

Inter-Zonal Congestion Payments

- Using Constraint Shadow Costs:

$$R = \sum_j \mu_j P_{j \max}$$

j : zonal interface index

μ_j : constraint shadow cost

$P_{j \max}$: zonal interface rating

Inter-Zonal Congestion Charges

- Using Zonal Prices:

$$R_l = \sum_k \lambda_{l,k} \sum_{i \in Z_k} (D_{l,i} - G_{l,i})$$

$$\lambda_{l,k} = \frac{\sum_{i \in Z_k} \lambda_{l,i} \sum_l (D_{l,i} - G_{l,i})}{\sum_{i \in Z_k} \sum_l (D_{l,i} - G_{l,i})}$$

$$R = \sum_l R_l = \sum_k \sum_{i \in Z_k} \lambda_i (D_i - G_i) = \sum_i \lambda_i (D_i - G_i)$$

l : SC index

Z_k : set of nodes in zone k

k : zone index

$\lambda_{l,i}$: nodal price

i : node index

$\lambda_{l,k}$: zonal price

D : demand

G : generation

Revenue Adequacy

$$R = \sum_l R_l = \sum_j \mu_j P_{j\max} = \sum_i \lambda_i (D_i - G_i)$$

l : SC index

i : node index

j : zonal interface index

Congestion Management and Pricing

Congestion Pricing

- Fundamental Assumptions:
 - ◆ Inter-zonal congestion:
 - relatively frequent; global effect; high cost
 - marginal pricing
 - congestion revenue allocated to TCCs
 - ◆ Intra-zonal congestion:
 - infrequent; local effect; low cost
 - cost-based (pay as bid) pricing
 - congestion cost rolled in as a zonal uplift

Inter-Zonal CM

- Fundamental Assumptions:
 - ◆ It is performed over the whole network.
 - ◆ It has a minimum cost objective.
 - ◆ SC portfolios are kept in balance.
 - ◆ SC portfolios are not optimized within zones.
 - ◆ Only inter-zonal constraints are monitored.
 - ◆ Lossless linear network models are used.

Inter-Zonal CM Algorithm

$$\min \sum_{l=1}^L \sum_{i=1}^N C_{l,i} \Delta P_{l,i}$$

$$s.t. \mathbf{B}' \Delta \delta = \Delta \mathbf{P}$$

$$\mathbf{F} \delta \leq \mathbf{P}_{F \max}$$

$$P_{l,i \min} \leq P_{l,i} \leq P_{l,i \max} \quad \therefore l = 1, 2, \dots, L; i = 1, 2, \dots, N$$

$$\sum_{i=1}^N \Delta P_{l,i} = 0 \quad \therefore l = 1, 2, \dots, L-1$$

P : power injection

l : SC index

\mathbf{P} : nodal power injection vector

i : node index

\mathbf{B}' : linearized Jacobian

c : inc.bid

\mathbf{F} : branch power flow coefficient matrix

$\mathbf{P}_{F \max}$: branch power flow limit vector

δ : voltage phase vector

Intra-Zonal CM

□ Fundamental Assumptions:

- ◆ In is performed for each zone separately.
- ◆ It has an “economic” minimum shift objective.
- ◆ Only zonal resources are used and pooled.
- ◆ Only zonal constraints are monitored, including zonal ties and interfaces.
- ◆ Lossless linear network models are used.

Intra-Zonal CM Algorithm

$$\min \sum_{i=1}^N (c_i^+ \Delta P_i^+ + c_i^- \Delta P_i^-)$$

$$s.t. \mathbf{B}' \Delta \delta = \Delta \mathbf{P}$$

$$\mathbf{F} \delta \leq \mathbf{P}_{F \max}$$

$$P_{i \min} \leq P_i = P_i^+ - P_i^- \leq P_{i \max} \quad \therefore i = 1, 2, \dots, N$$

$$\Delta P_i^+ \geq 0, \Delta P_i^- \geq 0 \quad \therefore i = 1, 2, \dots, N$$

$$c_i^+ \geq 0, c_i^- \geq 0 \quad \therefore i = 1, 2, \dots, N$$

P : power injection

i : node index

\mathbf{P} : nodal power injection vector

c : cost coefficients

\mathbf{B}' : linearized Jacobian

$\mathbf{P}_{F \max}$: branch power flow limit vector

\mathbf{F} : branch power flow coefficient matrix

δ : voltage phase vector