ATTACHMENT DD

Day-Ahead Locational Marginal Prices

The following procedures apply to both Day Ahead Ex Ante LMPs and Day Ahead Ex Post LMPs. The Transmission Provider calculates the price of Energy at the Load buses and Resource buses in the Transmission Provider's Market Footprint and at the External Interfaces between the Transmission Provider's Market Footprint and adjacent BAs on the basis of LMPs. LMPs can be set by Offers to sell or Bids to purchase Energy, including Physical Bilateral Transactions. The Transmission Provider establishes Hubs and Load Zones based on a pre-defined set of buses. The LMPs, Hub prices, External Interface prices, and Load Zone prices include separate components for the marginal costs of energy, congestion, and losses. Day-Ahead Market LMPs are calculated and posted on a Day-Ahead basis for each hour of the Day-Ahead Energy Market at 1330 hours EPT, or such later time as may be required from time to time due to unanticipated events.

A. LMP Components

In each hour of the Day-Ahead Energy Market, the Transmission Provider calculates the LMP for each CPNode, which is equal to the marginal cost of Energy available at the CPNode in the hour, based on the Offers of sellers and Bids of buyers selected in the Day-Ahead Energy Market. The Transmission Provider designates a Reference Bus, *r*, for all other buses in the power system. The Marginal Energy Component (MEC_r) is the marginal cost of energy available

to the Reference Bus, based on Offers and Bids selected in the Day-Ahead Energy Market. For each bus other than the Reference Bus, the Transmission Provider determines separate components of the LMP for the marginal costs of energy, congestion, and losses relative to the Reference Bus, consistent with the following equation:

$$LMP_i = MEC_r + MCC_i + MLC_i$$

$$LMP_r = MEC_r$$

where:

- MEC_r is the LMP component representing the marginal cost of Energy (also referred to as λ) at the Reference Bus, *r*.

- 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.

- MLC_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. Marginal Congestion Component Calculation

The Transmission Provider calculates the marginal costs of congestion at each bus as a component of the bus-level LMP. The Marginal Congestion Component (MCC_i) of the LMP at bus *i* is calculated using the equation:

$$MCC_i = -\left(\sum_{k=1}^{k} SF_{ik} * SP_k\right)$$

where:

- *K* is the number of thermal or interface transmission constraints (also called Flowgate), or Sub-Regional Power Balance Constraint.

- SF_{ik} is the shift factor at bus *i* on Flowgate or Sub-Regional Power Balance Constraint *k*. The industry convention is to ignore the effect of losses in the determination of SFs.

- SP_k is the Shadow Price on the Flowgate or Sub-Regional Power Balance Constraint *k* and is equivalent to the reduction in system cost expressed in $/MWh that results from an increase of 1MW of the constraint limit on the Flowgate or Sub-Regional Power Balance Constraint *k*.

C. Marginal Losses Component Calculation

The Transmission Provider calculates the Marginal Losses Component (MLC*i*) at each bus *i*. The MLC of the LMP at any bus *i* within the Transmission Provider's Market Footprint is calculated using the equation:

$$MLC_i = (DF_i - 1) * MEC_r$$

where:

- DF_i is the Delivery Factor for bus *i* to the system Reference Bus.

- DF_i is equal to $(1 - \partial L/\partial G_i)$, where: L is system losses, G_i is "generation injection" at bus *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*.

- MEC_r is the LMP component representing the marginal cost of energy at the Reference Bus, *r*.

D. Hub Price Calculation

The Transmission Provider calculates a hub price based on the LMPs for a set of Elemental Pricing Nodes that comprise the hub. These hub prices are the weighted average of the LMPs at the Elemental Pricing Nodes that comprise the hub. The weights are pre-determined by the Transmission Provider and remain fixed, except as provided below for an ARR Zone administered as a Hub Commercial Pricing Node. Where an ARR Zone is administered as a Hub Commercial Pricing Node, the weighting factor for a specific Elemental Pricing Node is equal to the ratio of the ARR Zone's Demand at the Elemental Pricing Node to the total demand of the ARR Zone, as determined by the results of the State Estimator solution from the average over the twenty-four (24) hours of seven (7) Days prior to the Operating Day.

The price for Hub *j* is:

$$\text{Hub Price}_j = \sum_{i=1}^{NH} (W_{Hi} * \text{LMP}_i)$$

where:

- *NH* is the number of buses in Hub *j*.

- W_{Hi} is the weighting factor for bus *i* in Hub *j*. The sum of the weighting factors must add up to 1.

E. Load Zone Price Calculation

The Transmission Provider calculates a Load Zone price based on the LMPs for a set of buses that comprise the Load Zone. These Load Zone prices are the weighted average of the LMPs at the set of buses that comprise the Load Zone. The Load Zone bus weight is equal to the fractional share of each Load bus in the total Load in the Load Zone in the hour.

The price for Load Zone *j* is:

$$\text{Load Zone Price}_j = \sum_{i=1}^{NZ} (W_{Zi} * \text{LMP}_i)$$

where:

- *NZ* is the number of Load buses in Load Zone *j*.

- W_{Zi} is the load-weighting factor for bus *i* in Load Zone *j*. The sum of the weighting factors must add up to 1. These weights are based on State Estimator results from the 24-hour period, seven days prior to the Operating Day.

When the Load Zone Price is used for Settlements, it is subject to the following rules:

- Each Load Zone includes only the buses of Asset Owners who are in the zone and who have Load that is represented by that zone's definition. Asset Owners that have metered Load must either be settled at a zone defined by their Load points (zonal settlement) or must have a separate Load Zone created for each Load point (nodal settlement). Asset owners in retail choice areas where profiling, rather than metering is used, can be settled at an aggregate of all Load buses in the BA area.

- MPs who want to be billed at a zonal price must include in their zone all of the buses where energy deliveries are billed at the zonal price.

- **Multi-Element Flowgate Shadow Price Calculation**

The Transmission Provider, in addition to the calculation of the LMPs, calculates Flowgate Shadow Prices (FSPs) on sets of transmission constraints. The Transmission Provider calculates the FSP on the set of transmission elements designated as a Flowgate, based on a weighted average of the transmission FSPs that comprise the Flowgate:

$$\text{Flowgate Shadow Price } f = \sum_{k=1}^{M} (W_k * FSP_k)$$

where:

f is the index of Flowgates.

- *k* is a transmission element in the Flowgate *f*.

- *M* is the set of the transmission elements that comprise Flowgate *f*.

- W_k is the weights attached to each of the *M* transmission elements that comprise Flowgate *f*. The sum of the weighting factors adds up to 1. For Flowgates comprised of one transmission element, the W_k for that element is equal to 1. The Transmission Provider determines the W_k for transmission elements defined as Flowgates.

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

F. External Interface Price Calculation

The Transmission Provider calculates an External Interface price for all non-Transmission Provider Balancing Authorities. These prices are based on the LMPs for a set of generator buses that exist in external Balancing Authorities. Generally speaking, the set of buses used for an External Interface price is the set of generators in the external Balancing Authority for which the calculation is being done. If the external Balancing Authority is not in the Transmission Provider Network model, then an electrically equivalent Balancing Authority will be assigned for the Balancing Authority and the interface price for that non-modeled Balancing Authority will use the same interface price as is used for the electrical equivalent. The Transmission Provider may need to change, which EPNodes are used in the External Interface price calculations as operational experience dictates.

The price for an External Interface *j* is:

$$\text{External Interface Price} = \left[\sum_{j=1}^{NE} LMP_i \right] / \textit{NE average of LMPs}$$

where:

- *NE* is the number of buses in External Interface *j*