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# Appendix C - Locational Marginal Price

***This is an existing appendix.******All changes due to the EDAM initiative are added in redline. These second round revisions accept the deleted text from the first round and use yellow highlighting to indicate any subsequent revisions****.*

# Appendix CLocational 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. The CAISO establishes Trading Hub prices and LAPs as provided in the CAISO Tariff. The LMPs at PNodes, Scheduling Points, and Aggregated Pricing Nodes include separate components for the Marginal Energy Cost, Marginal Cost of Congestion, Marginal Cost of Losses, and Marginal GHG Cost. As provided in Sections 6.5.3.2.2 and 6.5.5.2.4, LMPs are calculated and posted for each hour of the Day-Ahead Market and for each interval of the Real-Time Market.

## A. LMP Composition in the Day-Ahead Market and the Real-Time Market

In each hour of the Day-Ahead Market, each 15-minute interval of the Fifteen-Minute Market, and each 5-minute interval of the Real-Time Dispatch, the CAISO calculates the LMP for each PNode, which is based on the Bids of sellers and buyers selected in the Day-Ahead or Real-Time Market as calculated below. The CAISO uses a Reference Bus for the calculation of the Locational Marginal Prices. The Reference Bus is the distributed load in the Market Area used in the AC power flow solution to distribute the deviations for Transmission Losses between iterations, and also in sensitivity calculations that yield rates for Marginal Losses and the Power Transfer Distribution Factors. If the CAISO Market solution reverts to a DC power flow solution, the Reference Bus is not used because Transmission Losses are not included. Nevertheless, the CAISO reflects the Transmission Losses for the Market Area in the DC power flow solution by adjusting the load by the average loss factor. The Locational Marginal Prices are not determined by resources that are not eligible to set the Locational Marginal Price as defined in Sections 31.3.1.4 and 34.20.2.3. For each PNode, the CAISO determines separate components of the LMP for the Marginal Energy Cost, Marginal Cost of Congestion, Marginal Cost of Losses, and Marginal GHG Cost, as follows:

where:

* *i* is the PNode index.
* is the LMP component representing the Marginal Energy Cost at PNode *i*.
* is the LMP component representing the Marginal Cost of Congestion at PNode *i*.
* is the LMP component representing the Marginal Cost of Losses at PNode *i*.
* is the LMP component representing the Marginal GHG Cost at PNode *i*.

## B. [Not Used]

## C. Marginal Energy Cost Component of the LMP

The MEC is the same for all PNodes in each Balancing Authority Area in the Market Area. The MEC is the Shadow Price of the power balance constraint for the respective Balancing Authority Area at the optimal solution. The power balance constraint for each Balancing Authority Area in the Market Area 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, plus the Net Market Transfer) is accounted for in the market solution. The MEC for the Transfer System Resources (TSRs) on each side of the Market Transfer that they model is the MEC of the respective Balancing Authority Area. The MEC may be different between two Balancing Authority Areas in the Market Area when Market Transfers between these Balancing Authority Areas are scheduled at their respective scheduling limits. The MEC difference between the Balancing Authority Areas on either side of a specific Market Transfer generates Market Transfer revenue.

## D. Marginal Congestion Component of the LMP

The CAISO calculates the Marginal Cost of Congestion at each PNode as the net contribution of the Shadow Prices of the binding Transmission Constraints at the optimal solution, weighed by the respective Power Transfer Distribution Factors, as follows:

where:

• *i* is the PNode index.

• *m* is the Transmission Constraint index in the Market Area; transmission constraints outside the Market Area are not enforced.

• *k* is the constraint case index; zero (0) indicates the base case where all transmission and generation facilities are in service, whereas a positive case indicates a preventive transmission or generation contingency case, or a deployment scenario for Uncertainty Awards, as applicable.

• *j* is the transmission component index of Transmission Constraint *m*. When Transmission Constraint *m* is a Nomogram, there can be more than one transmission components in it; otherwise, there is only one transmission component.

• *K* is the number of constraint cases, besides the base case.

• *M* is the number of Transmission Constraints.

• is the number of transmission components of Transmission Constraint *m*.

• is the Power Transfer Distribution Factor (PTDF) for PNode *i* on transmission component *j* of Transmission Constraint *m* in constraint case *k*; it is the flow contribution on that transmission component *j* when an increment of power is injected at PNode *i* and an equivalent amount of power is withdrawn at the Reference Bus. For Market Area Intertie resources at a Scheduling Point, and TSRs at a Transfer Location, the PTDF to an intertie constraint or intertie scheduling limit at that Scheduling Point is +1 for an import and –1 for an export. The CAISO does not consider the effect of Transmission Losses in the calculation of PTDFs; they depend only on the network configuration. Furthermore, the difference between the PTDFs at two PNodes with respect to any binding Transmission Constraint, and thus the difference between the MCCs of the LMPs at these PNodes, is independent from the selection of the Reference Bus.

• is the constraint coefficient for transmission component *j* of Transmission Constraint *m* when Transmission Constraint *m* is a Nomogram; otherwise, this constraint coefficient is always one.

• is the Shadow Price of Transmission Constraint *m* in constraint case *k*.

## E. Marginal Losses Component of the LMP

The CAISO calculates the Marginal Cost of Losses at each PNode as the product of the MEC and the rate for Marginal Losses at that PNode, as follows:

Where the rate for Marginal Losses at PNode *i* () is the sensitivity (partial derivative) of system losses (*L*) to an increment of power injected at that PNode () and absorbed by the distributed load reference. The distributed load reference is the scheduled load in the IFM and the distributed demand forecast in the RUC and RTM, within the Market Area. This calculation reflects the area interchange control feature of the AC power flow where the net scheduled interchange (NSI) of a Balancing Authority Area in the FNM is kept constant while the iterative solution distributes loss deviation from the previous iteration to the distributed load reference. Consequently, the MCLs of the TSRs that model a Market Transfer at a Transfer Location between two Balancing Authority Areas in the Market Area may be different because these TSRs belong to different Balancing Authority Areas. The MCL difference between the TSRs on either side of a specific Market Transfer generates Market Transfer revenue. The Marginal Losses on transmission facilities outside the Market Area are ignored in the calculation of the MCL.

## F. Marginal Greenhouse Gas Cost Component of the LMP

The CAISO employs a GHG model in the DAM and RTM as described in Sections 29.32 and 33.32. The GHG model calculates an optimal GHG Transfer for each GHG Regulation Area. If the GHG Transfer for a GHG Regulation Area is positive (denoting an import), it is allocated optimally to resources outside the GHG Regulation Area based on those resources’ GHG Bid Adders. In that case, the Marginal GHG Cost for all PNodes in a specific GHG Regulation Area is the Shadow Price of the GHG Transfer allocation constraint for that GHG Regulation Area. If the GHG Transfer is negative (denoting an export), the GHG Transfer allocation constraint is not binding, all GHG attributions are zero for that GHG Regulation Area, and the Marginal GHG Cost for all PNodes in the GHG Regulation Area is also zero. The Marginal GHG Cost outside of GHG Regulation Areas will always be zero. Furthermore, the Marginal GHG Cost of a TSR is always zero, even when its Transfer Location is within or at the border of a GHG Regulation Area, because the associated GHG regulation cost is collected from the Energy settlement of all physical resources within the GHG Regulation Area and paid explicitly to the respective resources or to the load in the GHG Regulation Area.

## 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 intertie resources at Scheduling Points, which are represented in the FNM as PNodes or aggregations of PNodes external to the Market Area (*i.e.*, at the boundary of a Balancing Authority Area inside the Market Area with a Balancing Authority Area outside the Market Area), through the same process that is used to calculate LMPs for PNodes within the Market 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 these cases, the Scheduling Points are represented in the FNM at the relevant Locations and used to schedule imports and exports to/from the CAISO Balancing Authority Area. The MCC of the LMP at a Scheduling Point includes contributions from binding intertie constraints and intertie scheduling limits that constrain import/export Schedules at the relevant Scheduling Point. Normally, System Resources are registered at a Scheduling Point to a Balancing Authority Area in the Market Area to model Energy or capacity imports/exports from/to a Balancing Authority Area outside the Market Area. In this case, the CAISO distributes the import/export Energy Schedule or capacity award of the System Resource to the Default Generation Aggregation Point (DGAP) of the Balancing Authority Area outside the Market Area that is the source/sink. If the source/sink Balancing Authority Area is unknown at the time the CAISO Market runs, the CAISO distributes the import/export Energy Schedule or capacity award of the relevant System Resource to the Generic Generation Aggregation Point (GGAP) for the relevant Scheduling Point, and the MCL and MCC of the LMP of the System Resource reflect the Marginal Losses and Congestion at the relevant DGAP or GGAP, respectively.

In certain cases, System Resources are registered at a Scheduling Point to a Balancing Authority Area in the Market Area to model Energy imports/exports from/to another Balancing Authority Area inside the Market Area. This occurs because of differences in the Market Area between the Day-Ahead Market and the Real-Time Market when a Balancing Authority Area is outside the EDAM Area in the Day-Ahead Market, but inside the EIM Area in the Real-Time Market. In this case, the day-ahead Energy schedule of the relevant System Resource cannot be distributed in the Real-Time Market to the DGAP of the source/sink Balancing Authority Area that is in the EIM Area because the resources in that Balancing Authority Area are optimally dispatched. Instead, the day-ahead Energy schedule of the relevant System Resource is distributed to the PNode(s) of the relevant Scheduling Point, but cancelled with an opposite base Energy schedule of an EIM Mirror System Resource at the same Scheduling Point. The EIM Mirror System Resource belongs to the source/sink Balancing Authority Area and its base Energy schedule matches the day-ahead Energy schedule of the System Resource it mirrors. The EIM Mirror System Resource that mirrors a System Resource has an export base schedule that matches the day-ahead import schedule of its mirrored System Resource, or a base import schedule that matches the day-ahead export schedule of its mirrored System Resource. The LMPs of the EIM Mirror System Resource and the System Resource it mirrors are different in general because the MEC, MCL, and MCC components differ since the two resources belong to different Balancing Authority Areas in the Market Area.

### I.1 Intertie Scheduling Point Price Calculation for IBAAs

### 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 I.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 I.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.