Agenda

• JCSP Update
• RTEP reliability baseline update
  – Review initial baseline generator deliverability testing results
  – Review initial baseline load deliverability testing results
• Market efficiency update
• Study area now includes most of the Eastern Interconnection
  – NYISO and ISO-NE have recently joined the effort
• Power flow case for reliability analysis complete
  – Studying 2018, monitoring above 200 kV facilities, running single and select double contingencies
• Power flow case for market efficiency analysis nearing completion
  – Studying 2024, 10% and 20% renewable scenarios will be studied
• Upcoming public meeting
  – Charleston, South Carolina
  – April 29 – 30
  – http://www.midwestmarket.org/page/Calendar%20Detail/MP_Details.cfm?meetingID=2957&nowDateTime=2008-04-29&action=newDay
• Power Flow model of 2013 completed
• Completed initial generation deliverability testing
  – Consolidating results for PJM West and PJM South
• Completed initial thermal and reactive load deliverability testing for all areas except ComEd and PJM West.
  – Also still need to complete reactive load deliverability testing for EMAAC and MAAC pending development of thermal upgrades
• Validating contingency lists for upcoming N-1-1 analysis
Potential Load Deliverability Violation - PSE&G

- Athenia – Saddle Brook 230 kV for the loss of Athenia – Bergen 230 kV
- Athenia – Saddle Brook 230 kV basecase
Potential Load Deliverability Violation - PSEG North

- Athenia - Saddle Brook 230 kV line / loss of Athenia - Bergen 230 kV line
- Athenia - Saddle Brook 230 kV line / basecase
- Roseland - Cedar Grove B 230 kV line / loss of the other circuit
- Roseland - Cedar Grove F 230 kV line / loss of the other circuit
Potential Load Deliverability Violation - PSEG North

- Cedar Grove F - Clifton K 230 kV line / loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line
- Cedar Grove B - Clifton B 230 kV line / loss of Roseland-Cedar Grove F - Clifton K - Athenia 230 kV line
- Clifton K - Athenia 230 kV line / loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line
- Clifton B - Athenia 230 kV line / loss of Roseland - Cedar Grove F - Clifton K - Athenia 230 kV line
Potential Load Deliverability Violation - PSEG North

- Saddle Brook - Maywood 230 kV line / loss of Athenia - Bergen 230 kV line
- Athenia - Bergen 230 kV line / loss of Athenia - Saddle Brook 230 kV line
- Athenia - Bergen 230 kV line / basecase
• Mickleton 230/69 kV transformer #4 / loss of the Mickleton 230/69kV transformer #1
Potential Load Deliverability Violation - Delmarva

- Reybold – Lums Pond 138 kV for the loss of Glasgow – Keeney 138 kV
- Glasgow – Mt. Pleasant for the loss of Lums Pond – Reybold 138 kV
Potential Load Deliverability Violation - DelMarva

- Voltage collapse / loss of Indian River unit 3
- Voltage collapse / loss of Cedar Creek - Red Lion 230 kV line
- Voltage collapse / loss of Keeney - Steele 230 kV line
• Glasgow - Mt. Pleasant 138 kV line / loss of Lums Pond - Reybold 138 kV line

• Delmarva South load deliverability test also has same voltage violations as Delmarva load deliverability as well as several issues on the underlying 138 kV and 69 kV
Potential Load Deliverability Violation - Penelec

- Erie South – Green Gardner for the loss of Erie West – Fairview East 115 kV line
Potential Load Deliverability Violation - Mid-Atlantic

- Burtonsville – Sandy Spring 230 kV line CKT 2334 / loss of the other circuit
- Burtonsville – Sandy Spring 230 kV line CKT 2314 / loss of the other circuit
Potential Load Deliverability Violation - Eastern Mid Atlantic

- Athenia - Saddle Brook 230 kV line / loss of Athenia - Bergen 230 kV line
- Roseland - Cedar Grove F 230 kV line / loss of the other circuit
- Roseland - Cedar Grove B 230 kV line / loss of the other circuit
- Roseland 500/230 kV transformer / loss of the other circuit (Ramapo PAR set to 0 MW)
- Cedar Grove F - Clifton K 230 kV line / loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line
- Erie West 345/115 kV transformer CKT 1 / Loss of Erie South – Erie West 345 kV line + Erie West breaker 6 failed (Line_FB)
- Warren 230/115 kV transformer CKT 4 / Loss of entire Erie South and North 230 kV station by Erie 230 kV bus section breaker failed (Line_FB)
- Warren 230/115 kV transformer CKT 4 / Loss of Forest – Elko 230 kV line and Forest breaker failed (Line_FB)
• Warren 230/115 kV transformer CKT 4 / Loss of Forest – Gladetap, Gladetap – Lewis Run, and Gladetap - Glade 230 kV lines and Forest breaker failed (Line_FB)
• Warren 230/115 kV transformer CKT 4 / Loss of Forest – Gladetap, Gladetap – Lewis Run, and Gladetap - Glade 230 kV lines and Glade breaker failed (Line_FB)
- Yorkana 230/115/13.8 kV 3-wndg transformer / Loss of Yorkana – Brunner Island - Middle Junction 230 kV line and Yorkana East breaker failed (Line_FB)
- Yorkana 230/115/13.8 kV 3-wndg transformer / Loss of Yorkana – Brunner Island - Middle Junction 230 kV line and Yorkana West breaker failed (Line_FB)
- Yorkana 230/115 kV transformer CKT 1 / Loss of Yorkana – Brunner Island - Middle Junction 230 kV line and Yorkana West breaker failed (Line_FB)
Potential Generation Deliverability Violation - MetEd

- Taxville – Westgate 115 kV line / Loss of Yorkana 230 kV and 115 kV buses (Bus)
• Bradford – Planebrook 230 kV line CKT 220-02 / Loss of the other 230 kV line (Single)

• Bradford – Planebrook 230 kV line CKT 220-31 / Loss of Bradford – Planebrook 230 kV line + Bradford CB 220 failed (Line_FB)
Potential Generation Deliverability Violation – PSE&G

- Branchburg – Jefferson 500 kV line / Loss of Jefferson – Roseland 500 kV line (Single)
- Athenia - Saddle Brook 230 kV line / Basecase
- Athenia - Saddle Brook 230 kV line / Loss of Waldwick – Hillsdale 230 kV line (Single)
- Cedar Grove B - Clifton B 230 kV line / Loss of Roseland- Cedar Grove F - Clifton K - Athenia 230 kV line (Single)
Potential Generation Deliverability Violation – PSE&G

- Cedar Grove F - Clifton K 230 kV line / Loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line + Roseland Breaker 3-4 to Cedar Grove B (Line_FB)
- Cedar Grove F - Clifton K 230 kV line / Loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line (Single)
- Cedar Grove F - Clifton K 230 kV line / Basecase
- Cedar Grove F - Clifton K 230 kV line / Loss of Waldwick – Hillsdale 230 kV line (Single)
Potential Generation Deliverability Violation – PSE&G

- Cedar Grove F - Clifton K 230 kV line / Loss of Roseland – Hudson 230 kV line (Single)
- Roseland - Cedar Grove B 230 kV line / Loss of Roseland – Cedar Grove F – Clifton K – Athenia 230 kV line + Roseland Breaker 1-2 to Cedar Grove F (Line_FB)
- Roseland - Cedar Grove B 230 kV line Loss of Roseland – Cedar Grove F – Clifton K – Athenia 230 kV line (Single)
- Roseland - Cedar Grove B 230 kV line / Loss of Ramapo – Jefferson 500 kV line (Single)
- Roseland - Cedar Grove B 230 kV line / Basecase
- Roseland - Cedar Grove B 230 kV line / Loss of Roseland – Hudson 230 kV line (Single)
- Roseland - Cedar Grove F 230 kV line / Loss of Roseland – Cedar Grove B – Clifton B – Athenia 230 kV line + Roseland Breaker 3-4 to Cedar Grove B (Line_FB)
- Roseland - Cedar Grove F 230 kV line / Loss of Roseland – Cedar Grove B – Clifton B – Athenia 230 kV line + Roseland Breaker 2-3 to Cedar Grove B (Line_FB)
Potential Generation Deliverability Violation – PSE&G

- Roseland - Cedar Grove F 230 kV line / Loss of Roseland – Cedar Grove B – Clifton B – Athenia 230 kV line (Single)
- Roseland - Cedar Grove F 230 kV line / Loss of Ramapo – Jefferson 500 kV line (Single)
- Roseland - Cedar Grove F 230 kV line / Basecase
- Roseland - Cedar Grove F 230 kV line / Loss of Roseland – Hudson 230 kV line (Single)
Potential Generation Deliverability Violation – PSE&G

- Roseland – West Caldwell 138 kV line / Loss of Roseland – Athenia 230 kV DCTL (Tower)
- Sewaren – Woodbridge 138 kV line / Basecase
- Sewaren – Woodbridge 138 kV line / Loss of Roseland – Jefferson 500 kV line (Single)
- Clifton B - Athenia 230 kV line / Loss of Roseland - Cedar Grove F - Clifton K - Athenia 230 kV line
Potential Generation Deliverability Violation – PSE&G

- Clifton K - Athenia 230 kV line / Loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line + Roseland 230/138 kV transformer (Line_FB)
- Clifton K - Athenia 230 kV line / Loss of Roseland-Cedar Grove B - Clifton B - Athenia 230 kV line (Single)
- Somerville – Bridgewater 230 kV line / Loss of Atlantic – Larrabee 230 kV line and New Prospect – Smithburg 230 kV line (Tower)
- Somerville – Bridgewater 230 kV line / Loss of Atlantic – Larrabee 230 kV line and New Prospect – Smithburg 230 kV line (Line_FB)
Potential Generation Deliverability Violation – PSE&G

- Somerville – Bridgewater 230 kV line / Loss of Parlin-Red Oak-Raritan River 230 kV line and South River – Red Oak – Raritan River 230 kV line DCTL (Tower)
Potential Generation Deliverability Violation – BG&E

- Brandon Shores – Hawkins Point Terminal 230 kV line / Loss of Brandon Shores – Hawkins Point Terminal – Sollers Point Terminal (#2344) 230 kV line and Brandon Shores 5T Breaker failed (Line_FB)
- Sollers Point Terminal – Riverside 230 kV line CKT 2345 / Loss of Brandon Shores – Hawkins Point Terminal – Sollers Point Terminal (#2344) 230 kV line and Brandon Shores 5T Breaker failed (Line_FB)
Potential Generation Deliverability Violation – BG&E

- Conastone 500/230 kV transformer CKT 1 / Loss of Conastone – Peachbottom 500 kV line + Conastone 500/230 kV transformer CKT 1 (Line_FB)
- Burtonsville – Sandy Spring 230 kV line CKT #2314 / Loss of High Ridge – Sandy Springs – Burtonsville CKT # 2334 (Single)
- Burtonsville – Sandy Spring 230 kV line CKT #2334 / Loss of High Ridge – Sandy Springs – Burtonsville CKT # 2314 (Single)
Potential Generation Deliverability Violation – BG&E

- Westport – Greene 115 kV line CKT 110553 / Loss of Riverside 115 kV bus to 230-1 CKT 110985 & 230-2 CKT 110986 (DCTL)
- Westport – Greene 115 kV line CKT 110554 / Loss of Riverside 115 kV bus to 230-1 CKT 110985 & 230-2 CKT 110986 (DCTL)
- Concord – Greene 115 kV line CKT 110564 / Loss of Riverside 115 kV bus to 230-1 CKT 110985 & 230-2 CKT 110986 (DCTL)
- Concord – Greene 115 kV line CKT 110562 / Loss of Riverside 115 kV bus to 230-1 CKT 110985 & 230-2 CKT 110986 (DCTL)
• Station H – Quince Orchard 230 kV line / Loss of Dickerson – Quince Orchard DCTL
• Scull #2 – Mill #2 138 kV line / Loss of the other circuit (Single)
• Keeney 500/230 kV transformer CKT 1 / Loss of Keeney – Red Lion + Keeney 500/230 kV transformer CKT 2 (Line_FB)

• Keeney 500/230 kV transformer CKT 2 / Loss of Keeney – Red Lion + Keeney 500/230 kV transformer CKT1 (Line_FB)
PECO Supplemental Projects

- Warminster – install additional 230 / 13 kV transformer to serve distribution load. Service date 6/1/10.
- Upper Providence – install additional 230 / 34 kV transformer to serve distribution load. Service date 6/1/10.
- Tunnel – New 230 /13 kV substation in the Grays Ferry to Parrish 230 kV line to serve distribution load. Service date 6/1/09.
Next Steps

- Develop upgrades for violations identified to date.
- Continue with analysis of 2013
  - Complete NERC TPL-003 testing
  - 15-year planning
- Consolidate and post BES upgrades
- Retool Work
  - Updated generation assumptions
  - Updated load model
  - Validate timing of previously identified upgrades
- Subregional RTEP
Transmission Expansion Advisory Committee Meeting

2008 Market Efficiency Analysis Input Assumptions

April 23, 2008
Market Simulation Input Data

• PROMOD IV model from New Energy Associates (NEA)
• Underlying input data contained in NEA’s Powerbase (November 2007 update) including generating units and unit characteristics, fuel costs and emissions costs
• NEA Powerbase data based on a variety of sources including Platts, EIA, NYMEX, Evomarkets.com, EPA, FERC, NERC, etc.
• Powerflow Cases
  – 2008 power flow case to represent today’s “as-is” system
  – 2012 RTEP power flow case to represent future system
Key Input Parameters

- Fuel prices
- Load and energy
- Future generation scenario
- Emissions prices
- Transmission topology
- Discount rate
- Upgrade Revenue Requirement
- RPM
Powerbase fuel prices based on NYMEX futures prices and long-run forecasts from Platts and the Energy Information Administration (EIA)
Load & Energy Input Data

- PJM zonal peak and zonal energy forecast from PJM 2008 Load Forecast Report
- Historical zonal hourly loads used to develop zonal hourly load shape

Table 1 - Forecast PJM Peak and Energy

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2011</th>
<th>2014</th>
<th>2017</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak (MW)</td>
<td>137,948</td>
<td>145,061</td>
<td>151,675</td>
<td>158,176</td>
<td>168,258</td>
</tr>
<tr>
<td>Energy (GWh)</td>
<td>729,819</td>
<td>764,785</td>
<td>798,307</td>
<td>831,606</td>
<td>883,531</td>
</tr>
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</table>
Demand Response Input Data

- Demand response values are sum of ILR forecast and DR (cleared and FRR) and from RPM auctions for 2008/09 and 2010/2011
- Zonal distribution of demand response MWs based on distribution shown in posted RPM planning period parameters

<table>
<thead>
<tr>
<th>Demand Response (MW)</th>
<th>2008</th>
<th>2011</th>
<th>2014</th>
<th>2017</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3014</td>
<td>3417</td>
<td>3417</td>
<td>3417</td>
<td>3417</td>
</tr>
</tbody>
</table>
• generation model includes all existing in-service generation
  plus active queue generation with executed ISA minus
  expected future deactivations
• installed reserve requirement is met through 2012
• To meet installed reserve requirement for study years 2014,
  2017 and 2022, 3,500 MW, 11,000 MW and 22,600 MW of
  new generation will be added to model, respectively
• New generation will be added to PJM regions in proportion to
  the regional location and regional generation type of future
  generation projects in Generation Interconnection Queues
  through Queue T
Figure 2 - PJM Market Efficiency Reserve Margin

Forecasted Summer Peak Net Internal Demand

- Reserve Requirement
- Existing + Queue with Signed ISA - Retirement

MW

Year


120,000
130,000
140,000
150,000
160,000
170,000
180,000
190,000
200,000
210,000
220,000
230,000

3,500 MW
11,000 MW
22,600 MW
### Table 2 - Location and Type of Generation Additions to Maintain Reserve Margin

<table>
<thead>
<tr>
<th>Region</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Gas</th>
<th>Oil</th>
<th>Wind</th>
<th>Other Renewable</th>
<th>Total Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>AECO/DPL/JCPL/PECO/PSEG</td>
<td>0.3%</td>
<td>2.7%</td>
<td>20.6%</td>
<td>1.5%</td>
<td>1.2%</td>
<td>0.1%</td>
<td>26.4%</td>
</tr>
<tr>
<td>AEP/APS/COM/DAY/DUQ</td>
<td>0.6%</td>
<td>20.4%</td>
<td>6.3%</td>
<td>0.0%</td>
<td>12.0%</td>
<td>0.8%</td>
<td>40.1%</td>
</tr>
<tr>
<td>BGE/PEP</td>
<td>3.4%</td>
<td>0.0%</td>
<td>8.3%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>11.6%</td>
</tr>
<tr>
<td>DOM</td>
<td>4.0%</td>
<td>0.4%</td>
<td>4.6%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.5%</td>
<td>9.5%</td>
</tr>
<tr>
<td>ME/PN/PPL</td>
<td>3.3%</td>
<td>4.5%</td>
<td>2.8%</td>
<td>0.0%</td>
<td>1.5%</td>
<td>0.4%</td>
<td>12.4%</td>
</tr>
</tbody>
</table>
- Powerbase emissions allowance prices from a variety of sources including Platt’s BASECASE, Evomarkets.com, and EPA studies.
- Powerbase emissions release rates from a variety of sources including Platt’s BASECASE, EPA CEMS data and EPA studies.
- Powerbase includes emission release rates but no prices for CO2.
- CO2 assumption will be for national program by study year 2011 with allowance prices based on Synapse study.
Note: The CAIR legislation requires the generators in 22 states in the East surrender 2 Title IV SO2 allowances beginning in 2010 and 2.86 Title IV SO2 allowances beginning in 2015 for every ton emitted. This is modeled in the Powerbase database by assigning these units with a separate CAIR SO2 allowance price which is twice the price shown from 2010 to 2014 and 2.86 times the price shown beyond 2015.
Figure 4 - NOx Emission Price Assumptions

Note: Beginning in 2009, the SIP Call program is replaced by CAIR NOx programs that are split into seasonal and annual trading programs. Figure 4 shows the addition of these programs for generators covered by both programs (during ozone season only).
Figure 5 - Mercury Price Assumptions

Note: Mercury regulation begins in 2010 with the CAMR legislation.
Figure 6 - CO2 Emission Assumptions

Note: It is assumed that a national CO2 program will be in place by study year 2011.
Transmission Topology and Constraints

- **Powerflow Cases**
  - 2008 power flow case to represent today’s “as-is” system
  - 2012 RTEP power flow case to represent future system

- **Thermal Constraints**
  - monitor/contingency pairs – will post when complete
  - NERC Book of Flowgates
  - Historical PJM congestion events

- **Voltage Constraints**
  - PJM reactive interface limits
  - MW limits based on historical values for “as-is” case adjusted for future upgrade impacts in 2012 case
Reactive Interface Limit Values

- Values used for as-is 2008 system model based on historical averages with Bed-BO(Post) adjusted upward for SVC impact
- Historical averages increased by anticipated effect of RTEP reactive reinforcements to develop future 2012 system values

<table>
<thead>
<tr>
<th></th>
<th>WESTERN</th>
<th>CENTRAL</th>
<th>EASTERN</th>
<th>BO-BED (POST)</th>
<th>APS (PRE)</th>
<th>APS (POST)</th>
<th>50045005</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-is 2008 System</td>
<td>6000</td>
<td>4000</td>
<td>6200</td>
<td>2600</td>
<td>3200</td>
<td>3900</td>
<td>4000</td>
</tr>
<tr>
<td>Future 2012 System</td>
<td>6500</td>
<td>4500</td>
<td>6700</td>
<td>2600</td>
<td>3200</td>
<td>3900</td>
<td>4500</td>
</tr>
</tbody>
</table>
Discount Rate

• Federal Office of Management and Budget guidance is to use 7% rate with sensitivity analysis at 5% and 9%
• Bright line test dictates use of a single value with no sensitivity analysis
• Discount rate of 9% recommended for cost-benefit analysis conducted as part of 2008 market efficiency analysis
Revenue Requirement

- Use information from recent TrAIL proceedings to develop a revenue requirement to project cost ratio to apply to study projects
- First year revenue requirement = $154M
- Total plant cost at time = $877M
- RR/Cost ratio = 17.6%
- Annual revenue requirements will decrease with depreciation but annual O&M increase will offset
- To determine annual cost of a study project for the 15-year study period, multiply total project cost by .176
• 2010/2011 RPM results show a single clearing price across majority of RTO footprint
• expectation of single RPM clearing price over time horizon of market efficiency analysis due to future major RTEP upgrades
• RPM-related benefits of study upgrades will not be calculated in 2008 market efficiency analysis
Next Steps

- PJM Board approval of input assumptions
- Complete base case setup
- Determine areas of interest on which to focus congestion analysis
  - Historical congestion
  - Future congestion from base case results
- Begin analysis with regular updates to TEAC