Reliability Analysis Update

Transmission Expansion Advisory Committee
October 12, 2017
2017 RTEP
Reliability Analysis Update
Baseline Reliability - TO Criteria Violation
Replacement of Fixed Series Capacitors on Line #547 Lexington–Bath County & Line #548 Valley–Bath County

Problem Statement: Dominion “End of Life Criteria”
- The fixed series capacitors (FSC) on 500kV Line #547 at Lexington and on 500kV Line #548 at Valley were constructed in 2000/2001 to mitigate the Bath County angular stability issue. These two series capacitors need to be rebuilt to current standards based on Dominion’s “End of Life” criteria. The existing summer emergency rating (Rating B) of the FSCs is 3118 MVA. The existing summer emergency rating for the line segments is 3954 MVA.
- Replacement is needed because:
  - Existing series capacitor units run out of spare parts, manufacturer no longer produce parts for legacy models.
  - The breaker module of the capacitor has a current rating of 3000 Amps, which makes the FSCs the thermal limiting factor (normal operation rating 2858 MVA; emergency rating 3118 MVA) to the transmission line (normal operation rating 3954 MVA; emergency rating 3954 MVA).

Potential Solution:
Replace the existing FSCs with newer models of the same size. The current rating on the device will be increased from 3kA to 4kA for normal operation to provide higher thermal capacity.

Alternatives:
Installation of 500kV Thyristor controlled series capacitor (TCSC) and FSC combined systems on Line #547 at Lexington and on Line #548 at Valley to replace existing FSCs. This device would be a TCSC unit combined with a fixed series capacitor unit which provides dynamic compensation at [43% 120%] of line impedance. The current rating on the device will be increased from 3 kA to 4 kA for normal operation. The combined capacitor system could potentially improve the stability of Bath County with higher a compensation range. Additionally, the TCSC could potentially help to mitigate transient stability and damp transient oscillations during a contingency that occurs close to the installation area.

Estimated Project Cost: $ 28.9 M (existing FSCs) / 35.7 M (alternative TCSC consideration)
Possible IS Date: 4/1/2020
Project Status: Conceptual
Existing b2361 Cost Increase and Scope Modification
Original: Baseline Project: Idylwood to Scott’s Run 230kV Line and Substation
Revised: Idylwood to Tysons 230kV Line and Rebuild Tysons with GIS

Problem Statement:
• N-1-1 loss of Line #2010 (Reston-Tysons) and Line #2035 (Idylwood-CIA) results in the loss of more than 300 MW (NERC Category P6 - Multiple Contingency – Two overlapping singles).

Date Original Project Presented: 08/21/2013 (SRRTEP); 09/12/2013 (TEAC)

Original Proposed Solution
• Construct a 230kV OH line along existing Line #2035 corridor, approx. 2.4 miles from Idylwood to Dulles Toll Road (DTR) and 2.1 miles on new right-of-way (ROW) along DTR to new Scott’s Run Substation. (Est. cost $32M)

Reason for Scope Modification and Cost Increase:
• Project scope had to be modified due to issues with siting of the new Scott’s Run substation in Fairfax County.
• Area is very densely populated and is in close proximity to interstate highways and the DC Metro rail system limiting the options of bringing an additional source into the area. Multiple substation options were also considered. (Refer to the next slide.)
• Very narrow existing right-of-way also limits the ability to expand.
• Conversion of Tysons to GIS was determined to be the best option given the obstacles presented.
• High real estate and land costs along with conversion to GIS drove costs considerably higher.

Continued on next slide…
Illustration of space constraints in the area and all the substation options considered

Primary Site
- Tysons Substation

Alternate Sites
- Jones Branch Road
- Chain Bridge Road*
- Scotts Run Road
- Cloverleaf

Eliminated Sites
- Liberty Crossing
- Transit Depot*
- Old Meadow Road

*Sites identified by Fairfax DOT

Continued on next slide…
Existing b2361 Cost Increase and Scope Modification
Original: Baseline Project: Idylwood to Scott’s Run 230kV Line and Substation
Revised: Idylwood to Tysons 230kV Line and Rebuild Tysons with GIS

Revised Proposed Solution
• Construct a 230kV UG line approx. 4.5 miles from Idylwood to Tysons. Tysons Substation will be rebuilt, within its existing footprint, with a 6-breaker ring bus using GIS equipment. (Est. cost $111.7M)
• Cost increase due to change in terminal location (Scott’s Run to Tysons), detailed evaluation of routes, and $29.2M to rebuild Tysons Sub using GIS equipment

Alternatives
• Construct a 230kV OH line approx. 5.2 miles from Idylwood to Tysons. Rebuild Tysons Substation, within its existing footprint, with a 6-breaker ring bus using GIS equipment. (Est. cost $122.6M)

Original Projected IS Date: 6/1/2017
Revised Projected IS Date: 6/11/2022
Project Status: Conceptual
Baseline Reliability - TO Criteria Violation
Line #205 and #2003 Partial Rebuild

Problem Statement: Dominion “End of Life Criteria”
• 230kV line #205 and #2003 run from Chesterfield to Locks and Poe respectively. An approximate 3 mile section of these lines from Chesterfield to Tyler was built on double circuit weathering steel (Corten) towers in 1962. The corten structures are in poor condition.
• Permanent MW load loss for removal of these lines is 140MW.
• These line sections need to be rebuilt to current standards based on Dominion’s “End of Life” criteria.

Potential Solution:
• Approximately 3 miles of line #205 and line #2003 will be rebuilt to current standard using with a summer emergency rating of 1047 MVA at 230kV. Proposed conductor is 2-636 ACSR. Considered structures include double circuit steel pole and double circuit galvanized steel tower. The Chesterfield - Tyler segments of line #205 and #2003 have an existing summer emergency rating of 478MVA.

Alternatives: No feasible alternatives

Estimated Project Cost: $9.5 M
Possible IS Date: 12/31/2022
Project Status: Conceptual
Project Cancellation
Baseline Reliability - Operational Performance
b2181 Prince George Line #2141 Auto-Sectionalizing Scheme

Problem Statement:
• Lockout of Line #2124 Hopewell – Prince George 230 kV causes an outage of Prince George Electric Cooperative’s Brickhouse DP.

Recommended Solution:
• Install a transmission line sectionalizing scheme at Prince George Substation to automatically open the 230kV switch at Prince George for Line #2124 (Hopewell to Prince George 230 kV) lockout and allow Brickhouse DP to be re-energized from the 115kV source. This project adds a motor operator to an existing switch at Prince George and the control scheme. (b2181)

Reason for Cancellation:
• Coop has no current time frame for the installation of field ties to support required outage window.

Previous TEAC Date: 11/5/2012
Estimated Project Cost: $1.11 M
Projected IS Date: 5/31/2017
Immediate Need Projects
XLPE Cable Technology

- Cross-linked polyethylene
- No insulating oil required
  - Environmentally sound
  - No oil, associated pumps and loss of rating due to loss of pumping plant
- Lower O&M costs
- Higher Rating
- Industry moving to XLPE
- HPFF (High Pressure Fluid Filled a.k.a. Pipe Type Cable PTC) conductor future supply chain in question
Problem Statement:
• The VFT – Warinanco 230 kV circuit is overloaded for several contingencies. (FG# GD-S26, GD-S27, GD-S28, GD-S33, GD-S556, GD-W37, GD-W38, GD-W39, and GD-W348)
• The Warinanco – Aldene 230 kV circuit is overloaded for tower contingency loss of the Linden to Deans and Linden to Sewaren 230 kV circuits. (FG# GD-W353)

Immediate Need:
• Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Recommended Solution:
• Wreck and re-build the VFT – Warinanco – Aldene 230 kV circuit with paired conductor. Addresses tower age. Does not require new right of way. Paired conductor can address load requirement with room for future growth.

Alternative Solutions:
• Install parallel towerline - Dense, industrial area with limited property available. Would require new right of way and new station terminations.
• Install parallel XLPE cable - Requires opening the street. Adjacent to a railroad. Requires two new terminations. Create an impedance imbalance with the parallel overhead circuit. Cable will have lower impedance and lower capacity than the overhead circuit.

Estimated Project Cost: $90.4 M

Required IS date: 6/1/2018

Project Status: Conceptual
Generation Deliverability (Summer):
Previously presented: 9/14/2017

Problem Statement:
- The Cedar Grove – Jackson Rd. 230 kV circuit is overloaded for tower contingency loss of the Cedar Grove – Athenia 230 kV circuits B2228 and K2263. (FG# GD-S601)

Immediate Need:
- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Recommended Solution:
- Replace existing cable with 5000kcmil XLPE cable.

Alternative Solution:
- Re-conductor circuit with HPFF with 3500kcmil underground, pipe-type cable. Address age but not age of pipe. Alternative not recommended. Only one vendor for HPFF remains. Future availability of HPFF in question due to supply chain availability
- Abandon circuit - would leave a single transmission source from Waldwick 230kV for 215MW of load at Waldwick/Hawthorne/Hinchman/Jackson Rd. Violates FERC 715 criteria by leaving two sources to Jackson Rd. Would also render Waldwick PAR ineffective; 69kV would be the only outlet/inlet for PAR adjustments. Thermal overload on 69kV system for n-1-1.
- Replace with overhead construction - need right of way. Surrounding area is developed and densely populated. Requires two river crossings, interstate highway crossing, and a U.S. route crossing. Airport nearby. The construction of this alternative is not feasible.

Estimated Project Cost: $80 M

Required IS date: 6/1/2018

Project Status: Conceptual
N-1-1 Thermal (Summer):
Previously presented: 9/14/2017

Problem Statement:
- The Maywood – Saddle Brook 230 kV circuit is overloaded (Rate A) for the loss of the Leonia – Bergenfield 230 kV circuit. (FG# N2-ST13)

Immediate Need:
- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Recommended Solution:
- Replace existing cable with 5000kcmil XLPE cable.

Alternative Solution:
- Re-conductor circuit with HPFF - Replace 2.71mi with 3500kcmil underground, pipe-type cable. Address age but not age of pipe. Alternative not recommended. Only one vendor for HPFF remains. Future availability of HPFF an issue in question due to supply chain availability
- Abandon circuit - Would leave a Maywood with a single underground transmission source. Violates FERC 715 criteria by leaving one source to Maywood.
- Replace with overhead construction - Need right of way. Surrounding area is developed and densely populated. Airport nearby. The construction of this alternative is not feasible.

Estimated Project Cost: $57.5 M
Required IS date: 6/1/2018
Project Status: Conceptual
2017 Proposal Window #1 Update
Preliminary Recommendations
Generation Deliverability and Baseline (Summer), (GD-S579, GD-S587, and N1-S175):

Problem Statement:
- The Pruntytown – White Hall Junction – McAlpin – Glen Falls 138 is overloaded for towerline outage loss of the Pruntytown – Maple Lake and Pruntytown – Shinns Run 138 kV circuits.

Alternatives considered:
- 2017_1-2A ($39.1 M)
- 2017_1-5A ($30.1 M)
- 2017_1-7E ($34.74 M)
- 2017_1-10G ($4.01 M)
- 2017_1-10H ($11.1 M)
- 2017_1-10I ($40.06 M)
- 2017_1-10J ($34.82 M)

Preliminary Recommendation:
- Replace terminal equipments at Pruntytown and Glen Falls 138 kV station.
- Reconductor approximately 8.3 miles of the McAlpin - White Hall Junction 138 kV circuit. 2017_1-10G

Estimated Project Cost: $ 4.01 M

Required IS date: 6/1/2022

Project Status: Conceptual
Generation Deliverability (Summer):

Problem Statement:

- The Yukon – Smithon 138 kV circuit is overloaded for multiple contingencies. (GD-S857, GD-S577 and GD-S578)
- The Smithon – Shepler Hill Jct Tap 138 kV circuit is overloaded for tower line outages loss of the Charleroi – Yukon and Charleroi – Westraver 138 kV circuit OR loss of the Yukon – Chaleroi and Yukon – Westraver 138 kV circuits. (GD-S583 and GD-S584)
- The Allenport – Charleroi 138 kV circuit is overloaded for tower line outages loss of the Charleroi – Yukon and Charleroi – Westraver 138 kV circuit OR loss of the Yukon – Chaleroi and Yukon – Westraver 138 kV circuits. (GD-S581 and GD-S582)

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Generation Deliverability (Summer):

Alternatives considered:
- 2017_1-2B ($17 M)
- 2017_1-10A ($7.08 M)
- 2017_1-2C ($22.2 M)
- 2017_1-10B ($3.19 M)
- 2017_1-2D ($64.8 M)
- 2017_1-10C ($6.96 M)
- 2017_1-3A ($120.3 M)
- 2017_1-10D ($0.12 M)
- 2017_1-4A ($4.49 M)
- 2017_1-10E ($2.69 M)
- 2017_1-5B ($11.7 M)
- 2017_1-10F ($23.4 M)
- 2017_1-5C ($11.8 M)
- 2017_1-7A ($29.46 M)
- 2017_1-7G ($9.91 M)

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<table>
<thead>
<tr>
<th>Proposal ID</th>
<th>Type Of Upgrade</th>
<th>Proposing Entity</th>
<th>Project Cost Estimate ($M)</th>
<th>FG #</th>
<th>Additional Issue</th>
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<td>Nextera</td>
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<td>Springdale - Pucketa 138kV #1&amp;2 (approximately 2.5mi per circuit, $2.5 M). Several Duquesne breakers overdutied</td>
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<td>2017_1-5C</td>
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<td>Nextera</td>
<td>11.8</td>
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<td>Belmont - Charleroi 138 kV Miracle - Mitchell 138 kV</td>
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<td>Duquesne</td>
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<td>Springdale-Plum 138kV Cheswick – Wycoff 138kV</td>
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<td>Cost not Competitive</td>
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<td>2017_1-7G</td>
<td>Greenfield</td>
<td>Transource</td>
<td>9.91</td>
<td>GD-S44, GD-S53, GD-S766, GD-S787, GD-S765, GD-S786</td>
<td>Short circuit under evaluation</td>
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<td>2017_1-10F</td>
<td>Greenfield</td>
<td>FirstEnergy</td>
<td>23.4</td>
<td>GD-S857, GD-S578, GD-S584, GD-S577, GD-S583, GD-S582, GD-S581</td>
<td>Cost not Competitive</td>
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</table>
Preliminary Recommendation:

- Reconductor the Charleroi –Allenport 138KV Line with 954 ACSR Conductor, Replace Breaker Risers at Charleroi and Allenport. (2017_1-10A)
- Reconductor the Yukon - Smithton - Shepler Hill Jct 138 kV Line with 795 ACSS Conductor, Replace Line Disconnect Switch at Yukon. (2017_1-10B)
- Convert the existing 6 wire Butler - Shanor Manor - Krendale 138 kV Line into two separate 138 kV lines. New lines will be Butler - Keisters and Butler - Shanor Manor - Krendale 138 kV. (2017_1-10C)

Estimated Project Costs:
- $7.08 M
- $3.19 M
- $6.96 M

Required IS date: 6/1/2022

Project Status: Conceptual
Problem Statement:
- The Tanner – Miami Fort 345 kV line is overloaded for multiple single contingencies

Alternatives considered:
- 2017_1-7B ($19.32 M)
- 2017_1-7D ($55.09 M)
- 2017_1-7F ($11.45 M)
- 2017_1-8C ($1.2 M)

Preliminary Recommendation:
- Upgrade existing 345kV terminal equipment at Tanner Creek station. 2017_1-8C

Estimated Project Cost: $ 1.2 M

Required IS date: 12/1/2022

Project Status: Conceptual
Problem Statement:
- The Maddox – East Lima 345 kV line is overloaded for the loss of the Marysville – Sorenson 765KV line

Alternatives considered:
- 2017_1-8A ($1.48 M)
- 2017_1-8B ($111.64 M)

Preliminary Recommendation:
- Replace terminal equipment on Maddox Creek - East Lima 345kV circuit. 2017_1-8A

Estimated Project Cost: $ 1.48 M

Required IS date: 12/1/2022
Project Status: Conceptual
Common Mode Outage and Basecase Analysis (Summer) (GD-S763, GD-S746, GD-S814, GD-S745, GD-S813, N1-S91, N1-S92 and N1-S126):

Problem Statement:

- The Pierce 345/138kV transformer #18 is overloaded for the loss of the Pierce 345/138kV transformer #17 with the breaker stuck at Pierce.
- The Pierce 345/138kV transformer #17 and the connected Pierce – Beckjord 138kV circuit are overloaded for the loss of the Pierce 345/138kV transformer #17 with the breaker stuck at Pierce.

Alternatives considered:

2017_1-6A ($20.16M): The two existing 345/138kV transformers that connect Pierce 345kV Substation to Beckjord 138kV Substation are fed radially. This project will Reconfigure Pierce 345kV Substation by adding new breakers, moving a feeder, adding a third 345/138kV transformer, and feed the Pierce-Beckjord transformers in a breaker and a half or double bus configurations. The three transformer feeds will be distributed across the three sets of buses at Beckjord.

2017_1-2E ($12.7 M): Build a 345 kV switching station ("Twelvemile") interconnecting the existing Silver Grove - Zimmer 345 kV transmission line and the Pierce - Buffington 345 kV transmission line

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<table>
<thead>
<tr>
<th>Project ID</th>
<th>Project Sponsor</th>
<th>2017 RTEP Window #1 target reliability flowgates solved?</th>
<th>Cost Analysis</th>
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<tbody>
<tr>
<td>2017_1-2E</td>
<td>NTD</td>
<td>Yes; But causes an N-1-1 thermal overload on the Beckjord – Pierce 138kV line (violation)</td>
<td>Estimated overall project cost by sponsor of $12.7M ($9.7 NTD scope + $3M TO scope in current year) Cost cap = $14M (in-service year $’s) for NTD scope of work The fix for the new overload on the Beckjord – Pierce 138kv line is approximately $1M;</td>
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<tr>
<td>2017_1-6A</td>
<td>DEOK</td>
<td>Yes, with no additional overloads</td>
<td>The submitted cost $20.16M includes the Y3-064 merchant project cost, $0.5M, which shouldn’t be included as baseline cost, The total estimated cost is $19.66M</td>
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</tbody>
</table>

Notes:
- NTD cost cap includes AFUDC and escalation, i.e. in-service year dollars
- Further reliability performance, economic performance and constructability/feasibility evaluations are in progress by PJM.
Generation Deliverability (Summer) (GD-S126, GD-S585 and GD-S661):

Problem Statement:
- The Pleasant View – Ashburn 230 kV is overloaded for single contingency loss of the (Brambleton – Yardley 230 kV, for a tower line outage loss of the (Brambleton – Yardley plus (Brambleton – Poland Rd. 230 kV circuits.
- The Ashburn - Beaumeade 230 kV is overloaded for a tower line outage loss of the (Brambleton – Yardley plus (Brambleton – Poland Rd. 230 kV circuits.

Alternatives considered:
- 2017_1-1A ($4.52 M)
- 2017_1-1B ($7.11 M)
- 2017_1-1C ($3.05 M)
- 2017_1-7C ($9.74 M)

Preliminary Recommendation:
- Split Line #227 (Brambleton – Beaumeade 230 kV )and terminate into existing Belmont substation. 2017_1-1C

Estimated Project Cost: $ 3.05 M

Required IS date: 6/1/2022

Project Status: Conceptual
Generation Deliverability (Summer) (GD-S107, GD-S159 and):

Problem Statement:

Alternatives considered:
- 2017_1-1D ($4.49 M)
- 2017_1-1E ($4.96 M)
- 2017_1-1F ($12.68 M)

Preliminary Recommendation:
- Reconductor the Woodbridge to Occoquan 230kV line segment of Line 2001 with 1047 MVA conductor and replace line terminal equipment at Possum Point, Woodbridge, and Occoquan. 2017_1-1D

Estimated Project Cost: $ 4.49 M

Required IS date: 6/1/2022

Project Status: Conceptual
Generation Deliverability (Summer) (GD-S798 and GD-S815):

Problem Statement:
• The Edge Moor – Claymont – Linwood 230 kV circuit is overloaded for line fault stuck breaker contingency loss of the Edge Moor – Linwood 230 kV circuit and two units at Philips Island.

Alternatives considered:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Cost</th>
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<tbody>
<tr>
<td>2017_1-9A</td>
<td>$1.83 M</td>
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<tr>
<td>2017_1-9B</td>
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<td>2017_1-9C</td>
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<td>2017_1-9N</td>
<td>$79.03 M</td>
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Status:
• Study in progress
PSE&G FERC 715 Local Criteria - Equipment Assessment

Roseland – Branchburg – Pleasant Valley Corridor
PSE&G’s FERC 715 Transmission Owner criterion addresses equipment condition assessments
- PSE&G assessed the condition of the Roseland to Branchburg to Pleasant Valley 230 kV circuits.
• Refer to PSE&G criteria:

**VII. EQUIPMENT ASSESSMENT AND STORM HARDENING**

[http://www.pjm.com/~/media/planning/planning-criteria/PSE&G-planning-criteria.ashx](http://www.pjm.com/~/media/planning/planning-criteria/PSE&G-planning-criteria.ashx)

- Roseland to Branchburg is approximately 30 miles of 230 kV circuit and the average structure age is approximately 90 years.
- Branchburg to Pleasant Valley is approximately 22 miles of 230 kV circuit and the average structure age is approximately 90 years.
- Parallel to Roseland-Branchburg 500kV corridor
- The terrain is variable and includes rural, National Wildlife Refuge and municipalities
- This facility also serves 240 MVA sub-transmission load in adjacent territory (JCP&L)
Roseland – Branchburg – Pleasant Valley Corridor

- PSE&G commissioned external consultants to assess tower foundations and tower structures of the 50 mile Pleasant Valley-Branchburg-Roseland corridor
  - Assessment result:
    - The assessments identified towers with foundations needing reconstruction, towers exceeding loading capability, Also identified through LiDAR are NESC ground conflicts; the Project was developed as a result.
  - These towers were built in 1927-1930. Small portions were rebuilt from 1961 to 2015 (see next slide). At 795 ACSR, some existing conductors are smaller than the current standard of 1590 ACSR.
  - The two major components of the overall corridor are the Roseland – Branchburg segment and the Branchburg – Pleasant Valley segment
• Assessment Result:
  – Consultant findings – Transmission Tower Foundation assessment
    • About 25% of structures for Roseland – Branchburg – Pleasant Valley will require either extensive foundation rehabilitation or total foundation replacement.
  – Consultant findings – Tower line assessment
    • Due to the present condition, 54% of the towers are exceeding 100% of the tower’s load bearing capability, and 84% of the towers are exceeding 95% of the tower’s capability.
    • 9% of spans violate LiDAR ground conflicts
## Tower Condition on Circuits U-2221, M-2265 (162 towers)

<table>
<thead>
<tr>
<th>Condition</th>
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*LiDAR conflicts as of 9/29/2017
Evaluate Towers on Circuits I-2209, Q-2243, Z-2357, L-220-12 (102 towers)

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*LiDAR conflicts as of 9/29/2017
Problem:

PSE&G FERC 715 local Transmission Owner Criteria

- Equipment condition assessment for the entire corridor
- Equipment has reached its end of life
Solution Alternatives Considered

1. Remove and retire the 230 kV corridor without replacing

2. Install new parallel circuit on new right-of-way and remove existing 230 kV corridor

3. Replace the existing 230 kV single-circuit corridor with new dual-circuit structures and initially string one 230 kV circuit
Solution Alternative #1: Remove the existing 230 kV corridor without replacing

- Would leave 240 MVA of JCP&L load supplied by 34.5kV sub-transmission with significant voltage and thermal violations
- Would require extensive construction, and associated cost, to relieve voltage and thermal violations on 34.5kV
- Loss of up to 996 MVA transmission system capacity
- Thermal/Voltage violations on the neighboring JCP&L system
- *Because of the above issues, removal without replacement is not a viable option.*
Solution Alternative #2: Install New Circuit and Remove Existing

• Potential permitting challenges due to new facility
• Martinsville, East Flemington, Readington and Rocktown require feeds from 230/34.5kV substations and associated additional lines to loop in and out of each station
• Would require more than 50 miles of new overhead construction, new ROW and new permitting
• *Due to the above issues, installing new equipment in new areas is the highest cost option*
Solution Alternative #3:
Replace the existing 230 kV corridor with new structures

- Maintain system reliability
- Eliminate safety risk from damaged structures
- No new ROW required
- No new substations or reactive devices required
- No topology change – additional studies, extensive protection coordination not needed
- Minimal new siting, permitting and construction involved
- Maintain transmission capacity between Branchburg and Lawrence substations
15 Year Analysis Results
• Test Procedure: Generator deliverability, load deliverability and common mode outage analysis for years 6 through 15

• Focus on events more likely to highlight long lead time violations single and tower line contingencies

• Full AC analysis followed by a linear extrapolation based on future forecasted load
# 2017 RTEP 15 Year Analysis

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<th>Fr Name</th>
<th>To Bus</th>
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Short Circuit Projects
Problem: Short Circuit

- The Conastone 230kV breakers ‘2322 B5’ and ‘2322 B6’ are overstressed

Significant Driver:

- Creating new Furnace Run 500kV and 230kV stations (b2752)*

Immediate Need:

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Alternatives Considered:

- Due to the immediate need of the project no alternatives were considered

Recommended Solution:

- Replace Conastone 230kV breakers ‘2322 B5’ and ‘2322 B6’ with 63kA breakers (b2752.8 & b2752.9)

Estimated Project Cost: $1.07 M

Required IS Date: 6/1/2020
Problem: Short Circuit
• The Keystone 500kV “NO. 14 Cabot” and “NO. 16 Cabot” breakers are overstressed

Proposed Solution:
• Replace the Keystone 500kV “NO.14 Cabot” and “NO. 16 Cabot” with 50kA breakers (b2953 &2954)

Estimated Project Cost: $1.24 M (per breaker)

Required IS Date:
June 1, 2020
Supplemental Projects
Supplemental Project: Broadford 765 kV CB-Q1 Replacement
Date Project Last Presented: 9/14/2017 TEAC

Problem Statement:

**Equipment Material/Condition/Performance/Risk:**
Broadford 765kV Q1 is a 50 kA air blast breaker type PK10D that will be replaced. PK's have historically presented a safety concern for field personnel in general. From experience, PK’s are prone to catastrophic bushing failures (shards of porcelain are usually violently expelled from the bushing) and can result in injury to anyone inside the station. Additional drivers include age (1969 Mfg. year), number of fault operations (32; Mfg. recommendation is 10) and lack of available repair parts.

Selected Solution:
- Replace the Broadford 765kV Q1 Circuit Breaker with a new 4000A, 63KA breaker. (S1381)

Alternatives: No feasible alternatives

Estimated Project Cost: $3.3 M

Projected IS Date: 3/31/2019

Project Status: Engineering
Supplemental Project: Jacksons Ferry 765/500 XFR Replacement
Date Project Last Presented: 9/14/2017 TEAC

Problem Statement:

Equipment Material/Condition/Performance/Risk:
Several circuit breakers at Jacksons Ferry station are showing signs of deterioration. These breakers are 3000 A 50 kA air blast PK breakers, which present a significant safety concern for individuals entering the station. From historical experience AEP has determined that PK breakers are prone to catastrophic bushing failures which could result in injury to anyone inside the substation fence. The drivers for replacement of these breakers are age, potential bushing damage, number of fault operations, and a lack of available repair parts.

Transformer 1 phases 1, 2, 3 are all showing significant signs of deterioration. Drivers for replacement include dielectric strength breakdown (winding insulation), short circuit strength breakdown (due to the amount of through fault events), and accessory damage (bushings). All three phases of Transformer 1 will be replaced with 500 MVA units. Larger sized units were evaluated but due to physical limitations (tunnel systems) in the area it was required to install 500MVA transformers. In addition to the physical limitations, there is no justification of installing units larger than 500MVA.

Selected Solution:
- Replace Jacksons Ferry 765/500 kV 500 MVA Transformer #1 (all three phases) and 138kV Circuit Breaker ‘R1’, ‘P’, and ‘P2’ with 3000A 63kA Circuit Breakers. (S1382)

Alternatives: No feasible alternatives

Estimated Project Cost: $27 M

Projected IS Date: 12/01/2020

Project Status: Scoping
Supplemental Project: Winter’s Branch 230kV Delivery

Problem Statement:
- Dominion Distribution has submitted a DP Request for a new substation to accommodate a new datacenter campus in Prince William County. Initial installation will include a 84MVA 230-34.5kV transformer.

Potential Solution:
- Interconnect the new substation by tapping the 230kV Line #2132 (Cloverhill – Cannon Branch) to the proposed Winter’s Branch Substation. The new substation will be set up for an ultimate six-breaker 230kV ring bus to meet the future growing demands of the region. Install line switches, a 230kV circuit switcher, and high side switches and necessary bus work for the new transformer.

Estimated Project Cost: $4.3 M

Possible IS Date: 7/15/2019

Project Status: Conceptual
Supplemental Project: Allied 230kV Line #2049 and #2050 Terminal Equipment Replacement

Date Project Last Presented: 9/14/2017 TEAC

Problem Statement:
• Allied substation 230kV Line #2049 and #2050 terminal equipment needs to be replaced due to age and operational issues.

Selected Solution:
• Replace three 230kV breakers, two line wave traps, and associated line terminal equipment at Allied substation (s1378)
• The two new 3000A wave traps increase the summer emergency rating of the National Welders – Allied segment of Line #2049, and the Alpine – Allied segment of Line #2050 from 797MVA to 956MVA.

Estimated Project Cost: $2.2 M

Projected IS Date: 11/30/2017

Project Status: Engineering
Supplemental Project: Chesterfield 230kV Line #2049 Wave Trap Replacement
Date Project Last Presented: 9/14/2017 TEAC

Problem Statement:
• Chesterfield 230kV Line #2049 wave trap and associated line terminal equipment needs to be replaced.

Selected Solution:
• At Chesterfield 230 kV, replace existing Line #2049 2000A wave trap with a 3000A wave trap. Chesterfield – Enon line segment summer emergency rating will be increased from 797MVA to 927MVA due to wave trap replacement. (s1379)

Estimated Project Cost: $0.5 M

Projected IS Date: 11/30/2017

Project Status: Engineering
Supplemental Project: Line #238 Wave Trap and Line Terminal Equipment

Date Project Last Presented: 9/14/2017 TEAC

Problem Statement:
• Clubhouse line #238 wave trap, Carson line #238 breaker and associated line terminal equipment need to be replaced due to age.

Selected Solution:
• Replace one 230kV breaker and #238 line relay at Carson. Replace existing line #238 1600A wave trap at Clubhouse with a 3000A wave trap. Sapony – Clubhouse segment summer emergency rating will be increased from 637MVA to 722MVA. (s1380)

Estimated Project Cost: $1.2 M

Projected IS Date: 11/15/2017

Project Status: Engineering
Upcoming TEAC Meetings and anticipated PJM Board Review

**October**
- 10/12 – TEAC Reliability Analysis Update and Market Efficiency Update – Today’s Meeting
- 10/17 – PJM Board of Managers Review of September TEAC Recommendations
- 10/19 – TEAC Market Efficiency Update
- 10/30 – Sub-regional RTEP – PJM South
- 10/31 – Sub-regional RTEP – PJM Mid-Atlantic

**November**
- 11/02 – Sub-regional RTEP – PJM West – Morning
- 11/02 – TEAC Reliability Analysis Update – Afternoon
  - 2017 RTEP Window #1 - Reliability Recommendations
- 11/9 – TEAC Reliability Analysis Update

**December**
- 12/04 – PJM Board of Managers Review of November TEAC Recommendations
- 12/14 – TEAC Reliability Analysis Update and 2018 RTEP Assumptions Review
- 12/18 – Sub-regional RTEP – PJM South – Morning
- 12/18 – Sub-regional RTEP – PJM West – Afternoon
- 12/19 – Sub-regional RTEP – PJM Mid-Atlantic
Upcoming TEAC Meetings and anticipated PJM Board Review

10/12 – TEAC Reliability Analysis Update and Market Efficiency Update – Today’s Meeting
10/17 – PJM Board of Managers Review of September TEAC Recommendations
10/19 – TEAC Market Efficiency Update
   • 2016/17 Long Term Window – RPM Market Efficiency
10/30 – Sub-regional RTEP – PJM South
10/31 – Sub-regional RTEP – PJM Mid-Atlantic
11/2 – Sub-regional RTEP – PJM West – Morning
11/2 – TEAC Reliability Analysis Update – Afternoon
   • 2017 RTEP Window #1 - Reliability Recommendations
12/4 – PJM Board of Managers Review of November TEAC Recommendations
12/14 – TEAC Reliability Analysis Update and 2018 RTEP Assumptions Review
12/18 – Sub-regional RTEP – PJM South – Morning
12/18 – Sub-regional RTEP – PJM West – Afternoon
12/19 – Sub-regional RTEP – PJM Mid-Atlantic

(If necessary, additional online/teleconference meetings to be held to review potential and recommended solutions)
Questions?
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<th>Type of Proposal</th>
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<th>Primary Grid Area</th>
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**APS/Duquesne Area Proposal Comparison**

**Table Note:**

- **PPS 3-28** refer to different proposals and project sizes.
- **Cost** is indicated for each proposal.
- **No construction** is noted for certain proposals, indicating no major construction or development work.

**Presented at the October 12, 2017 PECO meeting.**
Revision History

- V1 – 10/6/2017 – Original Slides Posted
- V2 – 10/9/2017 –
  - Removed original Slide #46
  - Added slide #9-13 and 26
- V3 – 10/11/2017 –
  - Slide #16: Correct the typo for Charlerio
  - Clarified costs on Slide #23
  - Corrected calendars on Slides #53-54
- V4 – 10/17/2017 –
  - Slide #47: Updated the problem statement
- V5 – 12/13/2017
  - Added table between slides 14 and 15.
- V6 - 1/5/2018 –
  - Slide #20: Corrected Required IS date to 12/1/2022 the problem statement
  - Slide #21: Corrected Required IS date to 12/1/2022 the problem statement
  - Moved “Comparison of APS/Duquesne Area Proposals” table to the Appendix.