Markets for Transmission Rights

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Views expressed here do not necessarily reflect the view of PG&E Corporation or any other organization.
Expanding/Shrinking RTOs

FTR/TCC/TCR auctions have been conducted in CA, NY, PJM, ERCOT and IMO.
Transmission Pricing: The Past

- Physical rights awarded on a first-come, first served basis
- Network Service or Point to point Service
- Firm or Non-firm
- Bundles embedded cost recovery with congestion
- Average losses
- Pancaked rates
- Little price risk, high quantity risk

<table>
<thead>
<tr>
<th></th>
<th>Firm ($)/kw-mo</th>
<th>Non-firm ($)/MWh</th>
<th>Loss Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP (East)</td>
<td>1.42</td>
<td>4.09</td>
<td>1.95</td>
</tr>
<tr>
<td>AEP (West)</td>
<td>1.05</td>
<td>3.02</td>
<td>1.44</td>
</tr>
<tr>
<td>Duke Energy</td>
<td>1.03</td>
<td>3.00</td>
<td>1.40</td>
</tr>
<tr>
<td>Southern</td>
<td>1.37</td>
<td>2.82</td>
<td>1.88</td>
</tr>
<tr>
<td>TVA</td>
<td>1.81</td>
<td>3.90</td>
<td>1.90</td>
</tr>
<tr>
<td>Virginia Power</td>
<td>1.07</td>
<td>3.08</td>
<td>1.46</td>
</tr>
<tr>
<td>Entergy</td>
<td>1.05</td>
<td>3.03</td>
<td>1.44</td>
</tr>
</tbody>
</table>
Transmission Pricing Tomorrow

- Access Charges without pancaking (embedded cost recovery)
- Congestion charges based on LMP differences
- Marginal Losses based on LMP differences

- Reduced quantity risk, high price risk
- Financial rights required for hedging
LMP Example with loop-flow

Unit A
270 MW
$20/MWh

Unit B
180 MW
$30/MWh

180 + 60 = 240 MW

(1/3) x 180 = 60 MW
(2/3) x 180 = 120 MW
(1/3) x 270 = 90 MW
(2/3) x 270 = 180 MW

Optimal Dispatch:
Unit A = 270 MW
Unit B = 180 MW

Prices:
Node 1: $20/MWh
Node 2: $30/MWh
Node 3: $40/MWh

All lines have equal impedance

minimize 20 q1 + 30 q2
subject to
q1 + q2 = 450,
(2/3) q1 + (1/3) q2 ≤ 240,
qu1 ≤ 400, q2 ≤ 400.
LMP components
(NYISO LBMPs June 5, 2002)

LMP decomposition depends on choice of reference bus

NYC

LMP components
- Energy
- Congestion
- Losses
Options vs. Obligations

**FTR Options**
the right to receive payment without the requirement to pay

**FTR Obligations**
the right to receive payment coupled with the requirement to pay

\[
\begin{align*}
(p_b - p_a) &= (p_{hub} - p_a) + (p_b - p_{hub}) \\
(p_b - p_a) &= -(p_a - p_b)
\end{align*}
\]

\[
\begin{align*}
\max(0, p_b - p_a) &\neq \max(0, p_{hub} - p_a) + \max(0, p_b - p_{hub}) \\
\max(0, p_b - p_a) &\neq -\max(0, p_a - p_b)
\end{align*}
\]
Flow-gate Example

$LMP_A = $20/MW$

$LMP_B = $20/MW$

$LMP_C = $21.50/MW$

$LMP_E = $30/MW$

100 MW transaction from A to E would pay:

$(60) \times \text{(Shadow Price of FGBE)} + (20) \times \text{(Shadow Price of FGCD)} = $1000$

Can be hedged by buying 60 MW FGRs on BE and 20 MW of FGRs on CD

Issues:

What happens if A-B becomes congested?
What if PTDFs change?

<table>
<thead>
<tr>
<th>Transactions</th>
<th>FGBE</th>
<th>FGCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A to E</td>
<td>0.6</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Shadow Price of FGBE = $15.00
Shadow Price of FGCD = $5.00

Number of nodes = N
Number of pt-to-pt rights = $2N \ (N-1), N>2$
Number of Flowgate rights= ?
Contingencies, PTDFs and OTDFs

Both Lines Operating: Transfer 500 MW

Contingency: One Line Might Go Out
Limit Transfer to 250 MW

Single Flowgate with an OTDF = 1

- PTDFs change with network topology
- Security constraints can be represented implicitly
RTO Congestion Costs

Congestion Costs


CAISO data excludes intra-zonal congestion
New England data represents uplift costs

Note: Different congestion management approaches were in effect in different markets in 2000-01. NY and PJM used a nodal LMP Approach, CA used a zonal approach and NE had a regional uplift approach. NE introduced nodal LMP in March 2003.
Design Choices for Transmission Rights

Nature of Rights
- Physical or Financial
- Options or Obligations
- Point to point (PTP) or Flow-gate rights (FGRs)
- Decomposition of PTP rights using hubs
- Fully funded or subject to outage/derate risks

Other Issues
- Auctions or Allocations
- Treatment of Auction Revenues
- Customer Switching
- Existing Contracts

“Revenue adequacy” requires any set of awarded rights to be “simultaneously feasible”
FERC SMD and Transmission Rights

- Transmission provider must offer source-to-sink obligations
- “Upon the request of market participants, the transmission provider must also offer source-to-sink options and flowgate rights as soon as it is technically feasible”
- Auctions are unlikely to be required at least initially
Revenue Adequacy

PJM FTR Payout

- Monthly
- Average

PJM Deficient/Excess Rents

Source: PJM
2003 PJM Auction: PTP Options and Obligations

- 4 round auction offered both PTP Options and Obligations
- Approximately 50 participants
- Over 600,000 submitted bids

Source: PJM
CA FTR Auctions

- Past auctions offered zone-zone options
- Future auctions to offer PTP obligations

Source: CAISO
**ERCOT TCR Auctions**

- TCRs offered as inter-zonal options

**ERCOT Annual TCR Auction**

- **$ (millions)**
  - 2002: 70
  - 2003: 15

**TCR Shift Factors**

- **$\mu = H' \mu$**
- $p$ = LMPs
- $\mu$ = Shadow prices
- $H'$ = Shift factor matrix

<table>
<thead>
<tr>
<th>Zone</th>
<th>W-N (G to P)</th>
<th>S-N (S to T)</th>
<th>S-H (Stp to Dow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston</td>
<td>0.027650492</td>
<td>0.204409959</td>
<td>-0.169735742</td>
</tr>
<tr>
<td>North</td>
<td>0.004613148</td>
<td>0.004989182</td>
<td>-0.003475207</td>
</tr>
<tr>
<td>South</td>
<td>0.04591408</td>
<td>0.396734818</td>
<td>0.190336475</td>
</tr>
<tr>
<td>West</td>
<td>0.580664652</td>
<td>0.032884411</td>
<td>0.016168457</td>
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</table>

Source: ERCOT
New England

- Monthly auctions initiated in March 2003
- Annual auction to be introduced in the future
- PTP obligations
- On-peak and off-peak FTRs

Source: ISO-NE
## Transmission Rights in different RTOs

<table>
<thead>
<tr>
<th>RTO</th>
<th>Physical or Financial</th>
<th>Type of FTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJM</td>
<td>Financial</td>
<td>PTP obligations and PTP options</td>
</tr>
<tr>
<td>NY</td>
<td>Financial</td>
<td>PTP obligations</td>
</tr>
<tr>
<td>NE</td>
<td>Financial</td>
<td>PTP obligations</td>
</tr>
<tr>
<td>CAISO</td>
<td>Financial with scheduling priority</td>
<td>zonal FGRs (old), PTP obligations (future)</td>
</tr>
<tr>
<td>MISO</td>
<td>Financial</td>
<td>PTP obligations and options, FGRs</td>
</tr>
<tr>
<td>ERCOT</td>
<td>Financial</td>
<td>zonal FGRs</td>
</tr>
<tr>
<td>SETrans</td>
<td>Financial</td>
<td>PTP obligations (day 2)</td>
</tr>
<tr>
<td>West Connect</td>
<td>Physical</td>
<td>FGRs</td>
</tr>
</tbody>
</table>