Transmission Expansion Advisory Committee

July 12, 2012
Issues Tracking
• Open Issues
  – None

• New Issues
2012 RTEP Status Update
2012 RTEP CETO Values

- **MAAC**
  - 2016 CETO from 2011 RTEP = 3620
  - 2017 CETO (current 2012 RTEP) = 1100

- **EMAAC**
  - 2016 CETO from 2011 RTEP = 6520
  - 2017 CETO (current 2012 RTEP) = 4260

- **DOMINION**
  - 2016 CETO from 2011 RTEP = 440
  - 2017 CETO (current 2012 RTEP) = 220

- Current CETO values are based on 2012 PJM Load Forecast Report

  - Include cleared RPM generation
2012 RTEP Assumptions

- PATH & MAPP not modeled
- Additional RPM cleared Demand Response
- RPM cleared new generation
- FSA/ISA generation
- 2011 RTEP topology changes
- Network enhancements due to deactivation
- Additional dynamic reactive
RTEP – 2017 Baseline Case Evaluation

- Baseline contingency analysis
  - Complete, upcoming TEAC review

- Generator deliverability test
  - Complete, upcoming TEAC review

- Common mode outage test
  - Complete, upcoming TEAC review

- Load Deliverability
  - Several areas complete

- N-1-1
RTEP – Base Cases Under Development

- 2020
  - 8 year case for 24 month RTEP cycle

- 2017
  - Additional RTEP base case that includes additional queued merchant transmission projects with an FSA pending light load criteria retool

- Retool cases
PATH Project Analysis Update
## 2010 RTEP Thermal Violations

<table>
<thead>
<tr>
<th>From Bus</th>
<th>To Bus</th>
<th>Voltage</th>
<th>First Thermal Violation Date</th>
<th>Load Deliverability Area Violation(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexington</td>
<td>Dooms</td>
<td>500 kV</td>
<td>2017</td>
<td>Dominion Load Deliverability</td>
</tr>
<tr>
<td>Mt. Storm</td>
<td>T157 Tap</td>
<td>500 kV</td>
<td>2015</td>
<td>MAAC Load Deliverability</td>
</tr>
<tr>
<td>T157 Tap</td>
<td>Dooms</td>
<td>500 kV</td>
<td>2015</td>
<td>PEPCO Load Deliverability</td>
</tr>
<tr>
<td>Pruntytown</td>
<td>Mt. Storm</td>
<td>500 kV</td>
<td>2020</td>
<td>SWMAAC Load Deliverability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MAAC Load Deliverability</td>
</tr>
<tr>
<td>Jacks Mountain</td>
<td>Juniata #1</td>
<td>500 kV</td>
<td>2018</td>
<td>EMAAC Load Deliverability</td>
</tr>
<tr>
<td>Jacks Mountain</td>
<td>Juniata #2</td>
<td>500 kV</td>
<td>2020</td>
<td>MAAC Load Deliverability</td>
</tr>
<tr>
<td>Greenland Gap</td>
<td>Meadow Brook</td>
<td>500 kV</td>
<td>2025</td>
<td>MAAC Load Deliverability</td>
</tr>
<tr>
<td>Mt. Storm</td>
<td>Greenland Gap</td>
<td>500 kV</td>
<td>&gt;2025</td>
<td>MAAC Load Deliverability</td>
</tr>
<tr>
<td>Bath County</td>
<td>Valley</td>
<td>500 kV</td>
<td>2022</td>
<td>Dominion Load Deliverability</td>
</tr>
<tr>
<td>Keystone</td>
<td>Jacks Mountain</td>
<td>500 kV</td>
<td>2022</td>
<td>EMAAC Load Deliverability</td>
</tr>
<tr>
<td>Harrison</td>
<td>Pruntytown</td>
<td>500 kV</td>
<td>&gt;2025</td>
<td>PEPCO Load Deliverability</td>
</tr>
<tr>
<td>Keystone</td>
<td>Conemaugh</td>
<td>500 kV</td>
<td>2025</td>
<td>MAAC Load Deliverability</td>
</tr>
</tbody>
</table>
2010 RTEP - Previous Reliability Violations

- 2010 RTEP MAAC Load Deliverability Voltage TEST
  - Over 40 non-converged contingency pairs for the 2010 RTEP MAAC load deliverability voltage test

Non-Converged Contingencies

- Bath County – Valley
- Bedington – Doubs
- Bedington Cap
- Black Oak – Bedington
- Black Oak - Black Oak SV
- Brighth – Conastone
- Brighun – Dut’s
- Brister – Chance, Jr.
- Brister – Ox
- Burches Hill - Possum Point
- Cabot – Cranberry
- Calvert Cliffs - Waugh Chapel
- Calvert Cliffs #1 generator
- Calvert Cliffs #2 generator
- Conemaugh – Hunterstown
- Conemaugh - Jacks Mountain
- Conemaugh – Keystone
- Cunningham – Dooms
- Cunningham – Elmont
- Doubs Cap
- Elmont – Ladysmith
- Fort Martin – Ronco
- Hatfield’s Ferry - Black Oak
- Hatfield’s Ferry - Brown Run
- Hatfield’s Ferry - Fort Martin
- Hatfield’s Ferry – Ronco
- Hunterstown – Conastone
- Jacks Mountain - Juniata #1
- Jacks Mountain - Juniata #2
- Keystone - Jacks Mountain
- Keystone - South Bend
- Ladysmith – Chancellor
- Loudoun – Possum Point
- Loudoun - Meadow Brook
- Loudoun – Moreland
- Loudoun - Pleasant View
- Mecklenburg – Greenland Gap
- Midlothian - North Anna
- Morrisville Cap
- Mt. Storm - Greenland Gap
- Mt. Storm - Meadow Brook
- Mt. Storm - T157_Tap
- T157_Tap – Doubs
- T174_Tap – Brown Run
- Wylie Ridge – Cranberry
- Yukon - South Bend
- Yukon - T174_Tap
• 15 Year Thermal Test
  – Preliminary Result
  – 2013 – 2028
  – Includes most severe thermal loading from generator deliverability, MAAC, EMAAC and Dominion load deliverability
  – No 500 kV potential thermal overloads identified

• MAAC Load Deliverability Voltage
  – Preliminary Result
  – All contingencies converged
  – CETL > CETO
MAPP Project Analysis Update
• Previous 2010 RTEP
  – EMAAC load deliverability voltage violations

• Current 2012 RTEP
  – Preliminary result
  – No EMAAC load deliverability voltage violations
  – No 15 Year thermal violations
• Continue to validate preliminary analysis

• Complete 2017 N-1-1 analysis

• Additional sensitivity analysis
Stage 1A 10-Year ARR Analysis
Upgrades- Stage 1A 10-Year ARR analysis

- COMED Zone
  - Following projects were studied
    - New Byron - Wayne 345 kV circuit
    - New Byron - Cherry Valley-Pleasant Valley 345 kV circuit
    - New Byron - Cherry Valley 345 kV circuit
    - New Cherry Valley - Pleasant Valley 345 kV circuit
    - New Byron - Pleasant Valley 345 kV circuit
  - At the June TEAC, Byron-Wayne 345 kV was identified as the most optimal project to fix 10-Year ARR violations.
    - Eliminates all COMED violations
  - Studied combinations other than Byron – Wayne 345 kV did not fix all 10-Year ARR violations and create additional violations
  - Since the June TEAC, the Byron - Pleasant Valley 345 kV circuit proposal has been revised to include a higher impedance conductor, adds a new transformer at Silver Lake 345 kV, uprates the existing Pleasant Valley – Silver Lake 345 kV circuit, and reconfigures the Pleasant Valley 345 kV station
• Reliability evaluations underway
  – Byron – Wayne 345 kV
  – Byron – Pleasant Valley 345 kV

• 10-year ARR Infeasibilities
  – ComEd Zone
    • Both the Byron – Wayne 345 kV and the Revised Byron – Pleasant Valley 345 kV proposal eliminate ComEd 10-year ARR Infeasibilities
  – Market to Market
    • Byron – Wayne 345 kV improves Market to Market Congested Flowgates more than all other proposals
Generation Deactivation Notification (Retirements) Update
## Deactivation Status

<table>
<thead>
<tr>
<th>Unit</th>
<th>Trans Zone</th>
<th>Requested Deactivation Date</th>
<th>PJM Reliability Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chesapeake 1 &amp; 2, Yorktown 1</td>
<td>DOM</td>
<td>12/31/2014</td>
<td>Reliability Analysis complete. Impacts identified. Upgrades expected to be completed by June 2015.</td>
</tr>
<tr>
<td>Chesapeake 3 &amp; 4</td>
<td>DOM</td>
<td>12/31/2015</td>
<td>Reliability Analysis complete. Impacts identified. Upgrades expected to be completed by June 2016.</td>
</tr>
<tr>
<td>Bergen 3; Burlington 8; National Park 1; Mercer 3; Sewaren 6</td>
<td>PSEG</td>
<td>6/1/2015</td>
<td>Reliability Analysis Complete. Impacts identified and expected to be resolved in three - four years. Working with affected TO to finalize upgrade schedule.</td>
</tr>
<tr>
<td>Armstrong 1 &amp; 2; Bayshore 2-4; Eastlake 4-5; R Paul Smith 3 &amp; 4</td>
<td>AP</td>
<td>9/1/2012</td>
<td>Reliability analysis complete. Impacts identified and expected to be resolved by June 2016. Further refinement of the reliability analysis, required upgrades, and generator deactivation schedule continues. Unit will deactivate as scheduled. See posting - FE Generator Deactivation Study Results and Required Upgrades.</td>
</tr>
<tr>
<td>Ashtabula 5; Eastlake 1-3; Lake Shore 18</td>
<td>AP</td>
<td>9/1/2012</td>
<td>Reliability analysis complete. Impacts identified and expected to be resolved by June 2016. Further refinement of the reliability analysis, required upgrades, and generator deactivation schedule continues. Unit will continue to operate as upgrades to transmission system are constructed - estimated till June 1, 2015. See posting - FE Generator Deactivation Study Results and Required Upgrades.</td>
</tr>
<tr>
<td>Walter C Beckjord 1</td>
<td>DEOK</td>
<td>5/1/2012</td>
<td>Reliability Analysis complete - no impacts identified.</td>
</tr>
<tr>
<td>Walter C Beckjord 2-6</td>
<td>DEOK</td>
<td>4/1/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2014.</td>
</tr>
<tr>
<td>Unit</td>
<td>Trans Zone</td>
<td>Requested Deactivation Date</td>
<td>PJM Reliability Status</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
<td>-----------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Albright 1-3; Rivesville 5 &amp; 6; Willow Island 1 &amp; 2</td>
<td>APS</td>
<td>9/1/2012</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by May 2013. Thus generator can be allowed to deactivate as scheduled on 9/1/2012 assuming all upgrades are still on track to be completed as scheduled.</td>
</tr>
<tr>
<td>New Castle 3-5; New Castle Diesels A &amp; B</td>
<td>ATSI</td>
<td>4/16/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2015. Thus generator can be allowed to deactivate as scheduled.</td>
</tr>
<tr>
<td>Portland 1 &amp; 2; Glen Gardner CT 1-8</td>
<td>MetEd</td>
<td>1/7/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades and operating procedures expected to be in place by May 2015 to allow generators to deactivate as scheduled.</td>
</tr>
<tr>
<td>Elrama 1-3</td>
<td>DUQ</td>
<td>6/1/2012</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2014. Unit deactivated on June 1, 2012.</td>
</tr>
<tr>
<td>Elrama 4</td>
<td>DUQ</td>
<td>6/1/2012</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2014. Evaluating options. Unit to be kept in service until October 1, 2012, pending analysis of outages required to implement required system upgrades.</td>
</tr>
<tr>
<td>Shawville 1-4; Titus 1-3</td>
<td>PenElec</td>
<td>4/16/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades and operating procedures expected to be in place by May 2015 to allow generators to deactivate as scheduled.</td>
</tr>
<tr>
<td>Niles 1</td>
<td>ATSI</td>
<td>6/1/2012</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2014. Evaluating options. Unit to be kept in service until October 1, 2012, pending analysis of outages required to implement required system upgrades.</td>
</tr>
<tr>
<td>Unit</td>
<td>Trans Zone</td>
<td>Requested Deactivation Date</td>
<td>PJM Reliability Status</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------</td>
<td>-----------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Niles 2</td>
<td>ATSI</td>
<td>6/1/2012</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2014. Unit deactivated on June 1, 2012.</td>
</tr>
<tr>
<td>Fisk Street 19, Crawford 7 &amp; 8</td>
<td>ComEd</td>
<td>12/31/2012</td>
<td>Reliability Analysis Complete. No impacts identified.</td>
</tr>
<tr>
<td>Conesville 3</td>
<td>AEP</td>
<td>12/31/2012</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2014. PJM continues to finalize details of required upgrades and completion dates.</td>
</tr>
<tr>
<td>Big Sandy 1; Clinch River 3; Glen Lyn 5 &amp; 6; Kammer 1-3; Kanawha River 1 &amp; 2; Muskingum River 1-4; Pickway 5; Sporn 1-4; Tanner Creek 1-3</td>
<td>AEP</td>
<td>6/1/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by June 2015.</td>
</tr>
<tr>
<td>Avon Lake 7 &amp; 9</td>
<td>ATSI</td>
<td>4/16/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by May 2015</td>
</tr>
<tr>
<td>Sewaren 1-4</td>
<td>PSEG</td>
<td>6/1/2015</td>
<td>Reliability Analysis complete. No impacts expected with PSEG contemplating re-use of Capacity Rights for a new generation project</td>
</tr>
<tr>
<td>Cedar 1 &amp; 2; Deepwater 1 &amp; 6; Missouri Ave CT B, C &amp; D</td>
<td>AE</td>
<td>5/31/2015</td>
<td>Reliability Analysis complete - impacts identified - upgrades scheduled to be completed by May 2015</td>
</tr>
<tr>
<td>Hutchings 1 &amp; 2</td>
<td>Dayton</td>
<td>6/1/2015</td>
<td>Reliability Analysis complete. No impacts identified</td>
</tr>
<tr>
<td>Smart Paper (St. Clair)</td>
<td>DEOK</td>
<td>8/10/2012</td>
<td>Reliability Analysis complete. No impacts identified</td>
</tr>
<tr>
<td>Hutchings 4</td>
<td>Dayton</td>
<td>6/1/2013</td>
<td>Reliability Analysis Underway</td>
</tr>
</tbody>
</table>
• 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 345kV + Mansfield – Leroy Center 345kV line
Reliability Analysis Update
Operational Performance – High System Voltages
Operational Performance – High System Voltages

• High voltage in PJM Operations today
  – MAAC
  – Dominion

• Drivers
  – Low RTO load (less than 50% of summer peak)
  – Generation Outages

• Future
  – Generation retirements (and associated loss of reactive)
    • Over +7500 / - 2300 MVAR of reactive lost due to retirements associated with deactivation notifications received since 11/2011
  – Additional transmission due to peak load reliability violations

• Next Steps
  – Continue to evaluate operational data
  – Review and recommend reactive solution
    • Technology – shunt reactors, Location, Size, Configuration
- **PJM Manual 03 – 3.5.3 High Voltage Operation**
  - **Controlling actions**
    - switching capacitors out-of-service
    - switching reactors in-service
    - adjusting voltage set point of static var compensators (SVC)
    - operating synchronous condensers
    - changing transformer tap positions
    - changing generation excitation
    - adjusting generation MW output (i.e.: to change line flows) for actual voltage violations only
    - adjusting PARs
    - switching transmission facilities in/out of service
  - **Corrective actions**
    - PJM dispatch requests, including opening of EHV circuits
MAAC - Locations With More than 500 High Voltage Alarms
Potential Reactive Upgrade (Shunt Reactor) Locations for Evaluation

Legend
- **Yellow**:
  - High Voltage Violations >500
- **Red**:
  - 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

Legend
- Red: High Voltage Violations >500
- Yellow: High Voltage Violations >750

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

Transmission Lines
- 230 kV
- 345 kV
- 500 kV
- 765 kV
- HVDC
Potential Reactive Upgrade (Shunt Reactor) Locations for Evaluation
Dominion Shunt Reactors – Proposed Locations

- **Northern Virginia**

- **Operational Performance:**
  - Dominion Virginia Power continues to experience high voltage on the 230kV transmission system in Northern Virginia during periods of light system load.
  - Light load studies identified the need for three additional shunt reactor banks.

- **Proposed Solution:**
  - Install three additional 230kV 100MVAR variable shunt reactor banks at Clifton Substation, Gallows Road Substation, and Virginia Hills Substation.

- **Total Estimated Cost:**
  - $18 M

- **Expected In-Service Date:**
  - Fall 2013
Dominion Shunt Reactors – Proposed Locations

• Eastern Virginia

• Operational Performance:
  – Dominion Virginia Power continues to experience high voltage on the 230kV transmission system in Eastern Virginia during periods of light system load.
  – Light load studies identified the need for two additional shunt reactor banks.

• Proposed Solution:
  – Install two additional 230kV 100MVAR variable shunt reactor banks at Churchland and Shawboro Substations

• Total Estimated Cost:
  $12 M

• Expected In-Service Date:
  Spring 2014
Locations With More than 500 High Voltage Alarms
• Continue to work with PJM Operations to determine optimal reactive locations

• Work with the Transmission Owners to determine feasibility and develop proposed solutions
EKPC Update
• 2016 & 2017 Baseline Integration Studies

  – 2016 Generator Deliverability Study
    • complete, one project identified

  – 2016 Load Deliverability Study
    • complete, no issues identified

  – 2017 Generator Deliverability Study
    • complete, no issues identified

  – 2017 Load Deliverability Study
    • complete, no issues identified

  – 2017 baseline thermal and voltage analysis study
    • In-progress, evaluating potential solutions
• Generator Deliverability Violation

• The JK Smith – Union City – Lake Reba Tap 138kV line is overloaded for the loss of either the JK Smith – Dale 138kV line or the JK Smith – Fawksek 138kV line fault with a stuck breaker at the JK Smith 138kV (breaker E63-91T). This facility is also overloaded for a bus fault at Fawksek 138kV

• Proposed solution: Upgrade the operating temperature of the existing conductor for the JK Smith – Union City – Lake Reba Tap 138kV line. (B2066)

• Estimated Project Cost: $0.28M

• Expected IS date: 6/1/2016
Short Circuit
• The Bluebell 138 kV breakers ‘301-B-11,’ ‘301-B-9,’ ‘301-B187,’ ‘301-B-206,’ and ‘301-B-10’ are overstressed

• Proposed Solution: Replace Bluebell 138 kV breakers ‘301-B-11,’ ‘301-B-9,’ ‘301-B187,’ ‘301-B-206,’ and ‘301-B-10’ (b2059-b2063)

• Estimated Project Cost: $180 K per breaker

• Expected IS Date: 06/1/2013
• The Knox 138 kV breaker ‘307-B-10’ is overstressed
• Proposed Solution: Replace Knox 138 kV breakers 307-B-10’ (b2064)
• Estimated Project Cost: $0.18 M
• Expected IS Date: 06/1/2013
Identified breakers in PSEG territory that are close to or exceeding 80 kA as of the 2016 planning year

- Kearny
- NJT Meadowlands
- Essex
PJM is currently evaluating potential alternatives to mitigate identified issues

- DC
  - Back-to-Back DC conversion of Hudson – Farragut PARs
  - Simplified DC conversion of Hudson – Farragut PARs

- Higher Rated Circuit Breakers
  - Discussions with several vendors about 90kA+ breakers
  - Additional considerations (station work, grounding, other physical considerations)
Potential DC Alternative

- Benefits:
  - Resolves short circuit issues in the Hudson vicinity
  - Mitigates fault current levels from ConEd
  - Provides more controllability
- Estimated Cost: $510 Million

Remove 230-345kV autotransformers
Remove PARs
Potential DC Alternative

- Benefits:
  - Resolves short circuit issues in the Hudson vicinity
  - Mitigates fault current levels from ConEd
  - Provides much better controllability on the B and C circuits

- Estimated Cost: $300 Million
Questions?

Email: RTEP@pjm.com