Issues Tracking
• Open Issues
  – None

• New Issues
2012 RTEP - Renewable Portfolio Standards Scenarios
Expected Update for October TEAC

• Progress Update
  – Scenario #1
    • Will have peak reliability, SCOPF, and Market Efficiency analysis complete
      – Will provide a map of the overloads
    • Transmission Overlay will be work in progress
  – Scenario #2
    • Will have peak reliability, SCOPF, and Market Efficiency analysis complete
      – Will provide a map of the overloads
    • Transmission Overlay will be work in progress
  – Scenario #3
Renewable Portfolio Standards (RPS)

• Status
  – RPS targets (MWh) update
  – Wind capacity factor update
  – Nameplate MW update
Renewable Portfolio Standards

• Overall Assumptions
  – Model the latest Renewable Portfolio Standards (RPS) state targets
    • Assume production from renewable wind
    • Update target PJM installed renewable MW requirements
    • Update installed reserve calculation

  – 2012 PJM Load Forecast Report
    • 15 Year Load Forecast
    • Include Demand Response (DR) and Energy Efficiency (EE)

  – Incorporate findings from 2011 RTEP RPS scenario studies
### 2027 RPS Study

<table>
<thead>
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<th>Solar</th>
<th>Wind</th>
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<td>Target Installed Nameplate for Renewables based on State Targets*</td>
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<td>Forecast Restricted Demand ** (2012 PJM Load Forecast)</td>
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<td>Installed Reserve Margin</td>
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<td>Expected Non-Renewable Capacity in 2017 Base Case</td>
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* Capacity factors will be based GE PRIS Task 2 Scenario Development - Final Report
** Assumes ~15,000 MW of DR
*** Assumes 38% for solar and 15% for wind

### Capacity Factors

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<tr>
<th>Location</th>
<th>Onshore</th>
<th>Offshore</th>
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<td></td>
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<tr>
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<tr>
<td>Indiana</td>
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<tr>
<td>Maryland</td>
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<td>Michigan</td>
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<tr>
<td>New Jersey</td>
<td>37%</td>
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<td>North Carolina</td>
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<tr>
<td>Ohio</td>
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<tr>
<td>Pennsylvania</td>
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<tr>
<td>Virginia</td>
<td>34%</td>
<td>37%</td>
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</tr>
<tr>
<td>West Virginia</td>
<td>35%</td>
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</tbody>
</table>
• Assumptions
  – Assume RPS supply from PJM resources
  – 7 GW Offshore
  – Study year: 2027

• Analysis
  – Reliability Analysis
    • Generator Deliverability (50/50 load level)
    • Common Mode Outage test (50/50 load level)
  – Market Efficiency Analysis
    • Security Constrained Optimal Power Flow (SCOPF)
    • Production cost simulation using PROMOD

• Result
  – Thermally overloaded facilities
  – Congestion $’s
  – Develop transmission overlay
### Renewable Resources

#### Solar

<table>
<thead>
<tr>
<th>Solar</th>
<th>Existing</th>
<th>Queue*</th>
<th>Additional**</th>
<th>Total</th>
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<td>227</td>
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<td><strong>17,399</strong></td>
<td><strong>19,924</strong></td>
<td><strong>43,551</strong></td>
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#### Wind

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<tr>
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<td></td>
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<tr>
<td>Nuclear</td>
<td>3,425</td>
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<td></td>
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<tr>
<td>Other (Coal, Diesel, Oil, etc.)</td>
<td>1,745</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Generator Interconnection projects that are not yet in service and are modelled in the 2012 RTEP 2017 base case
** Based on amount of wind & solar projected in each PJM state in GE PRIS Task 2 Scenario Development - Final Report
Scenario #1 Reliability Constraints

Legend
- Trans Lines >= 500 kV
- Subs >= 500 kV
- Trans Lines = 345 kV
- Subs = 345 kV
- Generator Deliverability Constraints Scenario 1
- SCOPF Constraints Scenario 1
• Assumptions
  – **Low GW Offshore**
  – Otherwise, same as RPS – Scenario #1 but with a low GW offshore assumption
  – The remainder of the state target RPS will be sourced from inland PJM resources
### Modeled Nameplate MW

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>Queue*</th>
<th>Additional**</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<td>UGI</td>
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<tr>
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### Other Resources To Meet IRM

<table>
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<tr>
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<th>Natural Gas</th>
<th>Nuclear</th>
<th>Other (Coal, Diesel, Oil, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>9,123</td>
<td>3,425</td>
<td>1,745</td>
</tr>
</tbody>
</table>

* Generator Interconnection projects that are not yet in service and are modeled in the 2012 RTEP 2017 base case
** Based on amount of wind & solar projected in each PJM state in GE PRIS Task 2 Scenario Development - Final Report
• Assumptions
  – **RPS Source from Neighboring Entities**
  – Otherwise, same as RPS – Scenario #2 (low MW offshore)
  – The remainder of the state target RPS will be sourced from inland PJM resources

• Neighboring Entities
  – Assume 40% of the PJM RPS supplied from renewable wind in the Midwest ISO (MISO)
    • Assume DC injection points from MISO to PJM
    • Injection points to PJM to be determined
## RPS Scenario #3

### Modeled Nameplate MW

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>Queue*</th>
<th>Additional**</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

### Other Resources To Meet IRM

| Natural Gas | 9,123 |
| Nuclear     | 3,425 |
| Other (Coal, Diesel, Oil, etc.) | 1,745 |

* Generator Interconnection projects that are not yet in service and are modelled in the 2012 RTEP 2017 base case

** Based on amount of wind & solar projected in each PJM state in GE PRIS Task 2 Scenario Development - Final Report

*** Assummes 38% capacity factor
Scenario #3 Reliability Constraints
2027 RPS Scenario 1 and 2 Initial Runs

• Preliminary Findings
  – Unrealistic high on-peak LMP
  – Emergency generation shortage on-peak
  – Significant Wind Curtailment ~ 2% to 4%
  – Minimum generation energy dump off-peak

• Next Steps:
  – Runs with increased operating reserves
  – Develop transmission overlays to address reliability and market efficiency issues
Artificial Island Voltage Analysis Update
Artificial Island and Surrounding Network

KEY
- Gen Bus
- Artificial Island

Artificial Island

Peach Bottom
- Gen Bus
- Peach Bottom: ~2200 MW

Rock Springs
- Gen Bus
- Rock Springs: ~650 MW

New Freedom
- Gen Bus

Keeney

Red Lion

Hope Creek
- Gen Bus
- Hope Creek: ~1160 MW

Salem
- Gen Bus
- Salem: ~2300 MW

Smithburg
- Gen Bus

East Windsor
- Gen Bus

to Branchburg
• Max power output for stable operation is expressed as:

\[ P_{\text{max}} = \frac{V_t \times E_i}{X_d} \]

*Vt* is system voltage
  » More is theoretically better, but has operational limits

*Ei* is internal machine voltage

*Xd* is system impedance
  » Smaller is better, but this value is fixed without series compensation option
Potential Solutions Considered

Near Term
• Voltage as operating guide (instead of reactive output)
• Fixed or Variable Reactor at New Freedom, Salem/Hope Creek
• Topology Change at New Freedom
  – Mitigate critical stuck breaker contingency at New Freedom
• Series reactor on line 5037 Hope Creek – Salem
• Braking Resistor
• Series Compensation on 5039 New Freedom – East Windsor

Long Term
• New 500 kV transmission out of Salem
Topology Change at New Freedom 500 kV

- Critical contingency for the 5015 out condition involves a fault with a stuck breaker at New Freedom 500 kV
- Add a breaker at New Freedom to mitigate the critical stuck breaker contingency during the 5015 out condition
- Only helps stability margins during this specific outage condition by reducing the reactive requirement at the Artificial Island
- Construction lead time is less than 1 year
- Estimated cost is less than $5 Million

- This option is being considered as a short term solution
Reactor at New Freedom / Salem / Hope Creek

- Switchable or Variable
- Stability Margin
- Potential need for two operating guides
  - With and without reactor
- Operation of reactor
  - System voltage vs. unit reactive output
- Loss of reactor
- Construction lead time 1.5-2.5 years

- This option requires more analytical work
• Considered 2% reactor on 5037
  – Attempts to electrically separate Salem & Hope Creek during fault conditions to improve fault voltages

• This approach is least effective during the 5015 outage, when it is needed most

• This option does not resolve the existing problems and will not be pursued at this time
• 1,400 MW example in-service at Bonneville Power Administration (Pacific Northwest) since the 1970’s
  – Only example in the United States

• The resistor is 1400 MW, 240 KV. It consists of 45,000 ft of ½ inch stainless steel wire on three towers.
  – Custom design and installation required
  – Physically large device

• This option does not resolve the existing problems and will not be pursued at this time
• Series Compensation
  – Lower impedance improves stability margin
  – Lower impedance raises voltage

• Potential for oscillation (SSR) issues
  – Requires more detailed stability studies

• This option would not help during scheduled outages of 5015 or 5038. Series compensation would be placed on Either 5015 or 5038. the critical contingency will be loss of either 5038 or 5015. in either case, series compensation will be either scheduled out or tripped

• This option does not resolve the existing problems and will not be pursued at this time
New 500 kV Transmission

• Potential Longer term solution
  – Stability margins throughout operational envelope
  – Maintenance flexibility

• Potential Transmission Solutions
  – New, Hope Creek – Peach Bottom 500 kV
  – New, New Freedom – Deans 500 kV
  – New, New Freedom – Smithburg 500 kV

• Continue to evaluate new 500 kV transmission solutions to resolve the issues
High Voltage in PJM Operations Analysis Update
• Correlated historical PI data to the high voltage alarm data
  – High correlation

• High voltage alarm data
  – Use to determine the locations

• PI data
  – Use to determine the historical worst high voltages
MAAC - Locations With More than 500 High Voltage Alarms
• Simulate high voltages

• High level magnitude & location of reactors

• Review findings with TOs and PJM Operations
Potential Reactive Upgrade (Shunt Reactor) Locations for Evaluation

Legend
- High Voltage Violations >500
- High Voltage Violations >1000

Substations
- 230 kV
- 345 kV
- 500 kV
- 765 kV

Transmission Lines
- 230 kV
- 345 kV
- 500 kV
- 765 kV
- HVDC
Dominion - Locations With More than 500 High Voltage Alarms
PSEG Potential Reactor Locations

- **Drivers**
  - High voltage in PJM Operations
  - Charging from existing and planned underground transmission in the PSEG zone
- **The total estimated cost is $84M**

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Size (MVAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saddlebrook</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Athenia</td>
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<td>50</td>
</tr>
<tr>
<td>Bergen</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Hudson</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Stanley Tce</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>West Orange</td>
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<td>50</td>
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<tr>
<td>Aldene</td>
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<tr>
<td>Camden</td>
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<td>150</td>
</tr>
<tr>
<td>Gloucester</td>
<td>1</td>
<td>100</td>
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<tr>
<td>Clarksville</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Hawthorne/Hinchmans/Jackson Rd</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12</td>
<td><strong>700</strong></td>
</tr>
</tbody>
</table>
• Next Steps

  – Continue to review potential locations with Transmission Owners and PJM Planning / Operations
Generation Deactivation Notification (Retirements) Update
Generation Deactivation Notifications – As of 9/10/2012
• Burlington 9 GT
  – 184 MW
  – Notification received 9/10/2012
  – Anticipated deactivation date 6/1/2014
  – Reliability analysis complete

• Issues identified
Ohio Area Deactivation Upgrade Alternative Analysis
No Alternative

Marysville – South Amherst 765 kV
- Also includes 2-5 miles of 345 kV from South Amherst – Beaver 345 kV

Trivalley – South Amherst 765 kV
- Trivalley will intersect Kammer – Vassell 765 kV near Conesville 345 kV
- Also includes 2-5 miles of 345 kV from South Amherst – Beaver 345 kV

Conesville – Beaver 345 kV
Conesville – Harmon 345 kV
Beaver Valley - Leroy Center 345 kV + Mansfield – Leroy Center 345 kV line
Ohio Alternatives - Analysis Update

- 2017 Analysis
- Existing deactivation notification impacts
- Analysis of the base case (no alternatives) and each of the 5 alternatives
- Complete:
  - Baseline Contingency Analysis, Generator Deliverability, Common Mode Outage Analysis, N-1-1 Thermal analysis completed
  - Multiple criteria violations identified in the base case
- In-progress:
  - N-1-1 Voltage
  - Voltage Stability
• Voltage Analysis

  – PV analysis to determine FirstEnergy criteria violation year for Base Case and Alternatives

  – Critical contingencies

  – Analysis is in-progress
Next Steps

• Continue to develop solutions to all violations
• Complete voltage stability analysis
• Compare solution alternatives
• Recommend solutions
Northern New Jersey Short Circuit / HVDC Update
Short Circuit Fault Duty Near PSEG / ConEd Interface

• Problem
  – Simulated fault duty exceeding 80 kV near the PSEG / Con Ed interface
  
  – Several 230 kV locations in PSEG exceed 80 kA in future years despite generation retirements
Solution alternatives considered

• Replace the stressed breakers with 90 kA breakers

• Series reactors

• Operating Hudson 230 kV bus tie open
  – Recommended in 2015
B-3402 & C-3403 would remain AC facilities

Back-to-back convertor stations

Hudson River

Remove PARs (Con Ed will determine)
Recommended Solution

• Construct HVDC back to Back facility at Hudson:
  – Construct back to back HVDC converter station at Hudson
  – Remove the PARs at Farragut
    • Ultimately determined by Con Ed
  – Modify/coordinate protection relay schemes at Hudson and Farragut

• Estimated Project Cost: $300 M
• Expected In-service date: 6/1/2015
Coordinated Study Work

• PJM / ISO NE / NYISO
  – Impacted Transmission Owners

• Scope of Study
  – Thermal
  – Stability / EMTP

• Model Coordination

• Next Steps
Reliability Analysis Update
RTEP – 2017 Baseline Case Evaluation

- Baseline contingency analysis
  - Completed (Most violations are below 230 kV and will be presented in the upcoming sub-regional TEAC)

- Generator deliverability test
  - Completed (Most violations are below 230 kV and will be presented in the upcoming sub-regional TEAC)

- Common mode outage test
  - Completed (Most violations are below 230 kV and will be presented in the upcoming sub-regional TEAC)

- Load Deliverability
  - Complete and no violation identified

- N-1-1 Thermal and Voltage
  - Analysis in progress (some results are already sent out and the remaining results will be sent by Mid October)
APS Transmission Zone

- Project Cancellation

- Cancel B0560: Install a 250 MVAR capacitor at Kemptown 500 kV

- Cost Estimate: $4M

- With the cancellation of the PATH Project, this substation, and the associated capacitor bank, will not be constructed.
• Basecase Analysis Violation

• Voltage drop violation at Dale Summit, Milesburg, and Shingletown 230KV buses for various contingencies

• Install a 75 MVAR 230 kV capacitor at Shingletown Substation.(B2156)

• Cost Estimate: $0.19M

• Required IS Date: 6/1/2017
• Project Cancellation

• B1811.1 and B1811.2 need to be canceled. They are not needed with the project B2017.

• B1811.1: Perform a sag study of 4 miles of the Waterford - Muskingum line IS Date: 6/1/2016 (Cancel)

• B1811.2: Rebuild 0.1 miles of Waterford - Muskingum 345 kV with 1590 ACSR IS Date: 6/1/2016 (Cancel)

• B2017: Reconductor or rebuild Sporn - Waterford - Muskingum River 345 kV line IS Date: 6/1/2015
Supplemental Projects
• PPL Supplemental Projects:
• Equipment damage as a result of operating on high temperature.
• Proposed Solution: Reconductor the Susquehanna – Harwood 230 kV circuits #1 and #2 (S0493).
• Estimated Project Cost: $10.81M
• Expected IS Date: 5/31/2013
RTEP Next Steps

• Ohio Area alternative analysis

• High voltage evaluation

• RTEP reliability analysis
  – Complete N-1-1

• Scenario analysis
Questions?

Email: RTEP@pjm.com