Electric Power Transmission

Paul F. Barber
Citizens Power - TEG
Harvard Electricity Policy Group
9/25/97
Outline

- Growing Complexity
- Evolving Processes and Systems
- Transmission Service Risk
- Understanding the Problem

Citizens Power - TEG
Historic Structure of the Regulated Utility Business

Vertically Integrated Utility

Vertically Integrated Utility

Franchise Boundaries

Power Sales Transactions

Citizens Power - TEG
Control Area - Basic Interchange

Citizens Power - TEG
Essential Elements of North American Electric Reliability

- Maintain AC Synch at or near 60 Hz
- Maintain Adequate, Responsive Supply Resources to meet expected energy and capacity demands
- Maintain Adequate Transmission Resources to geographically match demands with supplies
- Maintain Adequate Margins to sustain operations through reasonable contingencies
- Maintain Commercial Transaction Schedules to sustain efficient, economical, reliable commerce in electricity

Keep the lights on!
Keep the lights on in the future!
Keep commerce moving!

Citizens Power - TEG
North American Electric Reliability Council

10 Regions
4 Interconnections
22 Security Centers
153 Control Areas

Board of Trustees
Engineering Committee
Operating Committee

Task Forces
Work Groups

Citizens Power - TEG
## Organizational Elements of the North American Electric Power Industry

<table>
<thead>
<tr>
<th>National</th>
<th>NERC</th>
<th>Power Pools</th>
<th>Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>FERC</td>
<td>NPCC</td>
<td>NEPOOL</td>
<td>IOUs</td>
</tr>
<tr>
<td>DOE</td>
<td>MAAC</td>
<td>NYPP</td>
<td>Cooperatives</td>
</tr>
<tr>
<td>RUS</td>
<td>SERC</td>
<td>PJM</td>
<td>FPMAs</td>
</tr>
<tr>
<td>NEB</td>
<td>FRCC</td>
<td>MAPP</td>
<td>PUDs</td>
</tr>
<tr>
<td><strong>State/Provincial</strong></td>
<td><strong>ECAR</strong></td>
<td><strong>SPP</strong></td>
<td><strong>Municipals</strong></td>
</tr>
<tr>
<td>regulatory commissions</td>
<td>MAIN</td>
<td><strong>RMPP</strong></td>
<td>JAAs</td>
</tr>
<tr>
<td>siting commissions</td>
<td>MAPP</td>
<td><strong>WSPP</strong></td>
<td>IPPs</td>
</tr>
<tr>
<td>energy planning bodies</td>
<td>SPP</td>
<td><strong>...</strong></td>
<td>PMs</td>
</tr>
<tr>
<td><strong>RTGs</strong></td>
<td>ERCOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRTA</td>
<td>WSCC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRTA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWRTA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAPP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>...</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Associations/Institutes</strong></td>
<td><strong>EPRI</strong></td>
<td><strong>NARUC</strong></td>
<td></td>
</tr>
<tr>
<td>APPA</td>
<td>EPSA</td>
<td><strong>NRECA</strong></td>
<td></td>
</tr>
<tr>
<td>CEA</td>
<td>PTC?</td>
<td><strong>...</strong></td>
<td></td>
</tr>
<tr>
<td>EEI</td>
<td>ELCON</td>
<td>IEEE</td>
<td></td>
</tr>
<tr>
<td><strong>...</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ISOs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERCOT</td>
<td>PJM</td>
<td>NEPOOL</td>
<td></td>
</tr>
<tr>
<td>NYPP</td>
<td>CA</td>
<td>IndeGO</td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>Desert STAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAPP?</td>
<td>SPP?</td>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

*Citizens Power - TEG*
Current Conditions on the North American Electric Grid

- 4 Interconnections; 10 Regions; 153 Control Areas
- Fragmented transmission ownership/control
- Contract path transmission paradigm
- Significant parallel flows from unidentified transactions
- Simultaneous grid support of point-to-point and network services
- More extensive transmission service transactions
- Spotty secondary markets for transmission
- 3 ISOs formed; 22 SCs forming; 3 "tight" pools restructuring; several ISOs negotiating

Citizens Power - TEG
"Direct Connect" Parallel Path Flows on a Uniform Grid

<table>
<thead>
<tr>
<th>000°</th>
<th>100°</th>
<th>200°</th>
<th>300°</th>
<th>000°</th>
<th>100°</th>
<th>200°</th>
<th>300°</th>
</tr>
</thead>
<tbody>
<tr>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>300°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>300°</td>
</tr>
<tr>
<td>100°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>300°</td>
</tr>
<tr>
<td>200°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>300°</td>
</tr>
<tr>
<td>300°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>000°</td>
<td>100°</td>
<td>200°</td>
<td>300°</td>
</tr>
</tbody>
</table>

Citizens Lehman Power
Paul Barker
Control Areas under Open Access

Citizens Power - TEG
Transmission-Related Interactions in the Competitive Electric Power Marketplace

Marketing Interactions
Transmission Service Interactions
System Control Interactions

Citizens Power - TEG
Electric Power Transaction Process

Power Marketing/Trading Activity

Transaction Development
- Energy Title Chain
- Delivery Arrangements

Physical Delivery

Transmission & Ancillary Service Reservations

Transaction Schedule

Bookout

Settlement

Delivery

Control Area Actions

Citizens Power - TEG
Transmission Stakeholders

- Transmission Owners
- Transmission Operators
- Generating Entities
- Load Serving Entities
- Power Marketing Entities
- End Use Customers
- Regulators

Citizens Power - TEG
Commercial vs Technical Needs

Commercial Needs

KLM, Inc.

ABC, Inc.

XYZ, Inc.

Balance Tension Balance

Technical Needs

Citizens Power - TEG
Interconnected Transmission Systems

Commercial Operations Model

Citizens Lehman Power
Interconnected Transmission Systems

Technical as related to Commercial

Citizens Lehman Power
Transmission Service Risk

- Risk that the grid is unable to provide some or all of the transmission services that the market demands.

- Denial or interruption of transmission service or the application of expensive remedies - often after-the-fact.

- **Operational risks**
  Random events such as equipment failures and weather limit transfer capabilities during physical grid operations.

- **Market risks**
  The market demands deliveries beyond the designed transfer capabilities of the grid.

- **Structural risks**
  Full transfer capability may not be realized when transmission business structures leave major transmission issues unresolved.

*Citizens Power - TEG*
Operational TS Risk

- Incorrect ATCs
- Weather disruptions
- Equipment failures
- Maintenance outages
- Brownouts
- Blackouts

Transmission providers are best situated to manage these risks.
Market TS Risk

- Peak demand
- Unusual or extreme market demands
- Transmission congestion
- Congestion or redisplay charges

Transmission customers actively involved in the market are best situated to manage these risks.

Citizens Power - TEG
Structural TS Risk

- Conflicting claims to transfer capability
- Procedural conflicts at interfaces
  - ATC determination
  - Approval processes & deadlines
- Inconsistent or ineffective transmission service product specification (firm vs nonfirm, etc.)
- After-the-fact transmission charges
- Uncompensated parallel flows

*The industry must minimize these risks.*

Citizens Power - TEG
Layered View of Electric Power Transmission Systems

Commercial

Operational

Planning

Physical

Citizens Power - TEG
Finally . . .

- Need to understand
- Need to balance
- Need to optimize

Citizens Power - TEG