provide mileage in this 15 minute interval. The ISO will include the instructed mileage as an input to calculate the average actual mileage for the trading hour for the week. The ISO will use the system performance to calculate a system mileage multiplier that will serve as an input to estimating mileage requirements based on regulation capacity procurement targets.

Step 10

	Accuracy
Resource 1	79%
Resource 2	92%
Resource 3	N/A

	Accuracy	Mileage Multiplier	Prior Week
System	89%	4.9375	395

CERTIFICATE OF SERVICE

I hereby certify that I have served the foregoing document upon the parties listed on the official service lists in the above-referenced proceedings, in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure (18 C.F.R. § 385.2010).

Dated at Folsom, California this 6th day of July 2012.

/s/ Anna Pascuzzo

Anna Pascuzzo