

Market Bulletin # 30 – September 15, 2006

SPD Price Administration Process

A. Background

This document updates previous Market Bulletins # 5 and # 20 regarding the Price Administration process. The updates include changes made to the process as a result of the implementation of SCR747.

Because the ERCOT Protocols do not specify how ERCOT should calculate prices when it cannot solve constraint violations, ERCOT implemented a set of procedures and formulae for price administration. The procedures are post-processing of the Linear Programming (LP) solutions currently generated by the Scheduling, Pricing, and Dispatching software (SPD). If the LP-solution check detects a constraint violation, then price administration occurs based on the process described in this document. SCR747 eliminated a violation of any Zonal Constraint (OC1) as a trigger for Price Administration in the Real Time Balancing Market Clearing Engine (also known as the Scheduling, Pricing, and Dispatching (SPD) software).

Under normal operating conditions, SPD automatically calculates the zonal market clearing prices and CSC congestion prices. These prices are shadow prices of the optimization solution.

When one or more constraints (*e.g.* the demand – supply balance, Ramp Rate constraints, *etc.*) cannot be satisfied, these shadow prices become functions of the “penalty weights” or “penalty factors” associated with the violated constraints. ERCOT has set these penalty weights sufficiently high to minimize “nuisance” or marginal constraint violations. The shadow prices resulting from applying these penalty weights are fairly high when compared to the typical prices.

B. MCPE Price Administration Procedures

1) Initialization:

- a) Determine net BES clearing mode for the system (sMode) and for each zone (zMode). The net BES cleared includes only the “in-merit” BES cleared from portfolio bids. It does not include any BES cleared as “price-taker” to adhere to Ramp Rate, nor does it include any Resource-specific instructed deviation.
 - A) If $sNetBESMW = 0$ and $sUBESMW=0$, then $sMode = Null$
 - B) Otherwise:
 - (1) If $sNetBESMW > 0.0$, then $sMode=UP$, else $sMode=DN$
 - (2) If $zNetBESMW >= 0.0$, then $zMode=UP$, else $zMode=DN$

b) Calculate marginal price of cleared BES Bids:

A) System wide:

- (1) If $sMode=Null$, then $sMarginBESPrice = \text{Max (DBES bid price for the whole system)}$
- (2) If $sMode=UP$,
then $sMarginBESPrice = \text{Max \{Price of all cleared UBES bids\}}$
- (3) Else $sMode=DN$
then $sMarginBESPrice = \text{Min \{Price of all cleared DBES bids\}}$

B) For each zone z:

- (1) If $sMode=Null$,
then $zMarginBESPrice = sMarginBESPrice$
- (2) If $zMode=UP$ AND UBES Bid Cleared MW >0
then $zMarginBESPrice = \text{Max of UBES bids cleared in zone z}$
- (3) If $zMode=UP$ AND UBES Bid Cleared MW = 0
then $zMarginBESPrice = \text{null}$
- (4) Else $zMode=DN$
then $zMarginBESPrice = \text{Min of DBES bids cleared in zone z}$

Price in zones with null $zMarginBESPrice$ will be set to the average of all non-null $zMarginBESPrice$'s.

2) Check for Violation:

- a) Check if any of the following constraints has a violation:
 - i) System load balance constraint
 - ii) BES Ramp Rate constraints
 - iii) Resource capacity constraints
 - iv) BES bid limit constraints

Price-corrections for all zones as described below take place if any of the above constraints is violated or $sMode = Null$.

3) MCPE Price Adjustment:

- a) If power balance constraint is violated:

$$zMCPE = sMarginBESPrice \text{ for all zones}$$

- b) Else(power balance constraint is feasible, but other violations exist)

$$zMCPE = sMarginBESPrice \text{ for all zones}$$

C. MCPC Price Administration Procedures

Anomaly Check:

1. Determine the system-wide maximum price (MaxBidPrice) among all cleared RPRS bids for those Resources that are not used for solving Local Congestion.
2. If all original zonal MCPC are not greater than MaxBidPrice from (1), then no price-corrective actions take place; otherwise, proceed to price-adjustment.

Price Adjustment:

- Pre-Calculation

1. Identify highest original CSC shadow price. Denote it as SPCH.
2. Identify highest original MCPC. Denote it as MCPCH'.
3. If no RPRS is cleared, set MaxBidPrice = 0

- MCPC Correction:

1. If $SPCH < \text{Tolerance}$
All zone: $MCPC_i = \text{MaxBidPrice}$
2. If $SPCH > \text{Tolerance}$, calculate zonal MCPC separately
 - 1) If cleared RPRS $MW_i > 0$, $MCPC_i = \text{Highest cleared RPRS bid price in zone I for those Resources not used for solving Local Congestion.}$
If cleared RPRS $MW_i = 0$, $MCPC_i = 0$
 - 2) If cleared RPRS $MW_i = 0$ for all zones, $MCPC_i = 0$

- CSC Price Adjustment:

1. Identify highest adjusted MCPC of the two zones connected by the CSC. Denote it as Zone H with MCPCH.
2. Identify lowest adjusted MCPC of the two zones connected by the CSC. Denote it as Zonel L with MCPCL.

3. For each congested CSC K, its constraint shadow price is calculated based on the shift-factors and the adjusted MCPC at Zone H and Zone L:

$$\text{CSCPrice}_K = (\text{MCPCH} - \text{MCPCL}) / (\text{ShiftFactor}_{KL} - \text{ShiftFactor}_{KH})$$

- Other corrections in prices and/or MWs: None.

Calculation of Market Clearing Prices and Shadow Prices of Congestion, using linear programming to simultaneously solve for multiple CSC Constraint(s)

Background

Currently, ERCOT clears Balancing Energy Service using a Linear Program. Following is the simplified model for this process. The real software system is much more complicated than shown. The detail information appears in ESCA design document "ERCOT MOS Analytical Function Software Specification Document (SSD)". To minimize system cost and maximize system welfare, the following objective function is used to calculate Market Clearing Price and Balance Energy bid deployment.

Object:

$$\text{Min} \quad \sum_{i=1}^{NP} \sum_{j=1}^{NZ} BEUBP_{ij} * INSU_{ij} - \sum_{i=1}^{NP} \sum_{j=1}^{NZ} BEDBP_{ij} * INSD_{ij} \quad (1)$$

Subject to:

$$\sum_{i=1}^{NP} \sum_{j=1}^{NZ} P_{ij} - \sum_{j=1}^{NZ} LF_j + \sum_{i=1}^{NP} \sum_{j=1}^{NZ} (INSU_{ij} - INSD_{ij}) = 0 \quad (2)$$

$$\sum_{j=1}^{NZ} \left(\sum_{i=1}^{NP} (P_{ij} + INSU_{ij} - INSD_{ij}) - LF_j \right) * SF_{j,k} \leq TTC_k \quad k \in K_C \quad (3)$$

$$INSU_{ij} \leq MAXBEU_{ij} \quad i \in I_p, j \in J_Z \quad (4)$$

$$INSD_{ij} \leq MAXBED_{ij} \quad i \in I_p, j \in J_Z \quad (5)$$

$$\begin{aligned} (INSU_{ij,t} - INSD_{ij,t}) - (INSU_{ij,t-1} - INSD_{ij,t-1}) &\leq \min\left(\frac{\max(0, INSD_{ij,t-1} - INSU_{ij,t-1})}{Ramprate_{ij, Down}}, 10\right) * Ramprate_{ij, Down} \\ &+ [10 - \min\left(\frac{\max(0, INSD_{ij,t-1} - INSU_{ij,t-1})}{Ramprate_{ij, Down}}, 10\right)] * Ramprate_{ij, Up} \quad i \in I_p, j \in J_Z \end{aligned} \quad (6)$$

$$\begin{aligned} (INSU_{ij,t} - INSD_{ij,t}) - (INSU_{ij,t-1} - INSD_{ij,t-1}) &\geq -\min\left(\frac{\max(0, INSU_{ij,t-1} - INSD_{ij,t-1})}{Ramprate_{ij, Up}}, 10\right) * Ramprate_{ij, Up} \\ &- [10 - \min\left(\frac{\max(0, INSU_{ij,t-1} - INSD_{ij,t-1})}{Ramprate_{ij, Up}}, 10\right)] * Ramprate_{ij, Down} \quad i \in I_p, j \in J_Z \end{aligned} \quad (7)$$

In solving this LP, we can obtain shadow prices for all CSC Congestion constraints and shadow price for Power Balance. Then zonal MCPE can be calculated with the following equation:

$$MCPE_j = MCPE_{system} - \sum_k^{NC} SP_k * SF_{j,k} \quad k \in K \quad (8)$$

Re-write equation (8) using matrix:

$$\begin{bmatrix} MCPE_N \\ MCPE_S \\ MCPE_W \\ MCPE_H \end{bmatrix} = \begin{bmatrix} 1, -SF_{N,SN}, -SF_{N,SH}, -SF_{N,WN} \\ 1, -SF_{S,SN}, -SF_{S,SH}, -SF_{S,WN} \\ 1, -SF_{W,SN}, -SF_{W,SH}, -SF_{W,WN} \\ 1, -SF_{H,SN}, -SF_{H,SH}, -SF_{H,WN} \end{bmatrix} * \begin{bmatrix} MCPE_{system} \\ SP_{SN} \\ SP_{SH} \\ SP_{WN} \end{bmatrix} \quad (9)$$

Hence, the Shadow Prices can be calculated backward using:

$$\begin{bmatrix} MCPE_{system} \\ SP_{SN} \\ SP_{SH} \\ SP_{WN} \end{bmatrix} = \begin{bmatrix} 1, -SF_{N,SN}, -SF_{N,SH}, -SF_{N,WN} \\ 1, -SF_{S,SN}, -SF_{S,SH}, -SF_{S,WN} \\ 1, -SF_{W,SN}, -SF_{W,SH}, -SF_{W,WN} \\ 1, -SF_{H,SN}, -SF_{H,SH}, -SF_{H,WN} \end{bmatrix}^{-1} * \begin{bmatrix} MCPE_N \\ MCPE_S \\ MCPE_W \\ MCPE_H \end{bmatrix} \quad (10)$$

where:

- i***: Index of QSEs
- j***: Index of zones
- t***: Settlement interval
- I_p***: A set of QSEs
- I_p***: A set of QSEs
- J_Z***: A set of zones
- K_C***: A set of Zonal congestions
- NP***: Total number of QSEs
- NZ***: Total number of zones
- BEUBP_{ij}***: Balancing Energy Up Bid price curve for QSE *i* in zone *j*
- BEDBP_{ij}***: Balancing Energy Down Bid price curve for QSE *i* in zone *j*
- INSU_{ij}***: Deployed amount of Balancing Energy Up Bid from QSE *i* in zone *j*
- INSD_{ij}***: Deployed amount of Balancing Energy Down Bid from QSE *i* in zone *j*
- LF_j***: Load Forecast in zone *j*
- MAXBEU_{ij}***: Maximum amount of Balancing Energy Up bid from QSE *i* in zone *j*
- MAXBED_{ij}***: Maximum amount of Balancing Energy Down bid from QSE *i* in zone *j*
- MCPE_j***: Market Clearing Price in zone *j*
- MCPE_{system}***: Power Balance Shadow Price
- P_{ij}***: Total generation schedule of participant *i* in zone *j*, which includes both the balanced scheduled generation and mismatched scheduled generation
- Ramprate_{ij}***: Portfolio Balancing Energy ramp rate submitted by the QSE *i* in zone *j*
- SF_{j,k}***: Shift Factor of zone *j* to Zonal Constraint *k*
- SP_k***: Shadow Price of CSC Congestion *k*
- TTC_k***: Total Transfer Capacity of CSC Congestion Constraint *k*