Transmission Expansion Advisory Committee

Reliability Analysis Update

January 7, 2016
Review of 2016 RTEP Assumptions (Continued from December 2015 TEAC)
• TPL-001-4 R2.4.1: System peak Load levels shall include a Load model which represents the expected dynamic behavior of Loads that could impact the study area, considering the behavior of induction motor Loads. An aggregate System Load model which represents the overall dynamic behavior of the Load is acceptable.

• Enforceable – January 1, 2016
All TOs have submitted dynamic load models.

PJM has completed a sanity check and found several simulation issues with:

- Negative equivalent loads.
- Small (near zero MW) loads.
- High equivalent distribution network impedance (R&X) for low voltage level loads (e.g. below 34.5kV), etc.

Sensitivity studies are in progress to better understand the impact of the submitted dynamic load models.
• PJM is developing recommendations to resolve the identified issues and will notify the TOs soon

• PJM will develop an implementation plan that includes:
  – Stability study scenarios to evaluate the impact of dynamic load models.
  – Validation and mitigation process for potential stability issues due to dynamic load models.
  – Dynamic load model update and submission procedure

• Please send your comments to MOD-032@pjm.com regarding the dynamic load modeling.
• **Base Case**
  - TO updates incorporated
  - Updated queued generation information incorporated

• **In progress**
  - Contingency update and check
  - Update interchange
  - Update generation dispatch
    - Machine list will be presented at February TEAC
  - Update load per latest 2016 load forecast
Year 2021 Summer RTEP Case Build Update

• End of January 2016
  – Incorporate final TO feedback and updates
  – Finalize case and associated files

• February 2016
  – Exercise the model using analysis, coordinate quality control check and benchmark

• February 2016 - March 2016
  – Begin formal RTEP analysis
Year 2021 Summer RTEP Model Assumptions

- Load forecast
  - Latest 2016 load forecast for 2021 50/50 summer peak load
- Interchange
  - Based on latest reservations for 2021 in OASIS
- External topology
  - MMWG 2015 series 2021 summer peak
- Internal topology
  - Include all PJM Board approved upgrades through the December 2015 PJM Board of Manager approvals
Year 2020 Summer RTEP Model Assumptions

• Machine list
  – Updated Capacity Interconnection Rights (CIR’s) for existing units
  – Queues with an executed FSA or higher as of October 1, 2015 will be included in the base model
    • Consult posted machine list for exact modeling assumption
    • FSA will be turned off but allowed to contribute to problems in Generator Deliverability
    • Any identified network upgrades driven by included queue projects will also be modeled
    • Any exceptions will be reviewed with TEAC
  – Units that cleared in previous RPM auctions that do not yet have an executed FSA or higher will be modeled
  – 2021 RTEP machine list will be presented at February 2016 TEAC
• FERC approved the Order No. 1000 Project Proposal Window Fee on 11/3/2015
• Tiered, upfront, non-refundable per project fee
  – No fee ($0) for any proposed projects (upgrade and greenfield) with estimated costs below $20M
  – $5,000 fee for any proposed projects (upgrade and greenfield) with estimated costs greater than $20M and less than $100M
  – $30,000 fee for any proposed projects (upgrade and greenfield) with estimated costs greater than $100M
• Assumptions Next Steps
  – TOs to notify PJM of any planned Supplemental Upgrades
  – PJM to post the final machine list
  – PJM to finalize and quality control check models
Generation Deactivation Notification

Update
<table>
<thead>
<tr>
<th>Unit(s)</th>
<th>Transmission Zone</th>
<th>Requested Deactivation Date</th>
<th>PJM Reliability Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fauquier County Landfill (0 MW Capacity, 2 MW Energy)</td>
<td>DOM</td>
<td>02/29/2016</td>
<td>Reliability analysis complete. No impacts identified.</td>
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<tr>
<td>Elmer Smith Unit 1 (52)</td>
<td>LGEE (External)</td>
<td>06/01/2019</td>
<td>Reliability analysis complete. PJM did not identify any reliability violations.</td>
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<tr>
<td>Oyster Creek Nuclear Generating Station (607.7 MW)</td>
<td>JCPL</td>
<td>12/31/2019</td>
<td>Reliability analysis complete. No impacts identified.</td>
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<tr>
<td>Avon Lake unit 7 (94.6 MW)</td>
<td>ATSI</td>
<td>04/16/2016</td>
<td>Reliability analysis complete. Impacts identified.</td>
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<tr>
<td>Will County unit 4 (510 MW)</td>
<td>ComEd</td>
<td>05/31/2018</td>
<td>Reliability analysis complete. Impacts identified.</td>
</tr>
</tbody>
</table>
Deactivation Update: Deactivation Notifications

- Avon Lake Unit 7
  - ATSI Transmission Zone
  - 94.6 MW
  - Deactivation date: 04/16/2016
Common Mode Outage:
Beaver to Lake Avenue 345 kV line ckt 2F is overloaded for the line fault stuck breaker contingency outage of Beaver to Lake Avenue 345 kV line and Beaver to Carlisle 345 kV line for the breaker failure at Beaver B121 ('C2-BRK-CR016A1_NEW')

Immediate Need
- Due to the timing of the need for the reinforcement an RTEP proposal window is infeasible

Alternatives Considered
- Due to the immediate need of the project no alternatives were considered
- Existing Supplemental upgrade (S0663 and S0663.1) is being converted to a Baseline upgrade (B2725 and B2725.1): Build new 345/138 kV Lake Avenue substation w/breaker and a half high side (2 strings), 2-345/138 kV transformers and breaker and a half (2 strings) low side (138 kV). Substation will tie Avon - Beaver 345 kV #1/#2 and Black River - Johnson #1/#2 lines

Construction Designation
- Due to the immediate need, the local Transmission Owner will be the Designated Entity
- Cost estimate: $40 M
- Required IS Date: 06/01/2016
- Projected IS Date: 12/31/2016
- Interim Solution: PJM and ATSI (the local Transmission Owner) are reviewing possible operating measures
Deactivation – Avon Lake unit 7

- **Common Mode Outages:**
- Lakeview to Greenfield 138 kV line and the Ottawa to Lakeview 138 kV lines are overloaded for the tower contingency outage of Davis-Besse to Hayes 345 kV line and Davis-Besse to Beaver 345 kV line ("C5-TWL-CR040_X1-027")
- Existing Baseline upgrade (B1959): Build a new West Fremont-Groton-Hayes 138kV line
- Cost estimate: $45 M
- Required IS Date: 06/01/2016
- Projected IS Date: 08/31/2018
- Interim Solution: An operating procedure exists to open the Lakeview – Greenfield 138 kV line at Greenfield to avoid the overloads
ATSI Transmission Zone

- Common Mode Outage and N-1-1 Violation:
  - Black River to Lorain Q-2 138 kV line is overloaded for the line fault stuck breaker contingency outage of Lake Avenue to Avon 345 kV line ckt 1F and Lake Avenue to Avon 345 kV line ckt 2F ('C2-BRK-NR125') as well as being overloaded for the loss of Avon Lake 345/138 kV transformer #92 ('B_TRAN_SY_60B') followed by loss of Avon Lake 345/138 kV transformer #91 ('B_TRAN_SY_60A')
  - Existing Baseline upgrade (B2559): Reconductor the Black River - Lorain 138 kV line and upgrade Black River and Lorain substation terminal end equipment
  - Cost estimate: $9.6 M
  - Required IS Date: 06/01/2016
  - Projected IS Date: 06/01/2019
  - Interim Solution: The contingencies causing the violation may be observed in the PJM EMS and operated to in real time to maintain system security as an interim fix

Deactivation – Avon Lake unit 7
Deactivation Update: Deactivation Notifications

- Will County Unit 4
  - ComEd Transmission Zone
  - 510 MW
  - Deactivation date: 05/31/2018
• Common Mode Outage:
• Dresden 345/138 kV transformer 83 is overloaded for the line fault stuck breaker contingency loss of Goodings Grove to Elwood 345 kV circuit and Elwood bus tie (‘900-45-BT4-5’)
• Existing Baseline upgrade (B2561): Install a new 345 kV circuit breaker 5-7 at Elwood substation
• Cost estimate: $2.6 M
• Required IS Date: 06/01/2018
• Projected IS Date: 06/01/2018
• Common Mode Outages:
  - Goodings Grove 345/138 kV transformer is overloaded for the single contingency loss of Goodings Grove 345 kV line (‘116-CB_34___’) as well as being overloaded for the line fault stuck breaker contingency loss of Blue Island Tap Red bus to Blue Island Red bus 345 kV line, Goodings Grove to Blue Island Tap Red bus to Wilton Red bus 345 kV line (‘116-45-L11614_’)

• Immediate Need
  - Due to the timing of the need for the reinforcement an RTEP proposal window is infeasible

• Alternatives Considered
  - Due to the immediate need of the project no alternatives were considered
  - Existing Supplemental upgrade (S0884) is being converted to a Baseline upgrade (B2721): Goodings Grove – Balance Station Load (swap bus positions for 345 kV lines 1312 & 11620 and 345 kV lines 11604 & 11622) and replace 138 kV bus tie 2-3

• Construction Designation
  - Due to the immediate need, the local Transmission Owner will be the Designated Entity

• Cost estimate: $5.4 M

• Required IS Date: 06/01/2018
• Projected IS Date: 06/01/2016
ComEd Transmission Zone

- Common Mode Outages:
  - Oglesby to Mazon 138 kV line is overloaded for the bus fault contingency outage of La Salle County 138 kV bus ('001_LA-138B__1')

- Advance the required IS date of the existing Baseline upgrade (B2613): Replace relays at Mazon substation

- Cost estimate: $0.7 M

- Old Required IS Date: 06/01/2019

- New Required IS Date: 06/01/2018

- Projected IS Date: 06/01/2018
Reliability Analysis Update
Project Scope Change: B1912
Problem: N-1-1 Voltage

- Voltage collapse in the Va Beach area for an N-1-1 outage of Suffolk-Yadkin 500 kV Line and the Yadkin – Fentress 500 kV Line

Previous Scope:
- Install three +/- 125 MVAr STATCOM at three different Substations (Landstown, Yadkin, Fentress)
  - Re-consider this solution to optimize reliability in the area
- New Scope: Install four +/- 125 MVAr STATCOM at Landstown, Chesapeake, Fentress, Lynnhaven

Old Estimated Cost: $70 M
New Estimated Cost: $95 M

Projected IS Date: 06/01/2016
• Additional work is required to implement the B2269 Upgrade to Rebuild approximately 23.7 miles of the Susquehanna - Jenkins 230kV circuit:

• Due to the extended outage required to rebuild the Susquehanna-Jenkins 230 kV circuit, there are anticipated N-1 and N-1-1 violations in the Stanton vicinity.

• Proposed Solution:
  – Rearrange the 230 kV lines out of the Stanton substation. (B2269.1)
  – Upgrade relays at Mountain 230 kV substation. (B2269.2)

• Estimated Project Cost: $ 2.5 M

• Projected IS Date: 12/31/2016
2015 RTEP Proposal Window Update
As part of the 2015 RTEP, two locations in the Dominion Zone were impacted by FSA generation related violations.

The FSA generation has since signed an ISA and PJM is re-engaging the selection of a recommended solution — PJM Queue Z1-086.

Updated analysis.
Dominion Transmission Zone

- **Generation Deliverability Violations (FG# New-32, New-34, New-36 and New-37)**

- The Chesterfield – Messer Road – Charles City Road 230kV circuit is overloaded for several contingencies

- **Alternatives considered:**
  - 2015_1-1A ($17.54 M)
  - 2015_1-8S ($15.6 M)
  - 2015_1-8W ($29.4 M)
  - 2015_1-9A ($167.1 M)
  - 2015_1-9B ($118.9 M)
  - 2015_1-9D ($135.2 M)
  - 2015_1-9E ($94.2 M)
**Dominion Transmission Zone**

- **Generation Deliverability Violation (FG# New-52)**
  - The Carson – Rogers Rd 500 kV circuit is overloaded for single contingency loss of the Carson – Rawlings 500 kV circuit.

- **Alternatives considered:**

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<tr>
<th>2015_1-1B</th>
<th>2015_1-1C</th>
<th>2015_1-1D</th>
<th>2015_1-1E</th>
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<td>2015_1-6A</td>
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<td>2015_1-6C</td>
<td>2015_1-7D</td>
<td>2015_1-8X</td>
<td>2015_1-8Y</td>
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<td>2015_1-9B</td>
<td>2015_1-9C</td>
<td>2015_1-9D</td>
</tr>
<tr>
<td>2015_1-9E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Cost:** ($27.8 to 167.1 M)
• **Additional Generator Deliverability Violations:**
  
  – Assumptions updated
  
  – The Chesterfield – Messer Road – Charles City Road 230kV circuit is overloaded for new additional single and tower contingencies compared to the 2015 analysis
2016 Proposal Window #1

- 2016 Proposal Window #1 Announcement

- Updated Year 2020 study
  - Updated 2016 Load Forecast in DOM
  - Updated Queue Generation

- Generator Deliverability and Common Mode Outage Thermal
  - Initial version to be posted prior to opening of window

- Anticipated 2016 RTEP Proposal Window #1 Open in late January
• AEP Transmission Owner Criteria Violation (FG# AEP-T9)

• Violation description:
  – The Abingdon – Hillman 69 kV line is overloaded for single contingency loss of the Broadford 765/500 kV transformer and Broadford – Sullivan 500 kV circuit.

• PJM update:
  – With the local supplemental project (S1068), this is not a valid violation any more.
  – PJM expects the same flowgate and other flowgates in the same area will shown up in 2016 winter study.
  – Please stay tuned for the 2016 windows and analysis
Short Circuit Upgrades
Problem: Short Circuit
• The Loudoun 500kV 'H1T569' breaker is overstressed

Proposed Solution:
• Replace the Loudoun 500kV 'H1T569' breaker with a 50kA breaker

Estimated Project Cost: $900k
Projected IS Date: 06/01/2018
Supplemental Projects
• **Supplemental Project**

  • Replace the 345kV CB at Electric Junction on Electric Junction –Wolf Crossing 345kV line (line #1223). (S1108)

  • Increase Short Circuit Capability
    – Old: 42KV
    – New: 63KV

  • Material Condition, no line rating change

• Estimated Project Cost: $2.2M

• Projected IS Date: 12/31/2016
PPL Supplemental projects

- Development of the PPL Electric Utility 10 year plan: 2015-2024
- Aging Infrastructure
  - A majority of PPL EU’s transmission system was installed during expansion periods and it is now approaching the time where structures should be replaced to maintain integrity.
- Increase system reliability
  - Using latest PPL specifications in rebuilds will decrease the frequency and duration of outages due to failed components, lightning, and other weather-related events.
  - Rebuilding facilities to current standard designs will eliminate line tapped transformers at regional substations.
- Reduction in Maintenance Costs
- Combat specific line failure concerns
  - Particular assets though the industry standard at the time, such as cellon treated poles, wood upswept arms, conductor splices, were prone to increase in degradation.
PPL Supplemental projects

- Address Worst Performing Circuits
  - PPL has identified worst performing circuits which increase customer outages. Improvement on these lines will improve quality of service
- Increase in capabilities of equipment
  - Rebuilds utilizing new technology will provide better communication, analytics and operations that will restore customers in shorter periods of time.
- Work Efficiency
  - Bundling of work together will reduce outage impact to customers
- Relays and Control Houses
  - Reduced maintenance, remote monitoring, improved data recording, supports PPL EU fiber, upgrades, and upgraded battery systems.
• Supplemental Upgrade:
  • Build the Otter Creek 230kV station to current PPL design standards.
• Proposed Solution:
  – Upgrade the Otter Creek 230kV Yard to three bays breaker and a half arrangement, and replace relays (S1097)
• Estimated Project Cost: $10.7 M
• Projected IS Date: 12/31/2026
Supplemental Upgrade:
To improve reliability by building to current standards and separating PPL and merchant generation lines in different bay positions.

Proposed Solution:
- Montour - Build Bay 5 and 6 to standard breaker and a half configuration and Re-terminate the MONT-SU10 230kV Line into Bay 5 and the MONT-SUSQ 230kV Line into Bay 6. (S1098.1)
- Upgrade relaying at Susquehanna 230kV Switchyard and Susquehanna T10 Switchyard. (S1098.2)
- Remove two (2) Montour 230kV circuits breakers in Bay 1 and Bay 2. (S1098.3)

Estimated Project Cost:
$ 6.49 M

Projected IS Date:
12/31/2018
• Supplemental Upgrade:
• To improve reliability due to aging infrastructure.
• Proposed Solution:
  – Replace 3N and 3T Circuit breakers at Susquehanna 500 kV yard. (S1099)
• Estimated Project Cost: $ 2.8 M
• Projected IS Date: 4/30/2017
• Supplemental Upgrade:
• To improve reliability due to aging infrastructure.
• Proposed Solution:
  – Rebuild the existing Foxhill - Shawnee 230 kV line (Approximately 8.25 Miles). (S1100)
• Estimated Project Cost: $ 28.4 M
• Projected IS Date: 12/31/2020
• Supplemental Upgrade:
• To improve reliability due to aging infrastructure.
• Proposed Solution:
  – Rebuild the existing Shawnee - Bushkill 230 kV line (Approximately 2.2 Miles). (S1101)
• Estimated Project Cost: $6.8 M
• Projected IS Date: 5/31/2020
• Supplemental Upgrade:
• To improve reliability by replacing aging infrastructure and building the existing yard to current standards.
• Proposed Solution:
  – Construct a new 230 kV GIS yard at Sunbury Substation. (S1102)
• Estimated Project Cost: $ 25 M
• Projected IS Date: 4/30/2018
• Supplemental Upgrade:
  The Susquehanna triple circuit outage scheme is no longer required with the Susquehanna – Roseland project.
• Proposed Solution:
  – Retire and Remove the Susquehanna Triple Circuit Outage Special Protection Scheme. (S1103)
• Estimated Project Cost: $0.84 M
• Projected IS Date: 4/30/2016
• Supplemental Upgrade:
  • To improve reliability due to aging infrastructure.
• Proposed Solution:
  – Upgrade Alburtis 500 kV Switchyard by replacing old CBs, Cap bank, installing new control cubicle. (S1104)
• Estimated Project Cost: $6.6 M
• Projected IS Date: 12/31/2017
• Supplemental Upgrade:
• To improve reliability of Harrisburg region by reducing line exposure.
• Proposed Solution:
  – Build new 230 kV Line from Dauphin to New Harrisburg kV Substation. (S1105.1)
  – Build new UG 230 kV Line from West Shore to New Harrisburg Substation. (S1105.2)
• Estimated Project Cost: $ 88 M
• Projected IS Date: 5/31/2026
• Supplemental Upgrade:
• To improve instability in the Montour area for three phase fault on a double circuit tower.
• Proposed Solution:
  – Build new 500-230 kV Substation and associated transmission work (tap Sunbury - Susquehanna 500 kV and Colombia - Frackville 230 kV). (S1106)
• Estimated Project Cost:
  $ 95 M
• Projected IS Date:
  12/31/2018
• Supplemental Upgrade:
• To improve reliability by upgrading the Harwood station to the current PPL standard design.
• Proposed Solution:
  – Upgrade Harwood 230 kV Substation by building 230 kV yard to current standards and replacing old equipment. (S1107)
• Estimated Project Cost: $ 3.6 M
• Projected IS Date: 12/31/2020
Dominion Local TO Criteria - End Of Life Criteria Update
Dominion End of Life Criteria decision point metrics:

1) Facility is nearing, or has already passed, its end of life, and
2) Continued operation risks negatively impacting reliability of the transmission system.
• Dominion Local TO Criteria
  – End of Life Criteria

  1. End of Life Assessment
     – Industry guidelines indicate equipment life standards
       • Wood structures - 35-55 years,
       • Conductor and connectors - 40-60 years
       • Porcelain insulators - 50 years.

  2. Reliability and System Impact
     – PJM and DOM are analyzing the impacts of the facilities on the next slides
<table>
<thead>
<tr>
<th>Line</th>
<th>Voltage</th>
<th>Length (mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carolina-Roanoke Rapids Hydro</td>
<td>115</td>
<td>2.76</td>
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<tr>
<td>Acca-Lakeside</td>
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<td>Poe-Waverly</td>
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<td>Northeast-Carver</td>
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<td>Elmont-Four Rivers</td>
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Next Steps

• PJM will continue to assess the reliability impacts due to the End of Life Facilities and evaluate the need for Proposal Windows

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RTEP Next Steps
As a result of the 2014/15 Long Term Window and resulting evaluation, PJM anticipates recommending several projects to the PJM board in February 2016

- RPM Market Efficiency project in the ComEd transmission zone (Loretto – Wilton Center 345 kV uprate)
- Installation of capacitors at four existing locations (Brambleton, Ashburn, Shelhorn, Liberty)
- Acceleration of the existing baseline project B1254 – “Hanover Pike 500/230 kV”
RTEP Next Steps

- RPM Planning Parameters
- 2016 RTEP Models
- 2016 RTEP Analysis
  - 2016 RTEP Window #1
- February 2016 PJM Board approval of Market Efficiency Upgrades
  - See the Market Efficiency update posted with today’s presentation
Questions?

Email: RTEP@pjm.com
Revision History

- Original version posted to PJM.com – 1/5/2016
- Added slide #36 for a ComEd supplemental Project – 1/6/2016
- Updates to slide #22 for Will County Unit 4 deactivation -1/7/2016
- Updates to slide #36 for S1108 cost update and new short circuit capability – 1/7/2016