



November 25, 2015

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. ER15-1919-002**

**Compliance Filing Energy Imbalance Market Year One
Enhancements – Phase 1**

Dear Secretary Bose:

In this filing, the CAISO submits tariff revisions in compliance with the Commission's October 26, 2015 order in the above referenced docket ("October 26 Order").¹ The October 26 Order conditionally accepted the CAISO's tariff revisions governing the Energy Imbalance Market. The Commission directed the CAISO to make a compliance filing within 30 days of the date of the order revising Appendix C of the tariff to clarify that the marginal price of congestion in Energy Imbalance Market locational marginal prices ("LMPs") will reflect the shadow price of all binding transmission constraints, including binding physical and available transmission capacity intertie constraints. These revisions are included as Attachment A hereto, with the blackline changes reflected in Attachment B. The CAISO requests that the Commission accept the tariff revisions as complying with the October 26 Order, effective November 4, 2015.²

¹ *Cal. Indep. Sys. Operator Corp.*, 153 FERC ¶ 61,087 (2015) ("October 26 Order").

² See Letter Order, 153 FERC ¶ 61,138 (2015) (accepting CAISO's petition to permit the tariff revisions accepted by the October 26 Order to become effective on November 4, 2015).

I. BACKGROUND

On June 15, 2015, the CAISO filed proposed modifications to its tariff provisions governing the operation of the CAISO's Energy Imbalance Market to (1) allow the use of available transfer capability for EIM transfers, (2) provide a cost based approach for greenhouse gas bidding by EIM participating resources and a means for such resources to avoid dispatch for purposes of serving CAISO load, (3) align the EIM administrative charge with the grid management charge, and (4) include additional elements for the evaluation of resource sufficiency. On June 25, 2015, the CAISO submitted an *errata* to add a section of the transmittal letter (section III.E of the transmittal as corrected) that described one of the tariff changes that had been inadvertently omitted during editing.³ On July 1, 2015, the CAISO submitted an amendment to the original filing to revise the requested effective date of a single tariff provision proposed in the June 15 filing.⁴

On July 30, 2015, the Commission's Office of Energy Market Regulation issued a deficiency letter. The letter indicated that the Commission needed more information regarding the CAISO's proposed use of a EIM transfer cost parameter to optimize the scheduling of EIM transfers and its proposed compliance with the Commission's directive that it provide a mechanism for EIM market participants to opt out of energy sales into California. The letter asked specific questions regarding each issue and directed the CAISO to respond within 30 days. Separately, the Commission noticed a conference to discuss these questions, which occurred on August 11, 2015.

On August 21, 2015, the CAISO answered the questions in the Commission's July 30, 2015 letter requesting additional information regarding the CAISO's proposal and amended the proposed tariff language to address questions raised at the August 11, 2015 conference. The amendments to the proposed tariff provisions addressed the EIM transfer schedule cost, which the market optimization will use to select the most efficient path among multiple potential intertie scheduling paths for EIM transfers. Specifically, the CAISO ensured that the impact of the EIM transfer schedule cost will be *de minimis* by (1) requiring that the EIM transfer schedule cost be less than \$0.01/MWh (instead of \$0.10/MWh cap included in the June 15 filing), and (2) providing that the EIM transfer schedule cost will be the lowest cost that enables the CAISO's security constrained economic dispatch to identify a unique scheduling path that

³ See Docket No. ER15-1919-000 (noticing that comments on the errata are due July 16, 2015).

⁴ See Docket No. ER15-1919-001 (noticing that comments on the amended effective date are due July 16, 2015).

optimizes the objective of satisfying three criteria specified in the tariff. The proposed tariff provisions specified that the CAISO will reflect the EIM transfer schedule cost in the marginal cost of congestion component of the LMP.

In the October 26 Order, the Commission accepted the tariff provisions, subject to a compliance filing. The Commission found that Appendix C of CAISO's tariff is unclear as to whether and how available transfer capacity will be reflected in LMP calculations, especially the congestion component of the LMP. It noted, for example, that the CAISO's current definition of transmission constraint does not appear to reflect the usage of the value of available transfer capacity at any particular interface and how that value would flow through the marginal price of the congestion component in determining LMPs. The Commission directed the CAISO to make a compliance filing within 30 days proposing revisions to Appendix C of its tariff to clarify that the marginal price of congestion in Energy Imbalance Market LMPs will reflect the shadow price of all binding transmission constraints, including binding physical and available transfer capacity intertie constraints.

II. COMPLIANCE FILING

To comply with the Commission's directives, the CAISO proposes to revise Appendix C as shown in the attached tariff records. The revisions reflect the contribution of the shadow price for the power balance constraint of each EIM entity balancing authority area in the marginal congestion component at pricing locations within that EIM entity balancing authority area and for interchange schedules with that EIM entity balancing authority area.

Appendix C describes the components of the LMP. The CAISO's August 21 filing provided that the EIM transfer schedule cost would be included in the marginal cost of congestion component. To provide the level of detail necessary to comply with the October 26 Order, this compliance filing "unpacks" the previously proposed change. As discussed below, the compliance filing necessarily must separate the LMP formulation into a day-ahead and real-time components to accurately capture the marginal cost of congestion calculation associated with EIM transfers.

In that regard, because the Energy Imbalance Market is only a real-time market, day-ahead price calculations do not use a shadow price for the power balance constraint in EIM entity balancing authority areas. Therefore, including the shadow price of the power balancing constraint in the marginal cost of congestion component in sufficient detail, as the Commission directed, requires separate descriptions in the tariff for LMP formulation in the day-ahead market and in the real-time market. The day-ahead LMP formulation remains the same. The revised Appendix C includes a new provision to describe the LMP formulation in the real-time market separately from the LMP formulation in the day-ahead market. The real time market formulation includes additional

information regarding LMP formulation to incorporate the EIM transfer schedule cost.

To determine the real-time LMP, the CAISO designates a reference bus, r , for calculating the system marginal energy cost, which is the shadow price of the system power balance constraint. The CAISO uses the distributed load in the EIM area as the reference bus to calculate loss sensitivities and shift factors used to linearize the power balance and transmission constraints. Resources that have constraints that prevent them from being marginal are not eligible to set the LMP. For each bus other than the reference bus, the CAISO determines the separate components of the LMP, including the marginal cost of congestion.

Appendix C, as revised, provides that the real-time marginal cost of congestion at pricing locations in an EIM entity balancing authority area includes an additional contribution from the shadow price of the power balance constraint for that balancing authority area according to the following formula:

$$MCC_i = \lambda_j - \left(\sum_{k=1}^K PTDF_{ik} * FSP_k \right)$$

Where

- K is the number of thermal or interface transmission constraints
- $PTDF_{ik}$ is the shift factor for the generator at bus i on interface k , which is the change in the power flow across that interface when an increment of power is injected at bus i and an equivalent amount of power is withdrawn at the reference bus
- FSP_k is the constraint shadow price on interface k and is equivalent to the reduction in system cost expressed in \$/MWh that results from an increase of 1MW of the capacity on interface k
- (λ_j) is the shadow price of the power balance constraint for an EIM entity balancing authority area

The revisions explain that the shadow price of the power balance constraint for an EIM entity balancing authority area reflects (1) the shadow price of the EIM transfer distribution constraint, which distributes the EIM transfer for the EIM entity balancing authority area to energy transfers on interties with other EIM entity balancing authority areas, and (2) the shadow price of the EIM transfer scheduling limit for the EIM entity balancing authority area.⁵ The difference

⁵ A power balance constraint is not formulated for the CAISO balancing authority

between the shadow prices of the EIM transfer distribution constraints for two EIM entity balancing authority areas from any intertie used for energy transfers between these two EIM entity balancing authority areas reflects (1) the EIM transfer schedule cost that applies to that intertie, (2) the shadow price of the energy transfer schedule limit from the EIM entity balancing authority area to the other EIM entity balancing authority area that shares that intertie, and (3) the shadow price of the scheduling limit that constrains both energy transfers and additional schedules to an EIM entity balancing authority area on that intertie. The tariff language includes the formulas for each of these calculations, which reflect the shadow price of all constraints on the marginal cost of congestion.

III ATTACHMENTS

Attachment A: Clean Tariff Record

Attachment B: Marked Tariff Record

IV. CONCLUSION

For the reasons set forth in this filing, the CAISO respectfully requests that the Commission accept the proposed tariff revisions as providing the level of detail required by the October 26 Order.

area, because it would be redundant with the system power balance constraint and the power balance constraints for each EIM entity balancing authority area.

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Respectfully submitted,

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CERTIFICATE OF SERVICE

I certify that I have served the foregoing document upon the parties listed on the official service list in the captioned 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 25th day of November, 2015.

/s/ Martha Sedgley

Martha Sedgley

Attachment A – Clean Tariff Records

Appendix C – Locational Marginal Pricing

California Independent System Operator Corporation

Appendix C

Locational Marginal Price

The CAISO shall calculate the price of Energy at Generation PNodes, Scheduling Points, and Aggregated Pricing Nodes, as provided in the CAISO Tariff. LMPs can be set by Bids to sell or purchase Energy. The CAISO establishes Trading Hub prices and LAPs as provided in the CAISO Tariff. The LMPs at PNodes, including Scheduling Points, and Aggregated Pricing Nodes include separate components for the marginal cost of Energy, Marginal Cost of Congestion, and Marginal Cost of Losses. As provided in Sections 6.5.3.2.2 and 6.5.5.2.4, Day-Ahead Market LMPs are calculated and posted on a Day-Ahead basis for each hour of the Day-Ahead Market for Energy and for each Dispatch Interval for the Real-Time LMPs.

A. LMP Composition in the Day-Ahead Market

In each hour of the Day-Ahead Market for Energy, the CAISO calculates the LMP for each PNode, which is equal to the marginal cost of Energy available at the PNode in the hour, based on the Bids of sellers and buyers selected in the Day-Ahead Market for Energy as specified in the Day-Ahead Schedule. The CAISO designates a Reference Bus, r , for calculation of the System Marginal Energy Cost (SMECr). The CAISO uses a distributed Reference Bus to define an aggregate value of Energy for the CAISO Balancing Authority Area. The Locational Marginal Prices are not determined by resources that are not eligible to set the Locational Marginal Price, which includes resources that have constraints that prevent them from being marginal. For each bus other than the Reference Bus, the Transmission Provider determines separate components of the LMP for the marginal cost of Energy, Marginal Cost of Congestion, and Marginal Cost of Losses relative to the Reference Bus, consistent with the following equation:

$$LMP_i = SMEC_r + MCC_i + MCL_i$$

$$LMP_r = SMEC_r$$

where:

- SMEC_r is the LMP component representing the marginal cost of Energy (also referred to as λ) at the Reference Bus, r (System Marginal Energy Cost).

- MCC_i is the LMP component representing the Marginal Cost of Congestion (also referred to as ρ) at bus i relative to the Reference Bus.
- MCL_i is the LMP component representing the Marginal Cost of Losses (also referred to as γ) at bus i relative to the Reference Bus.

B. LMP Composition in the Real-Time Market

In each 15-minute interval and each 5-minute interval of the Fifteen Minute Market and Real-Time Dispatch, respectively, the CAISO calculates the LMP for each PNode, based on the Bids of sellers and buyers selected in those markets as specified in the FMM Schedule and 5-minute Real-Time Dispatch Instructions. The CAISO designates a Reference Bus, r , for calculation of the System Marginal Energy Cost (SMECr), which is the shadow price of the system power balance constraint. The CAISO uses the distributed load in the EIM Area as the Reference Bus to calculate loss sensitivities and shift factors used to linearize the power balance and Transmission Constraints. Resources that have constraints that prevent them from being marginal are not eligible to set the Locational Marginal Price. For each bus other than the Reference Bus, the CAISO determines separate components of the LMP for the marginal cost of Energy, Marginal Cost of Congestion, Marginal Cost of Losses, and EIM Bid Adder relative to the Reference Bus, consistent with the following equation:

$$LMP_i = SMEC_r + MCC_i + MCL_i + MCG_i$$

$$LMP_r = SMEC_r$$

where:

- MCG_i is the LMP component representing the EIM Bid Adder at bus i relative to the Reference Bus.

For each PNode within an EIM Entity Balancing Authority Area, the LMP shall include a fourth component, the EIM Bid Adder component.

C. The System Marginal Energy Cost Component of LMP

The SMEC shall be the same for each location throughout the system. SMEC is the sensitivity of the power balance constraint at the optimal solution. The power balance constraint ensures that the physical law of conservation of Energy (the sum of Generation and imports equals the sum of Demand, including exports and Transmission Losses) is accounted for in the network solution. For the designated reference

location the CAISO will utilize a distributed Load Reference Bus for which constituent PNodes are weighted using the Reference Bus distribution factors. The Load distributed Reference Bus distribution factors are based on the Load Distribution Factors at each PNode that represents cleared Load in the Integrated Forward Market or forecast Load for MPM, RUC and RTM. In the Integrated Forward Market, in the event that the market is not able to clear based on the use of a distributed load Reference Bus, the CAISO will use a distributed generation Reference Bus for which the constituent nodes and the weights are determined economically within the running of the Integrated Forward Market based on available economic bids. In the event that the CAISO employs a distributed generation Reference Bus, it will notify Market Participants of which Integrated Forward Market runs required the use of this backstop mechanism. A distributed Load Reference Bus will be used for RUC and RTM regardless of whether a distributed Generation Reference Bus were used in the corresponding Integrated Forward Market run. Once the Reference Bus is selected, the System Marginal Energy Cost is the cost of economically providing the next increment of Energy at the distributed Reference Bus, based on submitted Bids.

D. Marginal Congestion Component Calculation

The CAISO calculates the Marginal Costs of Congestion at each bus as a component of the bus-level LMP. The Marginal Cost of Congestion (MCC_{*i*}) component of the LMP at bus *i* is calculated in the Day-Ahead Market using the equation:

$$MCC_i = -\left(\sum_{k=1}^K PTDF_{ik} * FSP_k\right)$$

where:

- *K* is the number of thermal or interface Transmission Constraints.

PTDF_{*ik*} is the Power Transfer Distribution Factor for the generator at bus *i* on interface *k* which limits flows across that constraint when an increment of power is injected at bus *i* and an equivalent amount of power is withdrawn at the Reference Bus. The industry convention is to ignore the effect of losses in the determination of PTDFs.

- FSP_{*k*} is the constraint Shadow Price on interface *k* and is equivalent to the reduction in system cost expressed in \$/MWh that results from an increase of 1MW of the capacity on interface *k*.

The MCC at PNodes in an EIM Entity Balancing Authority Area *j* in the Real Time Market includes an

additional contribution from the shadow price of the power balance constraint for that Balancing Authority Area, λ_j , as follows:

$$MCC_i = \lambda_j - \left(\sum_{k=1}^K \text{PTDF}_{ik} * \text{FSP}_k \right)$$

A power balance constraint is not formulated for the CAISO Balancing Authority Area. The shadow price of the power balance constraint for EIM Entity Balancing Authority Area j (λ_j) has the following contributions:

- a) the shadow price of the EIM Transfer distribution constraint (φ_j), which distributes the EIM Transfer for Balancing Authority Area j to Energy transfers on interties with other Balancing Authority Areas in the EIM Area; and
- b) the shadow price of the EIM Transfer scheduling limit for Balancing Authority Area j , upper (v_j) or lower (ξ_j):

$$\lambda_j = \varphi_j - v_j + \xi_j$$

Where λ_j is zero for the CAISO Balancing Authority Area since the power balance constraint is not formulated for it.

The difference between the shadow prices of the EIM Transfer distribution constraints for two Balancing Authority Areas j and k in the EIM Area has the following contributions from any intertie l used for energy transfers between these two Balancing Authority Areas:

- a) the EIM Transfer schedule cost that applies to that intertie l (c_l);
- b) the shadow price of the Energy transfer schedule limit from Balancing Authority Area j to Balancing Authority Area k that applies to that intertie l , upper limit (ρ_l) or lower limit (σ_l); and
- c) the shadow price of the scheduling limit that constrains both Energy transfers and additional schedules to Balancing Authority Area j on that intertie l , upper limit (ζ_l) or lower limit (η_l):

$$\varphi_j - \varphi_k = -c_l - \rho_l + \sigma_l + \zeta_l - \eta_l$$

There may be multiple scheduling limits under (c) above that constrain schedules on a given EIM Intertie.

E. Marginal Losses Component Calculation

The CAISO calculates the Marginal Cost of Losses (MCLi) at each bus i as described in Section 27.1.1.2.

The MCL component of the LMP at any bus i within the CAISO's Balancing Authority Area is calculated using the equation:

$$MCL_i = MLF_i * SMEC_r$$

Where:

- MLFi is the marginal loss factor for PNode i to the system Reference Bus, based on an AC power flow solution. The marginal loss factor at a PNode is the incremental change in the quantity (MW) of transmission losses in the network resulting when serving an increment of Load at the PNode from the Reference Bus.
 - MLFi is equal to $1 - \partial L / \partial G_i$, where: L is system losses, G_i is "generation injection" at PNode i , $\partial L / \partial G_i$ is the partial derivative of system losses with respect to generation injection at bus i , that is, the incremental change in system losses associated with an incremental change in the generation injections at bus i holding constant other injection and withdrawals at all buses other than the Reference Bus and bus i .
- SMECr is the SMEC at the Reference Bus, r .

F. EIM Bid Adder Component Calculation

For EIM Participating Resources within an EIM Entity Balancing Authority Area and Energy imported to or exported from an EIM Entity Balancing Authority Area, the CAISO will include the marginal cost of the EIM Bid Adder in dispatching Energy from the relevant EIM Participating Resources to serve load in the CAISO Balancing Authority Area. The CAISO will allocate the Net Imbalance Energy Export optimally to EIM Participating Resources. This allocation does not depend on the location of the EIM Entity Participating Resource; i.e. the CAISO does not use a shift factor in the allocation. If the Net Imbalance Energy Export from all EIM Entity Balancing Authority Areas as a group is negative or zero, there is no associated Net Imbalance Energy Export allocation or EIM Bid Adder cost. Otherwise the net imbalance energy export allocation constraint is binding and it may have a nonzero EIM Bid Adder price. The CAISO will include the marginal EIM Bid Adder in the LMP charged to the Net Imbalance Energy Export for each PNode within the EIM Entity Balancing Authority Areas.

G. Trading Hub Price Calculation

The CAISO calculates Existing Zone Generation Trading Hub prices, as provided in Section 27.3, based

on the LMP calculations described in this Attachment and in Section 27.2.

H. Load Zone Price Calculation

The CAISO calculates LAP prices as described in Sections 27.2.2.

I. Intertie Scheduling Point Price Calculation

The CAISO calculates LMPs for Scheduling Points, which are represented in the FNM as PNodes or aggregations of PNodes, external to the CAISO Balancing Authority Area, through the same process that is used to calculate LMPs within the CAISO Balancing Authority Area. In some cases, facilities that are part of the CAISO Controlled Grid but are external to the CAISO Balancing Authority Area connect some Intertie Scheduling Points to the CAISO Balancing Authority Area, and in these cases the Scheduling Points are within external Balancing Authority Areas. In both of these cases, the Scheduling Points are represented in the FNM. The CAISO places injections and withdrawals at the Scheduling Point PNodes to represent Bids and Schedules whose supporting physical injection and withdrawal locations may be unknown, and the LMPs for Settlement of accepted Bids are established at the Scheduling Point PNodes.

I.1 Intertie Scheduling Point Price Calculation for IBAA

I.1.1 Scheduling Point Prices

As described in Section 27.5.3, the CAISO's FNM includes a full model of the network topology of each IBAA. The CAISO will specify Resource IDs that associate Intertie Scheduling Point Bids and Schedules with supporting injection and withdrawal locations on the FNM. These Resource IDs may be specified by the CAISO based on the information available to it, or developed pursuant to a Market Efficiency Enhancement Agreement. Once these Resource IDs are established, the CAISO will determine Intertie Scheduling Point LMPs based on the injection and withdrawal locations associated with each Intertie Scheduling Point Bid and Schedule by the appropriate Resource ID. In calculating these LMPs the CAISO follows the provisions specified in Section 27.5.3 regarding the treatment of Transmission Constraints and losses on the IBAA network facilities. Unless otherwise required pursuant to an effective MEEA, the default pricing for all imports from the IBAA(s) to the CAISO Balancing Authority Area will be based on the SMUD/TID IBAA Import LMP and all exports to the IBAA(s) from the CAISO Balancing Authority Area will be based on the SMUD/TID IBAA Export LMP. The SMUD/TID IBAA Import LMP will be calculated based on modeling of supply resources that assumes all supply is from the Captain Jack

substation as defined by WECC. The SMUD/TID IBAA Export LMP will be calculated based on the Sacramento Municipal Utility District hub that reflects Intertie distribution factors developed from a seasonal power flow base case study of the WECC region using an equivalencing technique that requires the Sacramento Municipal Utility District hub to be equivalenced to only the buses that comprise the aggregated set of load resources in the IBAA, with all generation also being retained at its buses within the IBAA. The resulting load distribution within each aggregated set of load resources within the IBAA defines the Intertie distribution factors for exports from the CAISO Balancing Authority Area.

I.1.2 Applicable Marginal Losses Adjustment

For import Schedules to the CAISO Balancing Authority Area at the southern terminus of the California-Oregon Transmission Project at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority and the Western Area Power Administration system, the CAISO will replace the Marginal Cost of Losses at the otherwise applicable source for such Schedules with the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system, provided that the Scheduling Coordinators certify as discussed further below that the Schedules originate from transactions that use: (a) the California-Oregon Transmission Project; or (b) transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, as described further below, the Scheduling Coordinator must certify that the Schedules are subject to: (a) charges for losses by the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) charges for losses by the Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. The CAISO will establish Resource IDs that are to be used only to submit Bids, including Self-Schedules, for the purpose of establishing Schedules that are eligible for this loss adjustment.

Prior to obtaining such Resource IDs, the relevant Scheduling Coordinator shall certify that it will only use this established Resource ID for Bids, including Self-Schedules, that originate from transactions that use: (a) the California-Oregon Transmission Project; or (b) transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, the Scheduling Coordinator must certify that the Schedules are subject to: (a) charges for losses by the Western Area Power Administration for

the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. Further, by actually using such Resource ID, the Scheduling Coordinator represents that such Bids, including Self-Schedules, that originate from transactions that use: (a) the California-Oregon Transmission Project; or (b) transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, the Scheduling Coordinator must certify that the Schedules are subject to: (a) charges for losses by the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. Schedules and Dispatches settled under such Resource IDs shall be subject to an LMP which has accounted for the Marginal Cost of Losses as if there were an actual physical generation facility at the Tracy Scheduling Point or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system as opposed to the Marginal Cost of Losses under the IBAA LMPs specified in Section G.1.1 of this Appendix. The CAISO may request information on a monthly basis from such Scheduling Coordinators to verify these certifications. Any such request shall be limited to transactions that use the designated Resource IDs during the six month prior period to the date of the request. The CAISO will calculate a re-adjustment of the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system to reflect the otherwise applicable source for such Schedules for any Settlement Interval in which the CAISO has determined that the Scheduling Coordinator's payments did not reflect transactions that meet the above specified certification requirements. Any amounts owed to the CAISO for such Marginal Cost of Losses re-adjustments will be recovered by the CAISO from the affected Scheduling Coordinator by netting the amounts owed from payments due in subsequent Settlements Statements until the outstanding amounts are fully recovered.

For export Schedules from the CAISO Balancing Authority Area at the southern terminus of the California-Oregon Transmission Project at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system, the CAISO will replace the Marginal Cost of Losses at the otherwise applicable sink for such Schedules with

the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system, provided that the Scheduling Coordinator certifies, as discussed below, where the export Schedules use: (a) the California-Oregon Transmission Project; or (b) any transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, the Scheduling Coordinator must certify that the affected Schedules are charged losses by: (a) the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. The CAISO will establish Resource IDs that are to be used only to submit Bids, including Self-Schedules, for the purpose of establishing Schedules that are eligible for this loss adjustment. Prior to obtaining such Resource IDs, the relevant Scheduling Coordinator shall certify that it will only use this established Resource ID for Bids, including Self-Schedules, where the export Schedules use: (a) the California-Oregon Transmission Project; or (b) any transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition the Scheduling Coordinator must certify that the affected Schedules are charged losses by: (a) the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. Further, by actually using such Resource ID, the Scheduling Coordinator represents that such Bids, including Self-Schedules, are used for the above specified conditions.

Schedules and Dispatches settled under such Resource IDs shall be subject to an LMP which has accounted for the Marginal Cost of Losses as if there were an actual physical generation facility at the Tracy Scheduling Point or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system as opposed to the Marginal Cost of Losses under the IBAA LMPs specified in Section G.1.1 of this Appendix. The CAISO may request information on a monthly basis from such Scheduling Coordinators to verify that schedules for such Resource IDs meet the above specified conditions. Any such request shall be limited to transactions that use the designated Resource IDs during the six month prior period to the date of the request.

The CAISO will calculate a re-adjustment of the Marginal Cost of Losses at the Tracy substation or at the

applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system to reflect the otherwise applicable sink for such Schedules for any Settlement Interval in which the CAISO has determined that the Scheduling Coordinator's payments did not reflect transactions that met the above specified conditions. Any amounts owed to the CAISO for such Marginal Cost of Losses re-adjustments will be recovered by the CAISO from the affected Scheduling Coordinator by netting the amounts owed from payments due in subsequent Settlements Statements until the outstanding amounts are fully recovered.

Attachment B – Marked Tariff Records

Appendix C – Locational Marginal Pricing

California Independent System Operator Corporation

Appendix C

Locational Marginal Price

The CAISO shall calculate the price of Energy at Generation PNodes, Scheduling Points, and Aggregated Pricing Nodes, as provided in the CAISO Tariff. LMPs can be set by Bids to sell or purchase Energy. The CAISO establishes Trading Hub prices and LAPs as provided in the CAISO Tariff. The LMPs at PNodes, including Scheduling Points, and Aggregated Pricing Nodes include separate components for the marginal cost of Energy, Marginal Cost of Congestion, and Marginal Cost of Losses. As provided in Sections 6.5.3.2.2 and 6.5.5.2.4, Day-Ahead Market LMPs are calculated and posted on a Day-Ahead basis for each hour of the Day-Ahead Market for Energy and for each Dispatch Interval for the Real-Time LMPs.

A. LMP Composition in the Day-Ahead Market

In each hour of the Day-Ahead Market for Energy, the CAISO calculates the LMP for each PNode, which is equal to the marginal cost of Energy available at the PNode in the hour, based on the Bids of sellers and buyers selected in the Day-Ahead Market for Energy as specified in the Day-Ahead Schedule. The CAISO designates a Reference Bus, r , for calculation of the System Marginal Energy Cost (SMECr). The CAISO uses a distributed Reference Bus to define an aggregate value of Energy for the CAISO Balancing Authority Area. The Locational Marginal Prices are not determined by resources that are not eligible to set the Locational Marginal Price, which includes resources that have constraints that prevent them from being marginal. For each bus other than the Reference Bus, the Transmission Provider determines separate components of the LMP for the marginal cost of Energy, Marginal Cost of Congestion, and Marginal Cost of Losses relative to the Reference Bus, consistent with the following equation:

$$LMP_i = SMEC_r + MCC_i + MCL_i$$

$$LMP_r = SMEC_r$$

where:

- SMEC_r is the LMP component representing the marginal cost of Energy (also referred to as λ) at the Reference Bus, r (System Marginal Energy Cost).

- MCC_i is the LMP component representing the Marginal Cost of Congestion (also referred to as ρ) at bus i relative to the Reference Bus; ~~which also reflects any EIM Transfer schedule costs applied pursuant to Section 29.17(g).~~
- MCL_i is the LMP component representing the Marginal Cost of Losses (also referred to as γ) at bus i relative to the Reference Bus.

B. LMP Composition in the Real-Time Market

In each 15-minute interval and each 5-minute interval of the Fifteen Minute Market and Real-Time Dispatch, respectively, the CAISO calculates the LMP for each PNode, based on the Bids of sellers and buyers selected in those markets as specified in the FMM Schedule and 5-minute Real-Time Dispatch Instructions. The CAISO designates a Reference Bus, r , for calculation of the System Marginal Energy Cost (SMECr), which is the shadow price of the system power balance constraint. The CAISO uses the distributed load in the EIM Area as the Reference Bus to calculate loss sensitivities and shift factors used to linearize the power balance and Transmission Constraints. Resources that have constraints that prevent them from being marginal are not eligible to set the Locational Marginal Price. For each bus other than the Reference Bus, the CAISO determines separate components of the LMP for the marginal cost of Energy, Marginal Cost of Congestion, Marginal Cost of Losses, and EIM Bid Adder relative to the Reference Bus, consistent with the following equation:

$$LMP_i = SMEC_r + MCC_i + MCL_i + MCG_i$$

$$LMP_r = SMEC_r$$

where:

- MCG_i is the LMP component representing the EIM Bid Adder at bus i relative to the Reference Bus.

For each PNode within an EIM Entity Balancing Authority Area, the LMP shall include a fourth component, the EIM Bid Adder component.

BC. The System Marginal Energy Cost Component of LMP

The SMEC shall be the same for each location throughout the system. SMEC is the sensitivity of the power balance constraint at the optimal solution. The power balance constraint ensures that the physical law of conservation of Energy (the sum of Generation and imports equals the sum of Demand, including

exports and Transmission Losses) is accounted for in the network solution. For the designated reference location the CAISO will utilize a distributed Load Reference Bus for which constituent PNodes are weighted using the Reference Bus distribution factors. The Load distributed Reference Bus distribution factors are based on the Load Distribution Factors at each PNode that represents cleared Load in the Integrated Forward Market or forecast Load for MPM, RUC and RTM. In the Integrated Forward Market, in the event that the market is not able to clear based on the use of a distributed load Reference Bus, the CAISO will use a distributed generation Reference Bus for which the constituent nodes and the weights are determined economically within the running of the Integrated Forward Market based on available economic bids. In the event that the CAISO employs a distributed generation Reference Bus, it will notify Market Participants of which Integrated Forward Market runs required the use of this backstop mechanism. A distributed Load Reference Bus will be used for RUC and RTM regardless of whether a distributed Generation Reference Bus were used in the corresponding Integrated Forward Market run. Once the Reference Bus is selected, the System Marginal Energy Cost is the cost of economically providing the next increment of Energy at the distributed Reference Bus, based on submitted Bids.

CD. Marginal Congestion Component Calculation

The CAISO calculates the Marginal Costs of Congestion at each bus as a component of the bus-level LMP; ~~and also reflects any EIM Transfer schedule costs applied pursuant to Section 29.17(g).~~ The Marginal Cost of Congestion (MCC_i) component of the LMP at bus *i* is calculated in the Day-Ahead Market using the equation:

$$MCC_i = -(\sum_{k=1}^K PTDF_{ik} * FSP_k)$$

where:

- *K* is the number of thermal or interface Transmission Constraints.

PTDF_{ik} is the Power Transfer Distribution Factor for the generator at bus *i* on interface *k* which limits flows across that constraint when an increment of power is injected at bus *i* and an equivalent amount of power is withdrawn at the Reference Bus. The industry convention is to ignore the effect of losses in the determination of PTDFs.

- FSP_k is the constraint Shadow Price on interface *k* and is equivalent to the reduction in system cost expressed in \$/MWh that results from an increase of 1MW of the capacity on

interface k .

The MCC at PNodes in an EIM Entity Balancing Authority Area j in the Real Time Market includes an additional contribution from the shadow price of the power balance constraint for that Balancing Authority Area, λ_j , as follows:

$$MCC_j = \lambda_j - \left(\sum_{k=1}^K \text{PTDF}_{jk} * \text{FSP}_k \right)$$

A power balance constraint is not formulated for the CAISO Balancing Authority Area. The shadow price of the power balance constraint for EIM Entity Balancing Authority Area j (λ_j) has the following contributions:

- a) the shadow price of the EIM Transfer distribution constraint (φ_j), which distributes the EIM Transfer for Balancing Authority Area j to Energy transfers on interties with other Balancing Authority Areas in the EIM Area; and
- b) the shadow price of the EIM Transfer scheduling limit for Balancing Authority Area j , upper (v_j) or lower (ξ_j):

$$\lambda_j = \varphi_j - v_j + \xi_j$$

Where λ_j is zero for the CAISO Balancing Authority Area since the power balance constraint is not formulated for it.

The difference between the shadow prices of the EIM Transfer distribution constraints for two Balancing Authority Areas j and k in the EIM Area has the following contributions from any intertie l used for energy transfers between these two Balancing Authority Areas:

- a) the EIM Transfer schedule cost that applies to that intertie l (c_l);
- b) the shadow price of the Energy transfer schedule limit from Balancing Authority Area j to Balancing Authority Area k that applies to that intertie l , upper limit (ρ_l) or lower limit (σ_l); and
- c) the shadow price of the scheduling limit that constrains both Energy transfers and additional schedules to Balancing Authority Area j on that intertie l , upper limit (ζ_l) or lower limit (η_l):

$$\varphi_j - \varphi_k = -c_l - \rho_l + \sigma_l + \zeta_l - \eta_l$$

There may be multiple scheduling limits under (c) above that constrain schedules on a given EIM Intertie.

~~The Shadow Price at a given binding Transmission Constraint is the value per MW of the next increment of generation that would flow across the constrained path by relaxing the binding Transmission Constraint. The PTDF of a PNode with respect to a transmission path (and direction on the path) measures the change in the power flow through the path (positive or negative, with respect to the designated direction on the path) as a result of an incremental injection at the Node, balanced by incremental change of Load at the Reference Bus.~~

DE. Marginal Losses Component Calculation

The CAISO calculates the Marginal Cost of Losses (MCL_i) at each bus *i* as described in Section 27.1.1.2. The MCL component of the LMP at any bus *i* within the CAISO's Balancing Authority Area is calculated using the equation:

$$MCL_i = MLF_i * SMEC_r$$

Where:

- MLF_i is the marginal loss factor for PNode *i* to the system Reference Bus, based on an AC power flow solution. The marginal loss factor at a PNode is the incremental change in the quantity (MW) of transmission losses in the network resulting when serving an increment of Load at the PNode from the Reference Bus.
 - MLF_i is equal to $1 - \partial L / \partial G_i$, where: *L* is system losses, *G_i* is "generation injection" at PNode *i*, $\partial L / \partial G_i$ is the partial derivative of system losses with respect to generation injection at bus *i*, that is, the incremental change in system losses associated with an incremental change in the generation injections at bus *i* holding constant other injection and withdrawals at all buses other than the Reference Bus and bus *i*.
- SMEC_r is the SMEC at the Reference Bus, *r*.

EF. EIM Bid Adder Component Calculation

For EIM Participating Resources within an EIM Entity Balancing Authority Area and Energy imported to or exported from an EIM Entity Balancing Authority Area, the CAISO will include the marginal cost of the EIM Bid Adder in dispatching Energy from the relevant EIM Participating Resources to serve load in the CAISO Balancing Authority Area. The CAISO will allocate the Net Imbalance Energy Export optimally to EIM Participating Resources. This allocation does not depend on the location of the EIM Entity

Participating Resource; i.e. the CAISO does not use a shift factor in the allocation. If the Net Imbalance Energy Export from all EIM Entity Balancing Authority Areas as a group is negative or zero, there is no associated Net Imbalance Energy Export allocation or EIM Bid Adder cost. Otherwise the net imbalance energy export allocation constraint is binding and it may have a nonzero EIM Bid Adder price. The CAISO will include the marginal EIM Bid Adder in the LMP charged to the Net Imbalance Energy Export for each PNode within the EIM Entity Balancing Authority Areas.

FG. Trading Hub Price Calculation

The CAISO calculates Existing Zone Generation Trading Hub prices, as provided in Section 27.3, based on the LMP calculations described in this Attachment and in Section 27.2.

GH. Load Zone Price Calculation

The CAISO calculates LAP prices as described in Sections 27.2.2.

HJ. Intertie Scheduling Point Price Calculation

The CAISO calculates LMPs for Scheduling Points, which are represented in the FNM as PNodes or aggregations of PNodes, external to the CAISO Balancing Authority Area, through the same process that is used to calculate LMPs within the CAISO Balancing Authority Area. In some cases, facilities that are part of the CAISO Controlled Grid but are external to the CAISO Balancing Authority Area connect some Intertie Scheduling Points to the CAISO Balancing Authority Area, and in these cases the Scheduling Points are within external Balancing Authority Areas. In both of these cases, the Scheduling Points are represented in the FNM. The CAISO places injections and withdrawals at the Scheduling Point PNodes to represent Bids and Schedules whose supporting physical injection and withdrawal locations may be unknown, and the LMPs for Settlement of accepted Bids are established at the Scheduling Point PNodes.

HJ.1 Intertie Scheduling Point Price Calculation for IBAA's

HJ.1.1 Scheduling Point Prices

As described in Section 27.5.3, the CAISO's FNM includes a full model of the network topology of each IBAA. The CAISO will specify Resource IDs that associate Intertie Scheduling Point Bids and Schedules with supporting injection and withdrawal locations on the FNM. These Resource IDs may be specified by the CAISO based on the information available to it, or developed pursuant to a Market Efficiency Enhancement Agreement. Once these Resource IDs are established, the CAISO will determine Intertie

Scheduling Point LMPs based on the injection and withdrawal locations associated with each Intertie Scheduling Point Bid and Schedule by the appropriate Resource ID. In calculating these LMPs the CAISO follows the provisions specified in Section 27.5.3 regarding the treatment of Transmission Constraints and losses on the IBAA network facilities. Unless otherwise required pursuant to an effective MEEA, the default pricing for all imports from the IBAA(s) to the CAISO Balancing Authority Area will be based on the SMUD/TID IBAA Import LMP and all exports to the IBAA(s) from the CAISO Balancing Authority Area will be based on the SMUD/TID IBAA Export LMP. The SMUD/TID IBAA Import LMP will be calculated based on modeling of supply resources that assumes all supply is from the Captain Jack substation as defined by WECC. The SMUD/TID IBAA Export LMP will be calculated based on the Sacramento Municipal Utility District hub that reflects Intertie distribution factors developed from a seasonal power flow base case study of the WECC region using an equivalencing technique that requires the Sacramento Municipal Utility District hub to be equivalenced to only the buses that comprise the aggregated set of load resources in the IBAA, with all generation also being retained at its buses within the IBAA. The resulting load distribution within each aggregated set of load resources within the IBAA defines the Intertie distribution factors for exports from the CAISO Balancing Authority Area.

HI.1.2 Applicable Marginal Losses Adjustment

For import Schedules to the CAISO Balancing Authority Area at the southern terminus of the California-Oregon Transmission Project at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority and the Western Area Power Administration system, the CAISO will replace the Marginal Cost of Losses at the otherwise applicable source for such Schedules with the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system, provided that the Scheduling Coordinators certify as discussed further below that the Schedules originate from transactions that use: (a) the California-Oregon Transmission Project; or (b) transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, as described further below, the Scheduling Coordinator must certify that the Schedules are subject to: (a) charges for losses by the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) charges for losses by the Transmission Agency

of Northern California for the use of the California-Oregon Transmission Project. The CAISO will establish Resource IDs that are to be used only to submit Bids, including Self-Schedules, for the purpose of establishing Schedules that are eligible for this loss adjustment.

Prior to obtaining such Resource IDs, the relevant Scheduling Coordinator shall certify that it will only use this established Resource ID for Bids, including Self-Schedules, that originate from transactions that use: (a) the California-Oregon Transmission Project; or (b) transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, the Scheduling Coordinator must certify that the Schedules are subject to: (a) charges for losses by the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. Further, by actually using such Resource ID, the Scheduling Coordinator represents that such Bids, including Self-Schedules, that originate from transactions that use: (a) the California-Oregon Transmission Project; or (b) transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, the Scheduling Coordinator must certify that the Schedules are subject to: (a) charges for losses by the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. Schedules and Dispatches settled under such Resource IDs shall be subject to an LMP which has accounted for the Marginal Cost of Losses as if there were an actual physical generation facility at the Tracy Scheduling Point or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system as opposed to the Marginal Cost of Losses under the IBAA LMPs specified in Section G.1.1 of this Appendix. The CAISO may request information on a monthly basis from such Scheduling Coordinators to verify these certifications. Any such request shall be limited to transactions that use the designated Resource IDs during the six month prior period to the date of the request. The CAISO will calculate a re-adjustment of the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system to reflect the otherwise applicable source for such Schedules for any Settlement Interval in which the CAISO has determined that the

Scheduling Coordinator's payments did not reflect transactions that meet the above specified certification requirements. Any amounts owed to the CAISO for such Marginal Cost of Losses re-adjustments will be recovered by the CAISO from the affected Scheduling Coordinator by netting the amounts owed from payments due in subsequent Settlements Statements until the outstanding amounts are fully recovered.

For export Schedules from the CAISO Balancing Authority Area at the southern terminus of the California-Oregon Transmission Project at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system, the CAISO will replace the Marginal Cost of Losses at the otherwise applicable sink for such Schedules with the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system, provided that the Scheduling Coordinator certifies, as discussed below, where the export Schedules use: (a) the California-Oregon Transmission Project; or (b) any transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition, the Scheduling Coordinator must certify that the affected Schedules are charged losses by: (a) the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. The CAISO will establish Resource IDs that are to be used only to submit Bids, including Self-Schedules, for the purpose of establishing Schedules that are eligible for this loss adjustment. Prior to obtaining such Resource IDs, the relevant Scheduling Coordinator shall certify that it will only use this established Resource ID for Bids, including Self-Schedules, where the export Schedules use: (a) the California-Oregon Transmission Project; or (b) any transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA. In addition the Scheduling Coordinator must certify that the affected Schedules are charged losses by: (a) the Western Area Power Administration for the use of transmission facilities owned by the Western Area Power Administration within the SMUD/TID IBAA; or (b) Transmission Agency of Northern California for the use of the California-Oregon Transmission Project. Further, by actually using such Resource ID, the Scheduling Coordinator represents that such Bids, including Self-Schedules, are used for the above specified conditions.

Schedules and Dispatches settled under such Resource IDs shall be subject to an LMP which has

accounted for the Marginal Cost of Losses as if there were an actual physical generation facility at the Tracy Scheduling Point or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system as opposed to the Marginal Cost of Losses under the IBAA LMPs specified in Section G.1.1 of this Appendix. The CAISO may request information on a monthly basis from such Scheduling Coordinators to verify that schedules for such Resource IDs meet the above specified conditions. Any such request shall be limited to transactions that use the designated Resource IDs during the six month prior period to the date of the request.

The CAISO will calculate a re-adjustment of the Marginal Cost of Losses at the Tracy substation or at the applicable Scheduling Point that connects the CAISO Balancing Authority Area and the Western Area Power Administration system to reflect the otherwise applicable sink for such Schedules for any Settlement Interval in which the CAISO has determined that the Scheduling Coordinator's payments did not reflect transactions that met the above specified conditions. Any amounts owed to the CAISO for such Marginal Cost of Losses re-adjustments will be recovered by the CAISO from the affected Scheduling Coordinator by netting the amounts owed from payments due in subsequent Settlements Statements until the outstanding amounts are fully recovered.