Market Efficiency 2014/15 Long Term Proposal Window Update
Market Efficiency updated case*
  • 2016 load forecast
  • 2016 February Board approved projects

PJM performed additional Sensitivity Analysis
  • +/- 2% Load Forecast, +/- $1 Gas Prices, Generation
  • Projects consistently pass B/C test
  • Results in Appendix A

*Updated PROMOD cases and Reactive Interface limits posted on Market Efficiency website
Combination Projects
<table>
<thead>
<tr>
<th>Sponsor</th>
<th>Project Cost</th>
<th>Additional Upgrades Description</th>
<th>Additional Upgrades Cost</th>
<th>Total Cost (w Upgrd)</th>
<th>ISD</th>
<th>Delta in AEP-DOM L/O BED-BLA</th>
<th>Delta in AP SOUTH L/O BED-BLA</th>
<th>Delta in Total Interfaces Cong</th>
<th>Delta in Total PJM Cong</th>
<th>B/C Ratio</th>
<th>Delta in Gross Load Payment</th>
<th>Delta in Production Cost</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sponsor: Transource /DOM HV</td>
<td>$281.6</td>
<td>Ringgold Transformers, Ringgold Station, Ringgold – Catoctin 138 kV</td>
<td>$30.0 - $60.0</td>
<td>$311.6 - $341.6</td>
<td>2020</td>
<td>-$4</td>
<td>-$49</td>
<td>-$54</td>
<td>-$83</td>
<td>2.48 – 2.72</td>
<td>-$30</td>
<td>-$31</td>
<td>Additional congestion in BGE Area</td>
</tr>
<tr>
<td>Sponsor: First Energy /Transource /DOM HV</td>
<td>$206.5</td>
<td>Replace Germantown Transformer, Rebuild Hunterstown-Lincoln, Convert to 230 kV (Lincoln-Carrol)</td>
<td>$14.0</td>
<td>$220.5</td>
<td>2020</td>
<td>-$5</td>
<td>-$19</td>
<td>-$24</td>
<td>-$41</td>
<td>2.46</td>
<td>-$9</td>
<td>-$16</td>
<td>Additional congestion in BGE Area</td>
</tr>
<tr>
<td>Sponsor: NTD/Transource/DOM HV</td>
<td>$187.4</td>
<td>Upgrade Fayette to Grand Point to Guilford Path</td>
<td>$11.4 - $24.8</td>
<td>$198.8 - $212.2</td>
<td>2020</td>
<td>-$4</td>
<td>-$26</td>
<td>-$31</td>
<td>-$44</td>
<td>2.22 – 2.36</td>
<td>-$33</td>
<td>-$17</td>
<td>Additional congestion in BGE Area</td>
</tr>
</tbody>
</table>

*Deltas represent totals of 2019 and 2022 study years*
Preliminary Reliability Analysis

- Preliminary Reliability Analysis
  - Performed Generation Deliverability and N-1-1 analysis

- 9A
  - Potential reliability upgrades
    - Replacing Ringgold 230/138 kV Transformers #3 & #4
    - Ringgold 230 kV Bus station work
    - Reconductor 138 kV Ringgold – Catoctin line
  - Estimated costs TBD

- Combo 19B + (9A-3 East)
  - Evaluation in progress

- Combo 19D + (9A-3 East)
  - Potential reliability upgrades
    - Replacing Ringgold 230/138 kV Transformer #3
    - Ringgold 230 kV Bus station work
  - Estimated costs TBD
**Recommended Market Efficiency Project: 1-9A**

<table>
<thead>
<tr>
<th>Project ID: 1-9A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposed by:</strong> DOM High Voltage / Transource</td>
</tr>
</tbody>
</table>

**Proposed Solution:**


Additional Reliability Upgrades: Replace the Ringgold #3 and #4 transformers with 230/138 kV autotransformers; Ringgold bus reconfiguration; Reconductor of Ringgold-Catoctin 138 kV.

**kV Level:** 230

**Cost ($M):** $311.6 - $341.6

**IS Date:** 2020

**Notes:**
- Recommendation Pending Cost Analysis
- Designated Entities: TBD

![Map of Recommended Market Efficiency Project: 1-9A](image-url)
Next Steps

- Verify Cost Estimates
- Identify Designated Entities
- Recommendation to the PJM Board
Market Efficiency 2016/17 Long Term Proposal Window Update
2016-2017  24-Month Market Efficiency Cycle Timeline

- Long Term proposal window: November 2016 - February 2017
- Analysis of proposed solutions: March 2017 - November 2017
- Determination of Final projects: December 2017
Market Simulation Input Data

- **Study Years**
  - 2017 and 2021 to study approved RTEP projects for accelerations and modifications
  - 2017, 2021, 2024, 2027, and 2031 to study new system enhancements
  - Underlying input data based on March 2016 PROMOD IV Data Release
    - 2016 update to loads, generation, demand resources, emissions, and fuels
    - Simulations performed using PROMOD IV v11.1 engine
Powerflow Models

- 2016/2017 PJM and external world topology based on the 2017 summer peak case from the 2015 ERAG MMWG series
  - Any significant upgrades will be included/excluded based on simulation year
- 2021 and later PJM topology will be based on the 2016 RTEP 2021 Summer topology case
  - External World representation will be developed in coordination with the Interregional Planning group
  - PJM topology will include all upgrades through February 2016 PJM board approvals
Key Input Parameters

- Fuel Prices*
- Emissions Prices*
- Load and energy
- Demand resource
- Future generation
- Transmission constraints
- Carrying charge rate and discount rate

*Fuel and emissions prices to be presented at next TEAC, May 2016
PJM zonal peak and energy forecast from 2016 Load Forecast Report

<table>
<thead>
<tr>
<th>Load</th>
<th>2017</th>
<th>2021</th>
<th>2024</th>
<th>2027</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak (MW)</td>
<td>154,149</td>
<td>157,358</td>
<td>159,991</td>
<td>162,988</td>
<td>167,469</td>
</tr>
<tr>
<td>Energy (GWh)</td>
<td>821,812</td>
<td>843,262</td>
<td>862,838</td>
<td>879,605</td>
<td>906,168</td>
</tr>
</tbody>
</table>

Notes: 1.) Peak and energy values from PJM Load Forecast Report Table B-1 and Table E-1, respectively.
2.) Model inputs are at the zonal level, to the extent zonal load shapes create different diversity - modeled PJM peak load may vary.
Model zonal demand resources consistent with Table B-7 of the 2016 Load Forecast Report.

<table>
<thead>
<tr>
<th>Demand Resource (MW)</th>
<th>2017</th>
<th>2021</th>
<th>2024</th>
<th>2027</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8,883</td>
<td>3,424</td>
<td>2,478</td>
<td>3,543</td>
<td>3,651</td>
</tr>
</tbody>
</table>

2016 PJM Demand Resource Forecast
Future Generation

PJM Market Efficiency Reserve Margin - Preliminary

Note: Includes existing and projected PJM internal capacity resources.
• Generation included in Market Efficiency models include all ISAs and FSAs

• Machine list posted at February TEAC
  • [http://www.pjm.com/~/media/committees-groups/committees/teac/20160211/20160211-2021-rtep-machine-list.ashx](http://www.pjm.com/~/media/committees-groups/committees/teac/20160211/20160211-2021-rtep-machine-list.ashx)
Transmission Constraints

- Thermal Constraints
  - NERC Book of Flowgates
  - Planning study results for monitored facilities and monitored/contingency pair facilities
  - Historical PJM congestion events

- Voltage Constraints
  - PJM reactive interface limits
  - MW limits based on historical values and voltage stability analysis
  - RTEP upgrades impact future reactive interface limits
• Discount rate and levelized carrying charge rate developed using information contained in TO Formula Rate sheets (Attachment H) \[1\]

• Discount rate based on weighted average after-tax embedded cost of capital
  Discount rate = 7.4%

• Levelized annual carrying charge rate based on weighted average net plant carrying charge levelized over an assumed 45 year life of project
  Levelized Annual Carrying Charge Rate = 15.3%

Next Steps

Market Efficiency Inputs:
- Fuel Prices May
- Emissions Prices May

Board Review of Market Efficiency Input Assumptions May

Market Efficiency Preliminary Results:
- Stakeholder feedback on model: June-September
- PJM review for acceleration candidates: June-September
- Proposal window opens: November
Questions?

Email: RTEP@pjm.com
APPENDIX A:
Market Efficiency Sensitivity Results
Sensitivity Scenarios Detailed Results – Congestion Reductions AP-South

<table>
<thead>
<tr>
<th>Project</th>
<th>AP-South Total Congestion Delta ($million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gas Decrement</td>
</tr>
<tr>
<td>9A</td>
<td>($41)</td>
</tr>
<tr>
<td>Combo 9A-3 + 18H</td>
<td>($19)</td>
</tr>
<tr>
<td>Combo 9A-3 + 19B</td>
<td>($23)</td>
</tr>
<tr>
<td>Combo 9A-3 + 19D</td>
<td>($28)</td>
</tr>
</tbody>
</table>

*Congestion delta is sum of 2019 + 2022 study years. Negative values represent congestion reductions (benefits).
### Sensitivity Scenarios Detailed Results – Congestion Reductions AEP-DOM

<table>
<thead>
<tr>
<th>Project</th>
<th>AEP-DOM Total Congestion Delta ($million)</th>
<th>Gas Decrement</th>
<th>Gas Increment</th>
<th>Load Decrement</th>
<th>Load Increment</th>
<th>Generation Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>9A</td>
<td></td>
<td>($4)</td>
<td>($9)</td>
<td>($5)</td>
<td>($5)</td>
<td>($4)</td>
</tr>
<tr>
<td>Combo 9A-3 + 18H</td>
<td></td>
<td>($4)</td>
<td>($10)</td>
<td>($4)</td>
<td>($4)</td>
<td>($3)</td>
</tr>
<tr>
<td>Combo 9A-3 + 19B</td>
<td></td>
<td>($2)</td>
<td>($8)</td>
<td>($4)</td>
<td>($4)</td>
<td>($4)</td>
</tr>
<tr>
<td>Combo 9A-3 + 19D</td>
<td></td>
<td>($5)</td>
<td>($12)</td>
<td>($6)</td>
<td>($6)</td>
<td>($5)</td>
</tr>
</tbody>
</table>

*Congestion delta is sum of 2019 + 2022 study years. Negative values represent congestion reductions (benefits).*
APPENDIX B:
Market Efficiency Project Details
### Project ID: 1-9A

**Proposed by:** DOM High Voltage / Transource

**Proposed Solution:**

Additional Reliability Upgrades: Replace the Ringgold #3 and #4 transformers with 230/138 kV autotransformers; Ringgold bus reconfiguration; Re-conductor of Ringgold-Catoctin 138 kV.

**KV Level:** 230

**Cost ($M):** $311.6 - $341.6

**IS Date:** 2020

**Notes:**
- Recommendation Pending Cost Analysis
- Designated Entities: TBD
<table>
<thead>
<tr>
<th>Proposed by: FirstEnergy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Solution: Rebuild and reconductor the Lincoln - Carroll 115/138kV path. <strong>Added:</strong> Path will be converted to 230kV operation; Rebuild Hunterstown-Lincoln.</td>
</tr>
<tr>
<td><strong>kV Level:</strong> 138</td>
</tr>
<tr>
<td><strong>Cost ($M):</strong> $72</td>
</tr>
<tr>
<td><strong>IS Date:</strong> 2019</td>
</tr>
<tr>
<td><strong>Target Zone:</strong> APS/Meted</td>
</tr>
<tr>
<td><strong>Notes:</strong> Moderate congestion reduction on ApSouth. Increased congestion on TMI-Jackson 230 kV line. Project has been modified from original proposal.</td>
</tr>
</tbody>
</table>
Project ID: 201415_1-19B

Proposed by: Northeast Transmission Development

Proposed Solution: Approximately 6-mile 138 kV Line from Grand Point to a new 500/138 kV substation on the Conemaugh-Hunterstown 500 kV Line ("Green Ridge"). Additional upgrades on Fayette-Grand Point-Guilford path.

kV Level: 138

Cost ($M): $50.3-$63.7

IS Date: 2020

Notes: Increases congestion on eastern area constraints near Conastone. Moderate congestion reduction on ApSouth.
<table>
<thead>
<tr>
<th>Project ID: 201415_1-19D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed by: Northeast Transmission Development</td>
</tr>
<tr>
<td>Proposed Solution: Approximately 26-mile 230 kV Line from Ringgold to a new 500/230 kV substation on the Conemaugh-Hunterstown 500 kV Line (&quot;Green Ridge&quot;). <strong>Additional upgrades required at Ringgold.</strong></td>
</tr>
<tr>
<td>kV Level: 230</td>
</tr>
<tr>
<td>Cost ($M): $134.5 - $154.5</td>
</tr>
<tr>
<td>IS Date: 2020</td>
</tr>
<tr>
<td>Target Zone: Meted/Penelec</td>
</tr>
<tr>
<td>Notes: Major congestion reductions on AP-South and other PJM facilities. Increases congestion on eastern area constraints near Conastone.</td>
</tr>
</tbody>
</table>

**Legend**

<table>
<thead>
<tr>
<th>Substations</th>
<th>Transmission Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>69 kV</td>
<td>110 kV</td>
</tr>
<tr>
<td>115 kV</td>
<td>120 kV</td>
</tr>
<tr>
<td>138 kV</td>
<td>138 kV</td>
</tr>
<tr>
<td>151 kV</td>
<td>151 kV</td>
</tr>
<tr>
<td>230 kV</td>
<td>230 kV</td>
</tr>
<tr>
<td>245 kV</td>
<td>245 kV</td>
</tr>
<tr>
<td>345 kV</td>
<td>345 kV</td>
</tr>
<tr>
<td>500 kV</td>
<td>500 kV</td>
</tr>
<tr>
<td>765 kV</td>
<td>765 kV</td>
</tr>
</tbody>
</table>

PJM TEAC 04/07/2016