MISO / PJM / SPP / TVA Inter-Regional Planning

Combined Stakeholder Meeting

November 1, 2007
Marriott, Pittsburgh Airport
Agenda

- Introduction of Joint Planning Committee (JPC) and Discussion of Joint Operating Agreement (JOA) / Joint Regional Coordination Agreement (JRCA) Obligations

- Discussion of Preliminary Joint Coordinated System Plan Scope (JCSP) of Work
  - Models required
  - Reliability Study for 2018
  - DOE Eastern Wind Integration & Transmission Study
  - Economic Study for 2024

- Stakeholder Discussion Concerning Joint Coordinated System Plan Scope
Introduction of Joint Planning Committee (JPC)

and

Discussion of JOA/JRCA Obligations
Joint Planning Committee (JPC)

- For this JCSP, combination of the Joint Regional Planning Committee and Joint Planning Committees under individual Joint Agreements

- Members are planning staff leadership from MISO, PJM, SPP and TVA:
  - John Lawhorn (Chair), Dale Osborn, Jeff Webb - MISO
  - Steve Herling, Paul McGlynn – PJM
  - Jay Caspary, Keith Tynes, Mak Nagle – SPP
  - David Till, Dennis Chastain - TVA
Joint Planning Committee (JPC)

General Responsibilities Under Joint Agreements:

- Develop common power system analysis models to perform coordinated system planning
- Conduct, on a regular basis, a Coordinated Regional Transmission Planning Study, or Plan
- Coordinate planning activities, including the exchange of planning data and developing necessary report and study protocols
- Maintain an Internet site and e-mail or other electronic lists for the communication of information related to the coordinated planning process.
- Meet at least semi-annually to review and coordinate transmission planning activities
- Establish working groups as necessary to address specific issues
- Conduct the necessary stakeholder review and approval process associated with transmission system planning, as required by its OATT and/or applicable Federal or State regulatory requirements
Stakeholder Input and Review

- Stakeholder group is formally a combination of entity planning stakeholder groups to the extent they exist plus other interested parties:
  - MISO PAC
  - PJM TEAC
  - SPP TWG
  - TVA stakeholders (CPPP being formed)

- In practice, will announce open forum stakeholder meetings on each web site

- Stakeholder meetings will be called, at a minimum:
  - Prior to the start of each cycle of the coordinated planning process
  - During the development of the Joint Coordinated System Plan
  - Upon completion of the Plan to review final results
JPC Recent and Scheduled Activities

• Completed first MISO / PJM coordinated system plan – end of year 2006

• Combined scope of study to include SPP and TVA for the 2007/2008 Joint Coordinated System Plan (JCSP)

• 2007/2008 JCSP will perform a long term planning study incorporating both economic and reliability analysis of system performance for the combined four JCSP areas

• Collaboration with the parallel DOE Eastern Wind Integration & Transmission Study will provide underlying input assumptions for generation scenarios

• Anticipate minimum of three stakeholder meetings with final reports due by the end of 2008
Discussion of Preliminary Joint Coordinated System Plan Scope of Work
JCSP Study – Major Objectives

- Develop required models to perform nearly Eastern Interconnect wide studies
- Perform Reliability Study
- Perform Economic Study
- Incorporate DOE Eastern Wind Integration & Transmission Study objectives into the JCPS study and provide technical support for the DOE Study
Schedule for JCSP Study

- Initial stakeholder meeting November 1, 2007

- Develop Models – Use ERAG 2018 model as starting point - All models developed/reviewed/documented by March 1, 2008

- Economic assumption workshops – December, 2007 and January 2008

- Reliability study begins – March 1, 2008
- Economic Study begins – March 1, 2008 \{ parallel

- Economic transmission development/analysis workshops – development in March, 2008 and May 2008 with analysis workshop in July

- Midterm stakeholder meeting – June, 2008

- DOE Eastern Wind Integration Study data available for study inclusion – August 2008 - Incorporate DOE wind results in study and test in Sept

- Final stakeholder meeting – November/December 2008
## JCSP Model Development – Common Activities

<table>
<thead>
<tr>
<th>Models required</th>
<th>Power flow (2018,2024)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRP (20 year capacity)</td>
</tr>
<tr>
<td></td>
<td>PROMOD (2018,2024)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power flow (PSS/E)</th>
<th>Reliability study – 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 30</td>
<td>solved AC</td>
</tr>
<tr>
<td></td>
<td>Economic study - 2024</td>
</tr>
</tbody>
</table>

| Regional Resource Planning Model (EGEAS) | Twenty year capacity forecasts for inclusion in power flow and PROMOD |

<table>
<thead>
<tr>
<th>PROMOD</th>
<th>Reliability study – 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Economic study - 2024</td>
</tr>
</tbody>
</table>
JCSP Reliability Study

Drivers

• **2006 CSP**
  • 2011 analysis of N-2 and generator deliverability
    • Examined independent and joint deliverability
    • Resulting continuing coordination improvements

• **2007 JCSP**
  • Order 890 – plan for aggregate resource integration + market efficiencies
  • 2006 ERAG reliability assessment called for longer term studies
  • Requires looking beyond 2011 time horizon
  • Extended reliability analysis – 2018
Objective

• 2018 Coordinated reliability plan
  • Merge most recent 2017/2018 plans.

• Baseline for market efficiency study
  • Test most critical bulk system contingencies from interregional perspective (230 kV and up)
  • NERC Category A, B and C

• Assess reliability needs
  • Redispatch, or
  • Conceptual reinforcement, where possible
JCSP Reliability Study

Objective

• Identify potential system reliability enhancements

• Quantify incremental 2018 transmission investment for reliability

• Quantify a system economy metric for reliability only system

• 2018 reliability baseline power flow basis for 2024 model

• Analyze 2024 model plus integration / efficiency reinforcements for reliability issues / upgrades.
Eastern Wind Integration and Transmission Study

David Corbus - Project Manager
Matt Schuerger (Consultant)
National Wind Technology Center
National Renewable Energy Laboratory
Golden, Colorado USA
303-384-6900
David_Corbus@nrel.gov
MattSchuerger@earthlink.net
Eastern Wind Integration & Transmission Study

Objectives

• Evaluate the power system impacts (operating due to variability and uncertainty of wind; transmission; reliability) associated with increasing wind capacity to 20% and 30% of retail electric energy sales in the Joint Coordinated System Plan region (MISO/PJM/SPP/TVA) by 2024;

• Build upon prior wind integration studies and related technical work;

• Coordinate with JCSP and current regional power system study work;

• Produce meaningful, broadly supported results through a technically rigorous, inclusive study process.
Key Issues & Questions include:

• What are the benefits from long distance transmission that accesses multiple wind resources that are geographically diverse?

• What are the benefits from long distance transmission that moves large quantities of remote wind energy to urban markets?

• How do remote wind resources compare to local wind resources? Does geographical diversity help reduce system variability and uncertainty?

• What additional system operational impacts and costs are imposed by wind generation variability and uncertainty?

• What is the role and value of wind forecasting?

• What benefit does balancing area cooperation or consolidation bring to wind variability and uncertainty management?

• How does wind generation capacity value affect reliability?
Wind Integration Methods & Best Practices

• Capture system characteristics and response through operational simulations and modeling;

• Capture wind deployment scenario geographic diversity through synchronized weather simulation;

• Match with actual historic utility load and load forecasts;

• Use actual large wind plant power statistical data for short-term regulation and ramping;

• Examine wind variation in combination with load variations;
Wind Integration Methods & Best Practices – con’t

• Utilize wind forecasting best practice and combine wind forecast
  errors with load forecast errors;

• Examine actual costs independent of tariff design structure.

• Examine impacts of BA consolidation and fast markets.
Eastern Wind Integration & Transmission Study

Key Tasks

• Develop high quality wind generation data sets for the JCSP area (mesoscale modeling, 3 years)

• Identify wind generation sites for 20% & 30% wind energy scenarios

• Develop transmission plan (coordinated with JCSP)

• Evaluate operating impacts
  • Regulation
  • Load Following
  • Unit Commitment

• Evaluate reliability impacts (ELCC/LOLP)
## Eastern Wind Integration & Transmission Study

### Preliminary Schedule

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 07 – Feb 08</td>
<td>Study Development</td>
</tr>
<tr>
<td>January 2008</td>
<td>Award Wind Mesoscale Modeling Contract</td>
</tr>
<tr>
<td>February 2008</td>
<td>Award Wind Integration Contract</td>
</tr>
<tr>
<td>Jan – Oct 2008</td>
<td>Develop Wind Data Sets</td>
</tr>
<tr>
<td>April – Dec 2008</td>
<td>Develop Transmission Plan in Coordination with JCSP</td>
</tr>
<tr>
<td>Sept 08 – May 2009</td>
<td>Evaluate Operating &amp; Reliability Impacts</td>
</tr>
<tr>
<td>June 2009</td>
<td>Complete Study</td>
</tr>
</tbody>
</table>
Objective

- Complete a preliminary joint transmission design of the combined MISO/PJM/SPP/TVA systems based off of the primary assumptions/premise of the DOE Eastern Wind Integration & Transmission Study

- Develop high voltage overlay
- Identify Areas of Highest LMP Spreads
- Identify Facilities Producing Highest Projected Congestion
- Identify Preliminary Solutions

- Value driven analysis on a regional to multi-regional level

- Requires generation, transmission, demand response, environmental realities, fuel supply, reliability and economics to be analyzed together
High Level Outline of Economic Study

• Define Each Future

• Perform Regional Resource Planning (RRP)
  • Develop input value drivers to develop generation forecasts inclusive of all resource types over twenty year horizon

• Create multiple linked resource and transmission models

• Create transmission plans linked to the RRP’s

• Test preliminary plans for flexibility across a wide variety of output value drivers
  • Reliability to economics
  • Local to national implications
  • Cost allocation
Defined JCSP Futures

**Future 1**

- Based off of DOE Eastern Wind Integration & Transmission Study
- 20% Wind mandate, on an energy basis, for the defined Eastern region

**Future 2**

- Based off of DOE Eastern Wind Integration & Transmission Study
- 30% Wind mandate, on an energy basis, for the defined Eastern region
## Uncertainties - Example

**JCSP Participants input needed to update**

<table>
<thead>
<tr>
<th></th>
<th>(All $ = $2008)</th>
<th>Low</th>
<th>Mid/Low</th>
<th>Reference</th>
<th>Mid/High</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overnight Capital Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal ($/KW)</td>
<td>1653</td>
<td>1835</td>
<td>2019</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT ($/KW)</td>
<td>545</td>
<td>605</td>
<td>665</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC ($/KW)</td>
<td>774</td>
<td>859</td>
<td>945</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGCC ($/KW)</td>
<td>1901</td>
<td>2111</td>
<td>2323</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear ($/KW)</td>
<td>2245</td>
<td>2493</td>
<td>2743</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind ($/KW)</td>
<td>1720</td>
<td>1910</td>
<td>2101</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC w/Sequestration ($/KW)</td>
<td>1003</td>
<td>1114</td>
<td>1226</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGCC w/Sequestration ($/KW)</td>
<td>2475</td>
<td>2748</td>
<td>3023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Load Demand</td>
<td>%</td>
<td>Reference -25%</td>
<td>50/50 Projected Demand</td>
<td>Reference +25%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Fuel Prices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas ($/MMBtu)</td>
<td>Reference -10%</td>
<td>Year 2007 w/4% Growth</td>
<td>Reference +10%</td>
<td>Reference + 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil ($/MMBtu)</td>
<td>Reference -10%</td>
<td>Year 2007 w/4% Growth</td>
<td>Reference +10%</td>
<td>Reference + 10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal ($/MMBtu)</td>
<td>Reference -10%</td>
<td>PowerBase/Consultant</td>
<td>Reference + 10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Environmental Allowance Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean Air Act Title IV SO2/CAIR SO2 ($/ton)</td>
<td>Reference -25%</td>
<td>PowerBase</td>
<td>Reference + 25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOx/SIP NOx/CAIR NOx ($/ton)</td>
<td>Reference -25%</td>
<td>PowerBase</td>
<td>Reference + 25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2 ($/ton)</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg ($/ton)</td>
<td>Reference -25%</td>
<td>PowerBase</td>
<td>Reference + 25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Fuel Supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas (MMBTU)</td>
<td>Annual Reduction in Limit</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Economic Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Credit (Thru 2016) ($/MWh)</td>
<td>0</td>
<td>19</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount Rate %</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation Rate%</td>
<td>2</td>
<td>3</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uneconomic Coal Retirement</td>
<td>As Scheduled</td>
<td>As Scheduled</td>
<td>Forced Retirement</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Futures and Uncertainties Matrix

### Uncertainties

<table>
<thead>
<tr>
<th>Futures</th>
<th>Capital Investments</th>
<th>Growth</th>
<th>Fuel Related Costs</th>
<th>Environmental Cost</th>
<th>Fuel Supply</th>
<th>Economic Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CC</td>
<td>CT</td>
<td>Coal</td>
<td>IGCC</td>
<td>Wind</td>
<td>Nuclear</td>
</tr>
<tr>
<td>1 20% Wind Mandate</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>2 30% Wind Mandate</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>
Variables Constant for all Futures

- Planning Period
- Area Assumptions
- Resources
- Scheduled Interchange
- Financial Variables
- Reserve Margins
- Existing Wind Mandates
Example of RRP Output 2008-2027 Futures

Future Capacity Requirements 2008-2027

- Reference Wind Mandate = 12,600 MW
- Coal Retirement = 6844 MW
- Demand Response = 1,235 MW
- Behind the Meter Generation = 1,425 MW

*Demand Response and Behind the Meter Generation reflect a "MISO Study" assumption that the current level of participation (as a percent of total demand by region) will continue into the future. This assumption was not discussed at a PAC meeting or stakeholder workshop. 2007 Demand Response = 3.22% and BTM = 3.58% of total load.
Example of Resource Placement
Reference with Existing System Generation Weighted LMP
Interface Contour: Annual Energy Difference
Full Copper Sheet to Full Constrained Case

August 8th and 9th Meeting
Stakeholder Comments on

MISO-PJM- SPP-TVA
Joint Coordinated System Plan