Market Efficiency Update

Nick Dumitriu
Sr. Lead Engineer, Market Simulation
Transmission Expansion Advisory Committee
November 14, 2019
2018/19 Market Efficiency Window
2018/19 Market Efficiency Window
Interregional Analysis
Conclusion of Interregional Market Efficiency Analysis

• Analysis is complete, concluding 2019 PJM-MISO Coordinated System Plan

• Three drivers identified:
  – Marblehead N 161/138kV Transformer
    ▪ No proposed project met B/C criteria in either region
  – Monroe – Wayne 345kV
    ▪ No proposed project effectively resolved congestion
  – Bosserman – Trail Creek 138kV
    ▪ Rebuilding Michigan City to Trail Creek to Bosserman 138kV to be recommended in both regional processes
• PJM selected BT_481, rebuilding Michigan City to Trail Creek to Bosserman 138 kV lines

• Results presented at Oct 2019 TEAC:
  - Highest B/C ratio
  - Robustly addresses congestion on identified issue
  - Passed reliability no-harm test
  - Passed all PROMOD sensitivity scenarios

• Recommended as Interregional Market Efficiency project in both PJM and MISO regional processes

• Interregional Cost allocation
  • PJM 89.1%  MISO 10.9%
Bosserman-Trail Creek Proposal Final Results

<table>
<thead>
<tr>
<th>Proposal ID</th>
<th>BT_481</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposal Description</strong></td>
<td>Rebuild Michigan City-Trail Creek-Bosserman 138 kV (10.7mi)</td>
</tr>
<tr>
<td><strong>Project Type</strong></td>
<td>Upgrade</td>
</tr>
<tr>
<td><strong>B/C Ratio Metric</strong></td>
<td>Lower Voltage</td>
</tr>
<tr>
<td><strong>In-Service Cost ($MM)</strong></td>
<td>$24.69</td>
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<tr>
<td><strong>Cost Containment</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>In-Service Month</strong></td>
<td>Jan 2023</td>
</tr>
<tr>
<td><strong>% Cong Driver Mitigated</strong></td>
<td>100%</td>
</tr>
<tr>
<td><strong>2023 Shifted Cong ($MM)</strong></td>
<td>$0.04</td>
</tr>
<tr>
<td><strong>PJM Benefit Metric ($MM)</strong></td>
<td>69.16</td>
</tr>
<tr>
<td><strong>PJM Base Case B/C Ratio</strong></td>
<td>2.63</td>
</tr>
<tr>
<td><strong>PJM Interregional Cost Allocation %</strong></td>
<td>89.1%</td>
</tr>
</tbody>
</table>

* Costs based on PJM’s Independent Cost/Constructability Review
** Cost split based on September 20 IPSAC Presentation: [https://www.pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/20190920/20190920-ipsac-presentation.ashx](https://www.pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/20190920/20190920-ipsac-presentation.ashx)
Trend for Net Load Benefits of Proposal BT_481

201819_BT_481

Net Load Payment Benefit
Simulated Results are PJM Total Benefits for zones that get allocation

2033 Simulation

2033 Trend
• Recommend BT_481 for provisional* approval at the December Board meeting

• Continue to coordinate with MISO

*Dependent on MISO Board approval of same project
2018/19 Market Efficiency Window
Hunterstown – Lincoln Proposals
• Preliminary results first presented at July 2019 TEAC
  – Calculated preliminary benefits and determined preliminary B/C ratios for all 22 proposals

• Top 5 proposals analysis completed
  – Cost/Constructability review completed
  – PROMOD base and sensitivity runs completed (see Appendix B)

• Three lower cost proposals fully relieve congestion on the driver with minimal shift in congestion
  – HL_622: Rebuild the Hunterstown-Lincoln 115 kV line
  – HL_469: Install SmartValve* power flow control series devices
  – HL_960: Build new Hunterstown-Lincoln 115 kV line

*SmartValve is a Trademark of Smart Wires Inc.
## Hunterstown-Lincoln Proposal Top5 Results

<table>
<thead>
<tr>
<th>Proposal ID</th>
<th>Proposal Description</th>
<th>Proposal Description</th>
<th>Proposal Description</th>
<th>Proposal Description</th>
<th>Proposal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rebuild the Hunterstown-Lincoln 115 kV line.</td>
<td>Install SmartValve™ power flow control 5% series reactance device in series with the Lincoln Tap-Hunterstown 115 kV line.</td>
<td>Build a 115 kV ring bus at the Lincoln tap.</td>
<td>Build Meade 115 kV substation.</td>
<td>Build new Hunterstown-Lincoln 115 kV line.</td>
</tr>
<tr>
<td>Proposal ID</td>
<td>HL_622</td>
<td>HL_469**</td>
<td>HL_007</td>
<td>BT_293</td>
<td>HL_960</td>
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<tr>
<td>Project Type</td>
<td>Upgrade</td>
<td>Greenfield</td>
<td>Greenfield</td>
<td>Greenfield</td>
<td>Greenfield</td>
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<tr>
<td>Proposer Cost ($MM)</td>
<td>$7.21</td>
<td>$4.65</td>
<td>$7.58</td>
<td>$8.95</td>
<td>$10.13</td>
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<tr>
<td>PJM/Independent Cost ($MM)*</td>
<td>$6.20</td>
<td>$7.15</td>
<td>$8.26</td>
<td>$8.40</td>
<td>$11.92</td>
</tr>
<tr>
<td>Cost Containment</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>In-Service Year</td>
<td>2023</td>
<td>2022</td>
<td>2023</td>
<td>2023</td>
<td>2021</td>
</tr>
<tr>
<td>% Cong Driver Mitigated</td>
<td>100%</td>
<td>100%</td>
<td>86%</td>
<td>86%</td>
<td>100%</td>
</tr>
<tr>
<td>2023 Shifted Cong ($MM)</td>
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<td>$2.03</td>
<td>$1.35</td>
<td>$1.35</td>
<td>$1.89</td>
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<tr>
<td>15-Yr NPV NLP Benefit ($MM)</td>
<td>$586</td>
<td>$552</td>
<td>$428</td>
<td>$428</td>
<td>$563</td>
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<tr>
<td>PJM Cost Used ($MM)</td>
<td>$7.21</td>
<td>$7.15</td>
<td>$8.26</td>
<td>$8.40</td>
<td>$11.92</td>
</tr>
<tr>
<td>B/C Ratio</td>
<td>76.41</td>
<td>72.61</td>
<td>48.78</td>
<td>47.97</td>
<td>44.39</td>
</tr>
</tbody>
</table>

*Costs based on PJM’s Independent Cost/Constructability Review
**SmartValve is a Trademark of Smart Wires Inc.
## SmartValve™ vs. Reconductoring Proposal

<table>
<thead>
<tr>
<th>Criteria</th>
<th>HL_622 Upgrade Solution</th>
<th>HL_469 SmartValve™ Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructability Risk</td>
<td>Upgrade, no additional property needed</td>
<td>Greenfield, permitting risk related to new property for substation due to location near historically sensitive area</td>
</tr>
<tr>
<td>PJM Operations and Markets</td>
<td>No changes needed to real-time operations procedures and practices</td>
<td>At this time, real-time operations would not be able to fully utilize the dynamic capabilities of this device without additional changes</td>
</tr>
<tr>
<td>Additional Integration Cost with Operations and Markets</td>
<td>No additional costs</td>
<td>May require updating Day-Ahead, Real-Time, SCADA systems to support full operational range of this type of device</td>
</tr>
<tr>
<td>Industry experience</td>
<td>Established well known solution</td>
<td>Limited experience with SmartValve™ device</td>
</tr>
<tr>
<td>Additional System Capability/Flexibility**</td>
<td>Yes/No</td>
<td>No/Yes</td>
</tr>
</tbody>
</table>

*SmartValve is a Trademark of Smart Wires Inc

**Capability in terms of line ratings increase / Flexibility in terms of dynamic flow control
Hunterstown – Lincoln Conclusion and Next Steps

• Completed comprehensive analysis considering both economic benefits and operational challenges of proposals

• HL_622, rebuild the Hunterstown-Lincoln 115 kV line, will be recommended to the PJM Board for RTEP inclusion
  – High B/C Ratio: 76.41
  – Low Cost: $7.21 million
  – Fully addresses target congestion driver Hunterstown – Lincoln 115 kV
  – Passes all PROMOD sensitivity scenarios
  – Reliability Analysis has been completed and no reliability violation identified

• PJM staff will recommend proposal HL_622 to the PJM Board
  – Proposal will be presented at the December Board meeting
  – Timeline supports RTEP model build
Trend for Net Load Benefits of Proposal HL_622

201819_HL_622
Net Load Payment Benefit

Simulated Results are PJM Total Benefits for zones that get allocation

Chart Area

2033 Trend

2033 Simulation

($ Million)

2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034
2019 Annual Reevaluation of Market Efficiency Projects
Reevaluation Overview

• Applies to Market Efficiency projects approved during the 2014/15 and 2016/17 RTEP Windows

• Using the most recent Market Efficiency case available:
  – Base case version 2019-07-26 (posted on 08/02/2019)
  – With First Energy generator deactivations withdrawn

• Projects already in-service, under construction or cancelled are no longer required to be reevaluated.

• Projects must continue to meet the B/C criterion of 1.25

• Reevaluation Process to be completed by December 2019
5E (b2992)
Reevaluation Analysis Overview
• History
  − Project 5E (B2992) approved during 2016/17 Window:
    • B/C Ratio: 5.93     (Cost: $39.65 mill)
  − Reevaluation Nov 2019
    • Updated Cost: $48.3 mill
    • B/C Ratio: 1.11
    • B/C Ratio: 1.80 (with Hunterstown – Lincoln congestion relieved)

• In the current Market Efficiency Base Case, benefits of 5E (b2992) are decreased because of Hunterstown – Lincoln 115 kV congestion
  − Once Hunterstown – Lincoln 115 kV congestion relieved, 5E (b2992) delivers expected benefits
Hunterstown – Lincoln 115kV congestion prevents 5E (b2992) benefits to be realized.

If Hunterstown – Lincoln 115 kV congestion is relieved, then 5E (b2992) delivers the expected benefits.
• Construction Status
  - Design and engineering - 95% complete
  - Construction scheduled to begin March 2020, with an expected 6/1/2021 in-service date

• Cost Update

<table>
<thead>
<tr>
<th>Baseline #</th>
<th>Costs (Direct &amp; Indirect)*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>b2992.1</td>
<td>Reconductor Conastone-Graceton 2323/2324 Circuits</td>
<td>$18,487,474</td>
</tr>
<tr>
<td>b2992.2</td>
<td>Bundle Conductor Graceton-Bagley-Raphael Road 2305/2313 Circuits</td>
<td>$20,306,088</td>
</tr>
<tr>
<td>b2992.3</td>
<td>Remove Windy Edge - Glenarm 110512 Substation Limitations</td>
<td>$237,592</td>
</tr>
<tr>
<td>b2992.4</td>
<td>Reconductor Raphael Road - Northeast 2315/2337 Circuits</td>
<td>$9,264,714</td>
</tr>
</tbody>
</table>

| Total In-Service Cost | $48,295,868 |

* A 2.5% inflation rate was used to escalate costs to in-service date
• Reevaluation of 201617_1-5E (b2992.1-4) project completed
  – PJM Staff will recommend keeping 5E (b2992) in the RTEP pending approval by the PJM Board of HL_622, reconductoring of Hunterstown – Lincoln 115 kV.

• Reevaluation of projects b2697, b2976, b2931 completed
  – All projects pass the 1.25 threshold
  – Results included in Appendix C

• This concludes the 2019 Reevaluation process
Alternative IEC East Portion of the IEC Project
(Transource 9A)
• IEC Project (Transource 9A) Details
  – PJM Baseline # b2743, b2752

• Original application
  – In December 2017, Transource filed CPCN applications to build the IEC Project (Transource 9A) before the Maryland Public Service Commission (MD Commission) and Pennsylvania Public Utility Commission (PA Commission).

• Proposed Alternatives
  – In the course of the regulatory proceedings, alternative reconfigurations of the IEC Project (Transource 9A) were introduced by various parties.
  – PJM analyzed these alternative routes to assess reliability and market efficiency impacts.
  – In addition to the IEC Project (Transource 9A), an Alternative IEC East Portion of the IEC Project has been filed as part of a proposed settlement in the pending proceedings before the MD and PA Commissions.
IEC Project inclusive of the Alternative IEC East Portion
Analysis and Next Steps

• PJM assessed the IEC Project (Transource 9A) inclusive of the Alternative IEC East Portion:
  – In Service Cost: $496.17 million
  – Benefits: $844.81 million
  – B/C Ratio: 1.60
  – Satisfies all PJM Reliability criteria

• PJM staff will present the IEC Project (Transource 9A) inclusive of the Alternative IEC East Portion at the December Board meeting
  – Request approval conditioned upon MD Commission approval and PA Commission approval

Note: Map from https://www.transourceenergyprojects.com/IndependenceEnergyConnection/
Appendix A

Bosserman – Trail Creek Sensitivities
<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>BT_481</th>
<th>BT_129</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost ($MM)</td>
<td>24.69</td>
<td>29.51</td>
</tr>
<tr>
<td>Base Case</td>
<td>2.63</td>
<td>1.91</td>
</tr>
<tr>
<td>FSA Included</td>
<td>5.13</td>
<td>4.4</td>
</tr>
<tr>
<td>High Load</td>
<td>3.12</td>
<td>3.19</td>
</tr>
<tr>
<td>Low Load</td>
<td>3.73</td>
<td>2.78</td>
</tr>
<tr>
<td>High Gas</td>
<td>3.62</td>
<td>3.03</td>
</tr>
<tr>
<td>Low Gas</td>
<td>2.26</td>
<td>1.96</td>
</tr>
<tr>
<td>Outage Library 1</td>
<td>4.62</td>
<td>3.78</td>
</tr>
<tr>
<td>Outage Library 2</td>
<td>3.87</td>
<td>3.38</td>
</tr>
<tr>
<td>Outage Library 3</td>
<td>4.21</td>
<td>3.25</td>
</tr>
<tr>
<td>Outage Library 4</td>
<td>4.62</td>
<td>3.94</td>
</tr>
<tr>
<td>Outage Library 5</td>
<td>3.62</td>
<td>3.50</td>
</tr>
<tr>
<td>FE Reactivations</td>
<td>4.62</td>
<td>3.95</td>
</tr>
</tbody>
</table>

Note: B/C ratios computed using Independent Cost / Constructability Review
Appendix B
Hunterstown – Lincoln 115 kV
Top5 Proposals Sensitivities
## B/C Ratio Sensitivities: Hunterstown - Lincoln

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>HL_622</th>
<th>HL_469</th>
<th>HL_007</th>
<th>HL_293</th>
<th>HL_960</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost ($MM)</td>
<td>7.21</td>
<td>7.15</td>
<td>8.26</td>
<td>8.4</td>
<td>11.92</td>
</tr>
<tr>
<td>Base Case</td>
<td>76.41</td>
<td>72.61</td>
<td>48.78</td>
<td>47.97</td>
<td>44.39</td>
</tr>
<tr>
<td>FSA Included</td>
<td>8.87</td>
<td>10.34</td>
<td>6.23</td>
<td>6.12</td>
<td>5.81</td>
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<tr>
<td>High Load</td>
<td>85.23</td>
<td>82.35</td>
<td>61.85</td>
<td>60.82</td>
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<td>Low Load</td>
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<td>75.94</td>
<td>58.09</td>
<td>57.12</td>
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<td>High Gas</td>
<td>65.13</td>
<td>63.37</td>
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<td>45.23</td>
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<tr>
<td>Low Gas</td>
<td>74.58</td>
<td>74.06</td>
<td>50.15</td>
<td>49.31</td>
<td>44.10</td>
</tr>
<tr>
<td>Outage Library 1</td>
<td>75.96</td>
<td>77.16</td>
<td>51.80</td>
<td>50.94</td>
<td>47.26</td>
</tr>
<tr>
<td>Outage Library 2</td>
<td>81.62</td>
<td>81.75</td>
<td>59.40</td>
<td>58.41</td>
<td>49.56</td>
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<tr>
<td>Outage Library 3</td>
<td>68.25</td>
<td>67.00</td>
<td>47.22</td>
<td>46.43</td>
<td>40.96</td>
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<td>Outage Library 4</td>
<td>86.68</td>
<td>85.71</td>
<td>60.21</td>
<td>59.21</td>
<td>50.96</td>
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<td>Outage Library 5</td>
<td>76.48</td>
<td>76.33</td>
<td>53.31</td>
<td>52.42</td>
<td>45.54</td>
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<tr>
<td>FE Reactivations</td>
<td>59.45</td>
<td>60.03</td>
<td>41.92</td>
<td>41.23</td>
<td>35.56</td>
</tr>
</tbody>
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Appendix C
2019 Reevaluation Results
Proposals b2697, b2976, b2931
Reevaluation Results b2697, b2976, b2931

• Overview
  – Projects with capital cost under $20 million are reevaluated using the original benefits* and updated capital costs.
  – Capital costs updated as of 11/13/2019

• 2019 Reevaluation B/C ratios for b2697, b2976, b2931

<table>
<thead>
<tr>
<th>PJM Window Project ID</th>
<th>Baseline#</th>
<th>Type</th>
<th>Area</th>
<th>Constraint</th>
<th>Initial TEAC Date</th>
<th>Initial Capital Cost ($ million)</th>
<th>Initial B/C Ratio</th>
<th>Current Status</th>
<th>Projected ISD</th>
<th>Updated Capital Cost</th>
<th>2019 Reevaluation B/C Ratio</th>
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</thead>
<tbody>
<tr>
<td>201415_1-4I</td>
<td>b2697.1-2</td>
<td>Upgrade</td>
<td>AEP</td>
<td>Fieldale to Thornton 138 kV</td>
<td>9/10/2015</td>
<td>$0.75</td>
<td>101.19</td>
<td>EP</td>
<td>1/1/2019 1:06</td>
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<td>28.11</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2: 12/31/2019</td>
<td></td>
<td></td>
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<tr>
<td>201617_1A_RP M_DEOK</td>
<td>b2976</td>
<td>Upgrade</td>
<td>DEOK</td>
<td>Tanners Creek to Dearborn 345 kV</td>
<td>11/2/2017</td>
<td>$0.60</td>
<td>151.61</td>
<td>EP</td>
<td>6/1/2021</td>
<td>$0.30</td>
<td>303.22</td>
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</table>

EP – Engineering Procurement
*Original benefits are the benefits that were determined when the projects were initially approved
\begin{itemize}
\item V1 – 11/11/2019 – Original slides posted
\item V2 - 11/13/2019
  \begin{itemize}
  \item Slide 12: Added clarifying note:
    \begin{itemize}
    \item **Capability in terms of line ratings increase / Flexibility in terms of dynamic flow control
    \end{itemize}
  \item Slide 21: Added
    \begin{itemize}
    \item Reevaluation of projects b2697, b2976, b2931 completed
      \begin{itemize}
      \item All projects pass the 1.25 threshold
      \item Results included in Appendix C
      \end{itemize}
    \item This concludes the 2019 Reevaluation process
    \end{itemize}
  \end{itemize}
  \item Added slides 29,30
  \begin{itemize}
  \item Appendix C - Reevaluation Results b2697, b2976, b2931
  \item V3 - 11/26/2019 – Corrected typo for MISO Cost Allocation on slide #5
  \end{itemize}
\end{itemize}