Market Efficiency Update

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2020/21 Long-Term Window 1

Cluster Analysis Status

- Cluster No. 1 (APS) - French's Mill to Junction 138 kV
  - Analysis completed: Proposal 756, terminal equipment upgrades at the French's Mill and Junction 138 kV substations, with a projected in-service date of 4/1/2022, selected as the preferred solution.
- Cluster No. 2 (PECO) - Plymouth Meeting to Whitpain 230 kV
  - Analysis completed: Proposal 704, terminal equipment upgrades at the Plymouth Meeting and Whitpain 230 kV substations, with a projected in-service date of 6/1/2025, selected as the preferred solution.
- Cluster No. 3 (PPL) - Juniata to Cumberland 230 kV
  - Analysis completed: Proposal 218, reconductor the Juniata-Cumberland 230 kV line, with a projected in-service date of 12/1/2023, selected as the preferred solution.
- Cluster No. 4 (DOM) - Charlottesville to Proffit 230 kV
  - Constraint was posted as a reliability violation but eliminated after the re-tool.
  - The reliability proposals received for the Charlottesville to Proffit 230 kV violation were also reviewed for market efficiency benefits.
  - Analysis completed: Proposal 651, series reactor on the Charlottesville-Proffit 230 kV line, with a projected in-service date of 6/1/2023, selected as the preferred solution.

2020/21 Long-Term Window Congestion Drivers – Sensitivity Analysis

- PJM performed a sensitivity study to determine the impacts on the congestion drivers associated with the removal of the 9A project from the base case used to perform the 2020/21 Long-Term Window analysis.

Cluster	2020/21 Long-Term Window Congestion Drivers	Area	Base Topology 2025 Annual Congestion ($million)	Topology with 9A Removed 2025 Annual Congestion ($million)	Difference ($million)
Cluster No. 1	Junction to French's Mill 138 kV	APS	$21.66	$45.02	$23.36
Cluster No. 2	Plymouth Meeting to Whitpain 230 kV	PECO	$4.36	$4.28	($0.09)
Cluster No. 3	Charlottesville to Proffit Rd. 230 kV	DOM	$9.29	$10.15	$0.86
Cluster No. 4	Juniata to Cumberland 230 kV	PLGRP	$11.41	$10.08	($1.33)

  - Simulated 2025 annual congestion on the Junction to French's Mill 138 kV (APS) congestion driver increases from $21.66 million to $45.02 million.
  - Congestion increases on Cluster Nos. 2, 3 and 4 are relatively small.

2020/21 Long-Term Window
1st Read

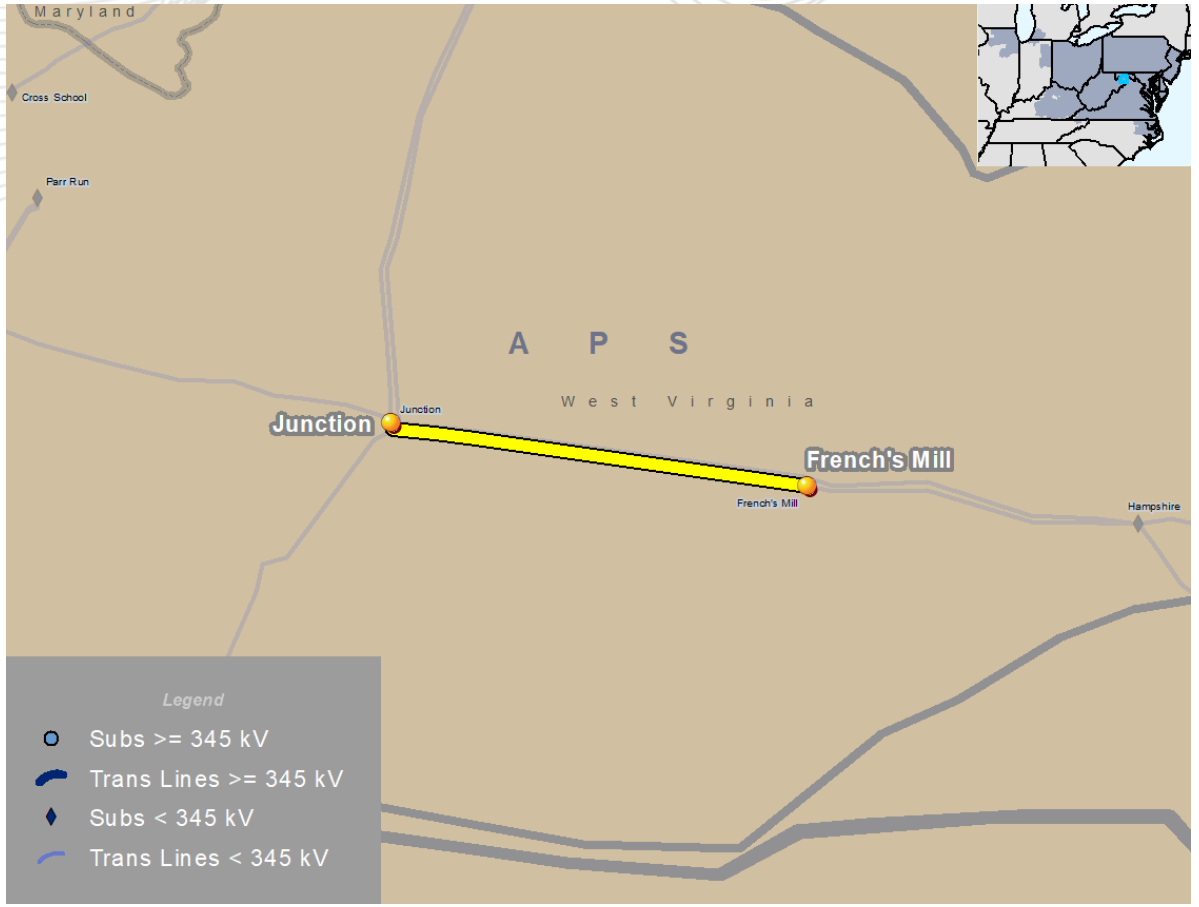
Cluster 1: Junction – French's Mill 230 kV (APS)

- Proposal 756, terminal equipment upgrades at the Junction and French's Mill 138 kV substations, selected as the preferred solution:
  - Addresses the target congestion and has the highest B/C Ratio, 119.03.
  - Lowest Cost: $0.77 million.
  - Projected in-service date: 4/1/2022.
  - Passes all PROMOD sensitivity scenarios.
  - Reliability analysis has been completed and no reliability violations identified associated with this solution.

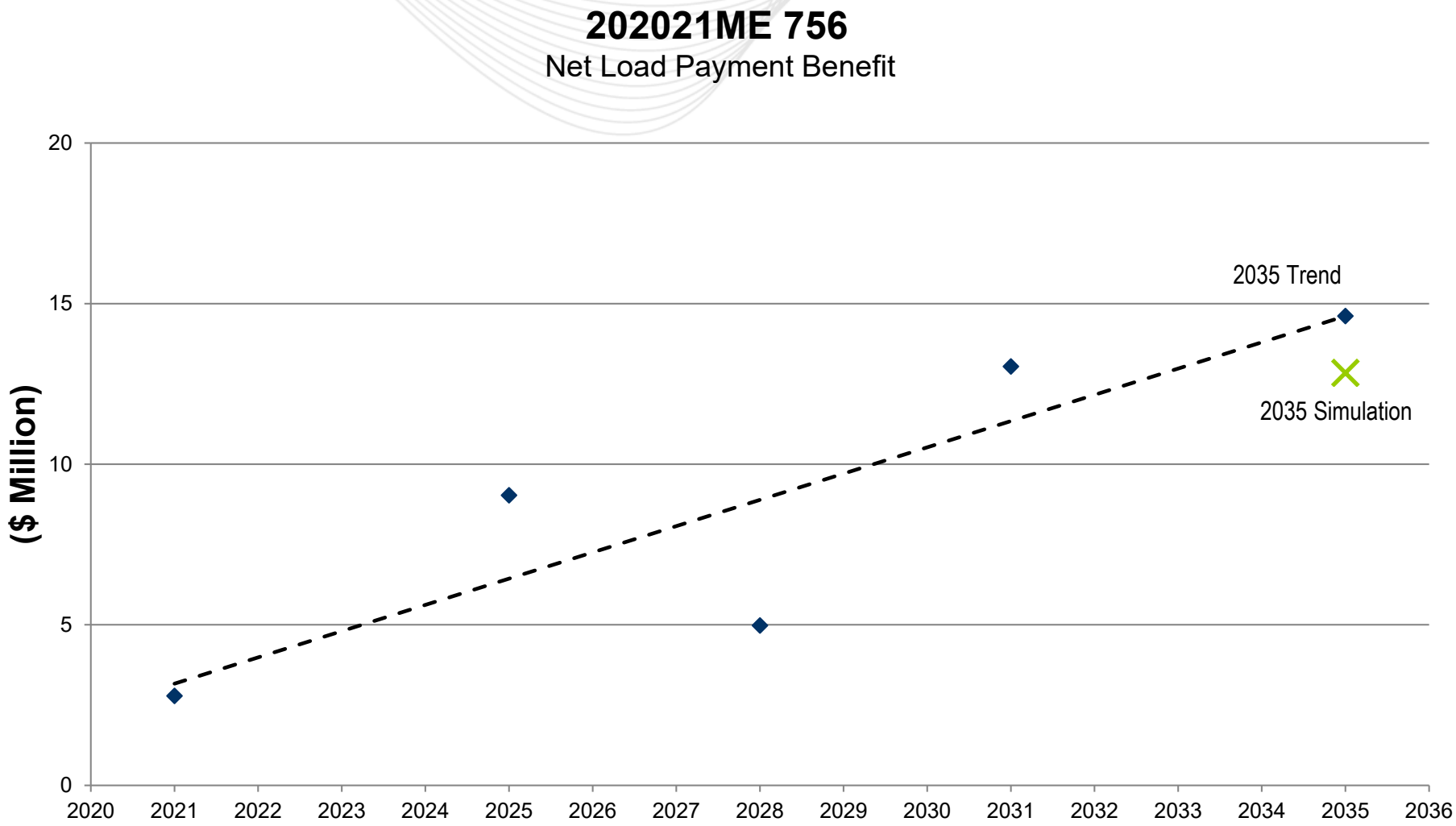
- PJM staff intends to submit Proposal 756 to be approved by the PJM Board for inclusion in the Regional Transmission Expansion Plan.

Proposal No. 756 (French's Mill - Junction Terminal Upgrades)

Project ID: 202021_756
Proposed Solution: Replace terminal equipment on the French's Mill-Junction 138 kV line.
Project Type: Upgrade
kV Level: 138 kV
In-Service Cost ($M): $0.77
In-Service Date: 4/1/2022
B/C Ratio = 119.03
Target Zone: APS
ME Constraints: Junction to French's Mill 138 kV
Notes: Redacted Public Proposal 756



Proposal 756 - Trend for Net Load Benefits



2020/21 Long-Term Window
2nd Read

Cluster 2: Plymouth Meeting - Whitpain 230 kV (PECO)

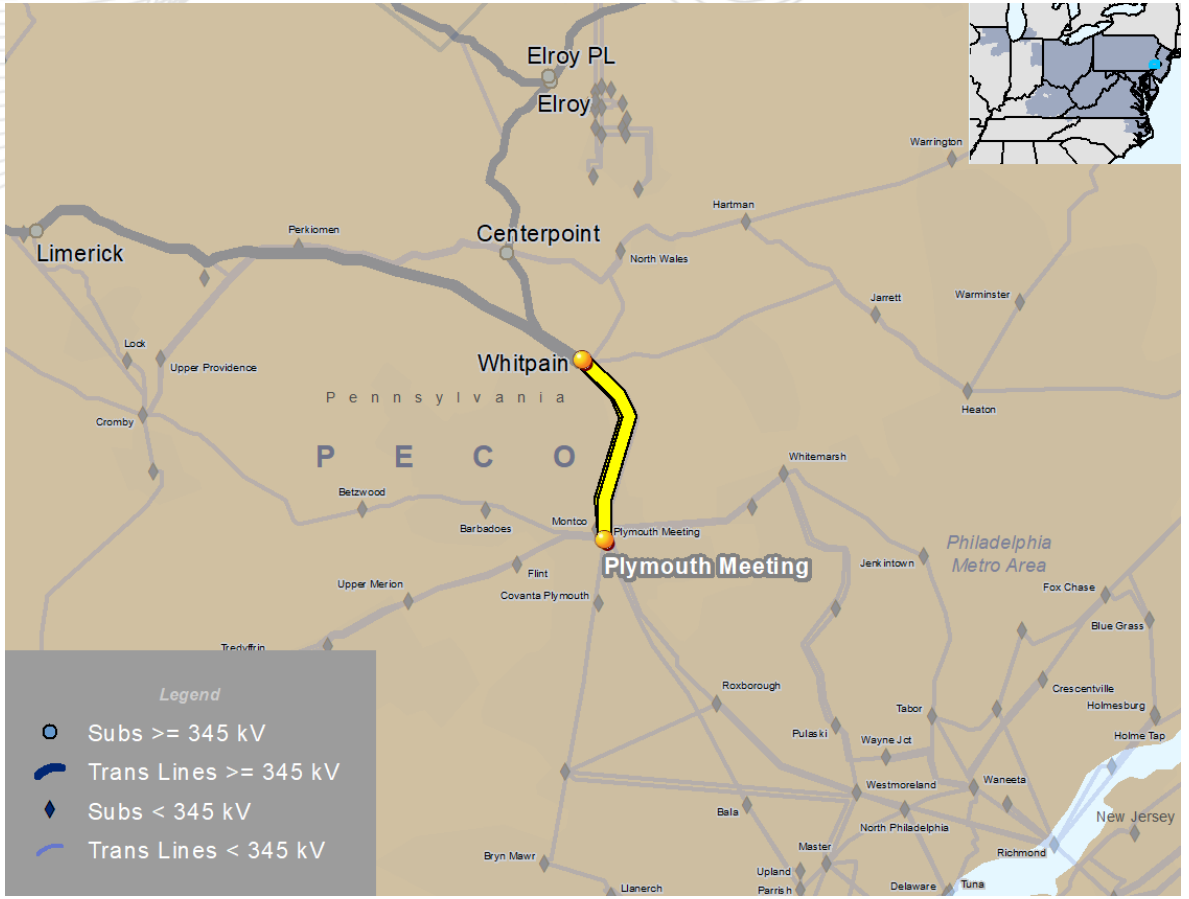
- Proposal 704, terminal equipment upgrades at the Plymouth Meeting and Whitpain 230 kV substations, selected as the preferred solution:
  - Addresses the target congestion and has the highest B/C Ratio, 75.30.
  - Lowest Cost: $0.62 million.
  - Projected in-service date: 6/1/2025.
  - Passes all PROMOD sensitivity scenarios.
  - Reliability analysis has been completed and no reliability violations identified associated with this solution.

- 1st Read presented at the November TEAC meeting.

- PJM staff intends to submit Proposal 704 to be approved by the PJM Board for inclusion in the Regional Transmission Expansion Plan.

Proposal No. 704 (Plymouth-Whitpain 220-13, 220-14 Terminal Upgrades)

Project ID: 202021_704
Proposed Solution: Replace station conductor and metering inside Whitpain and Plymouth substations.
Project Type: Upgrade
kV Level: 230 kV
In-Service Cost ($M): $0.62
In-Service Date: 6/1/2025
B/C Ratio = 75.30
Target Zone: PECO
ME Constraints: Plymouth Meeting to Whitpain 230 kV
Notes: Redacted Public Proposal 704



Cluster 3: Juniata-Cumberland 230 kV (PPL)

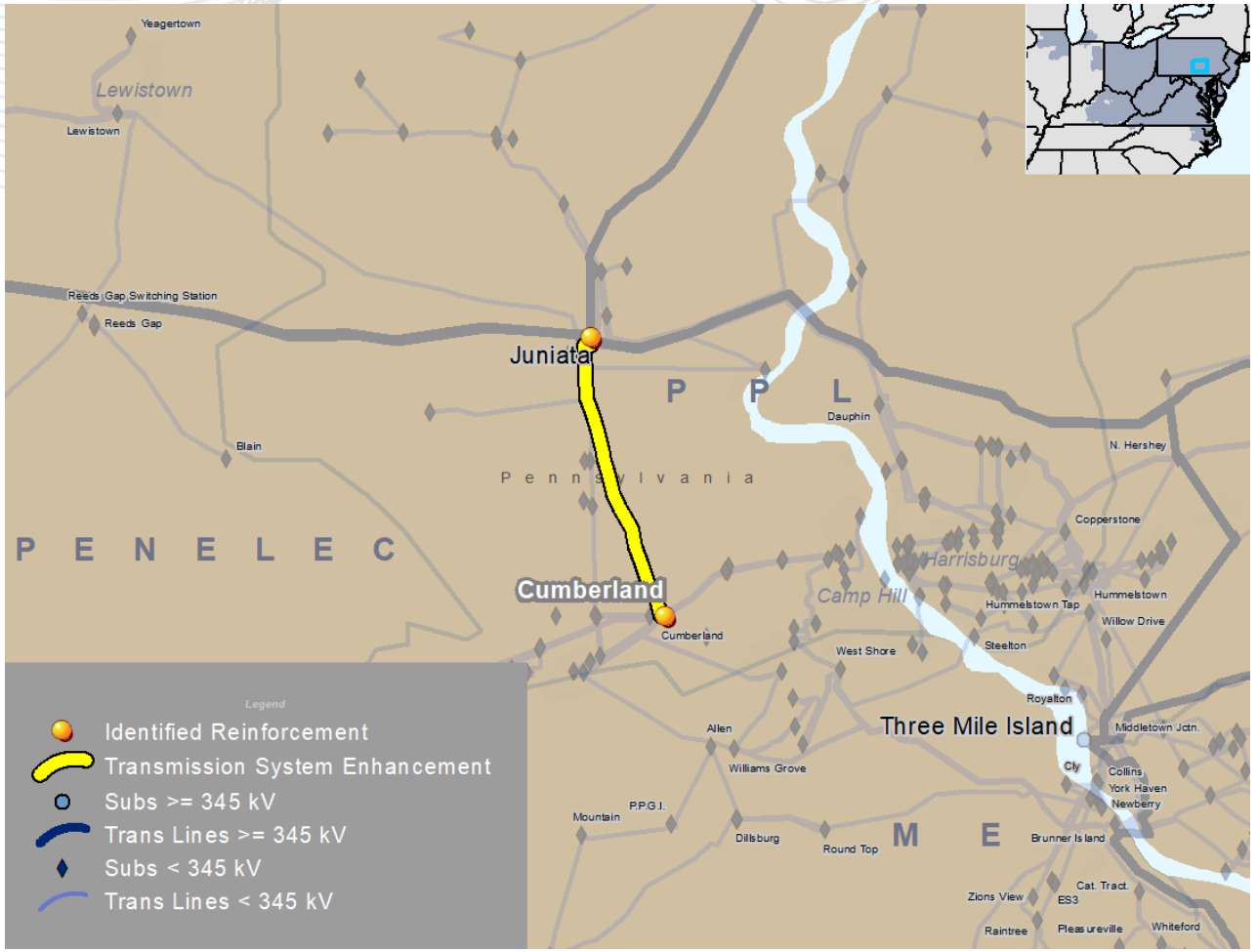
- Proposal 218, reconductor the Juniata-Cumberland 230 kV line, selected as the preferred solution:
  - Fully addresses the target congestion driver and has the highest B/C Ratio, 11.28.
  - Low Cost: $9.00 million.
  - Projected in-service date: 12/1/2023.
  - Passes all PROMOD sensitivity scenarios.
  - Reliability analysis has been completed and no reliability violation identified associated with this solution.

- 1st Read presented at the November TEAC meeting.

- PJM staff intends to submit Proposal 218 to be approved by the PJM Board for inclusion in the Regional Transmission Expansion Plan.

Proposal No. 218 (Juniata - Cumberland 230 kV Line Reconductor)

Project ID: 202021_218
Proposed Solution: Reconductor the Juniata - Cumberland 230kV line.
Project Type: Upgrade
kV Level: 230 kV
In-Service Cost ($M): $9.00
In-Service Date: 12/1/2023
B/C Ratio = 11.28
Target Zone: PPL
ME Constraints: Cumberland to Juniata 230 kV
Notes: Redacted Public Proposal 218



Cluster 4: Charlottesville-Proffit 230 kV (DOM)

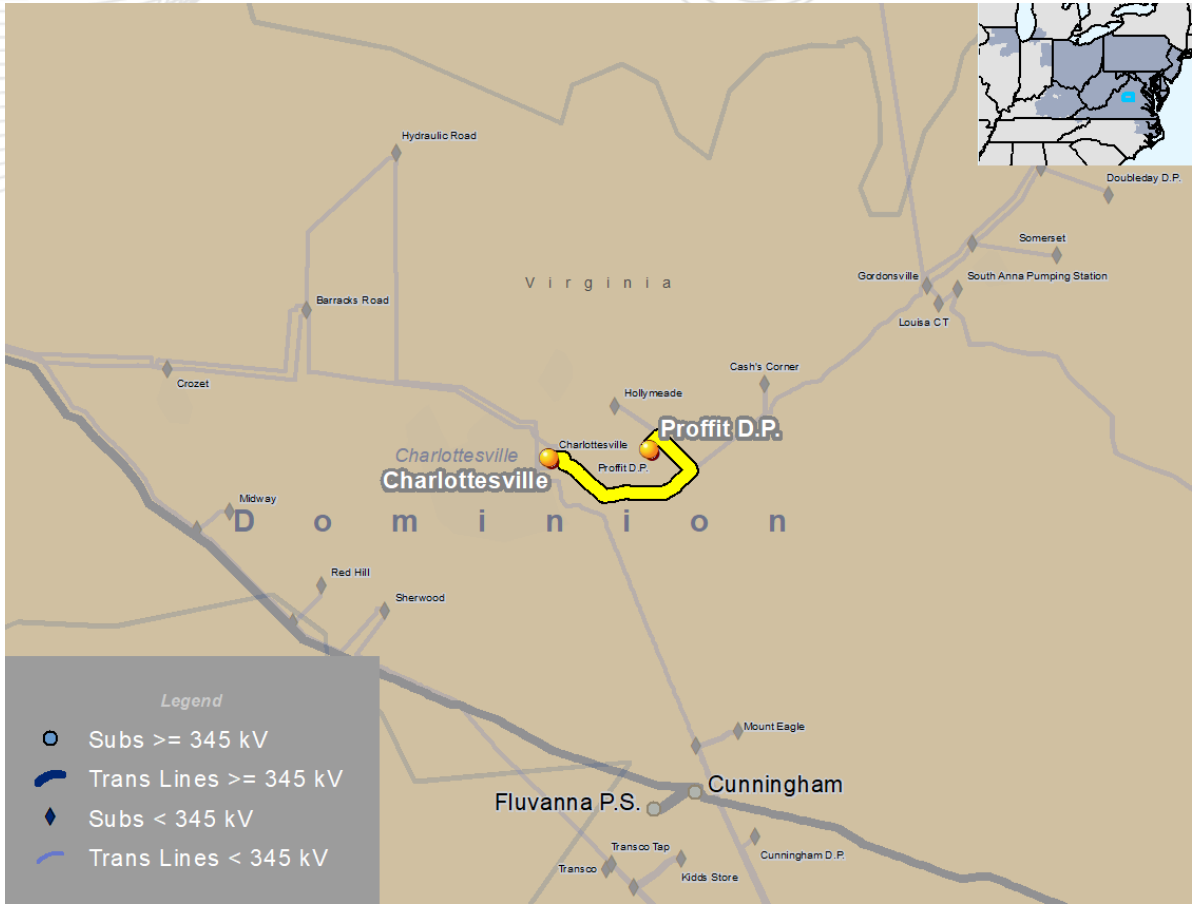
- Proposal 651, series reactor on the Charlottesville-Proffit 230 kV line, selected as the preferred solution:
  - Fully addresses target congestion driver and has the highest B/C Ratio, 16.05.
  - Low Cost: $11.38 million.
  - Projected in-service date: 6/1/2023.
  - Passes all PROMOD sensitivity scenarios.
  - Reliability analysis has been completed and no reliability violation identified associated with this solution.

- 1st Read presented at the November TEAC meeting.

- PJM staff intends to submit Proposal 651 to be approved by the PJM Board for inclusion in the Regional Transmission Expansion Plan.

Proposal No. 651 (Series Reactor Charles - Proffit)

Project ID: 202021_651
Proposed Solution: Install series reactor on the Charlottesville – Proffit Rd. 230 kV line.
Project Type: Upgrade
kV Level: 230 kV
In-Service Cost ($M): $11.38
In-Service Date: 6/1/2023
B/C Ratio = 16.05
Target Zone: DOM
ME Constraints: Charlottesville to Proffit Rd Del Pt 230 kV
Notes: Redacted Public Proposal 651



2020/21 Long-Term Window 1 - Next Steps

– Final recommendation to the PJM Board for review and approval.

2021 Market Efficiency Re-evaluation
Transource IEC (9A) Project

Congestion Relief in South-Central Pennsylvania and Northern Maryland

Overview

- PJM is required by Schedule 6 of the Operating Agreement (OA) to "annually review the cost and benefits" of Board-approved market efficiency projects that meet certain criteria to assure that a project continues to be cost beneficial.
  - The annual re-evaluation is not required for projects that have commenced construction or have received state siting approval.
  - Analysis performed with the latest re-tooled Market Efficiency case.

- Transource IEC (9A) is the only eligible project for 2021 re-evaluation.
  - On September 22, 2021, the PJM Board endorsed PJM's recommendation to suspend the Transource IEC (9A) Project, due to permitting risks, in order to remove it from the models pending future updates.

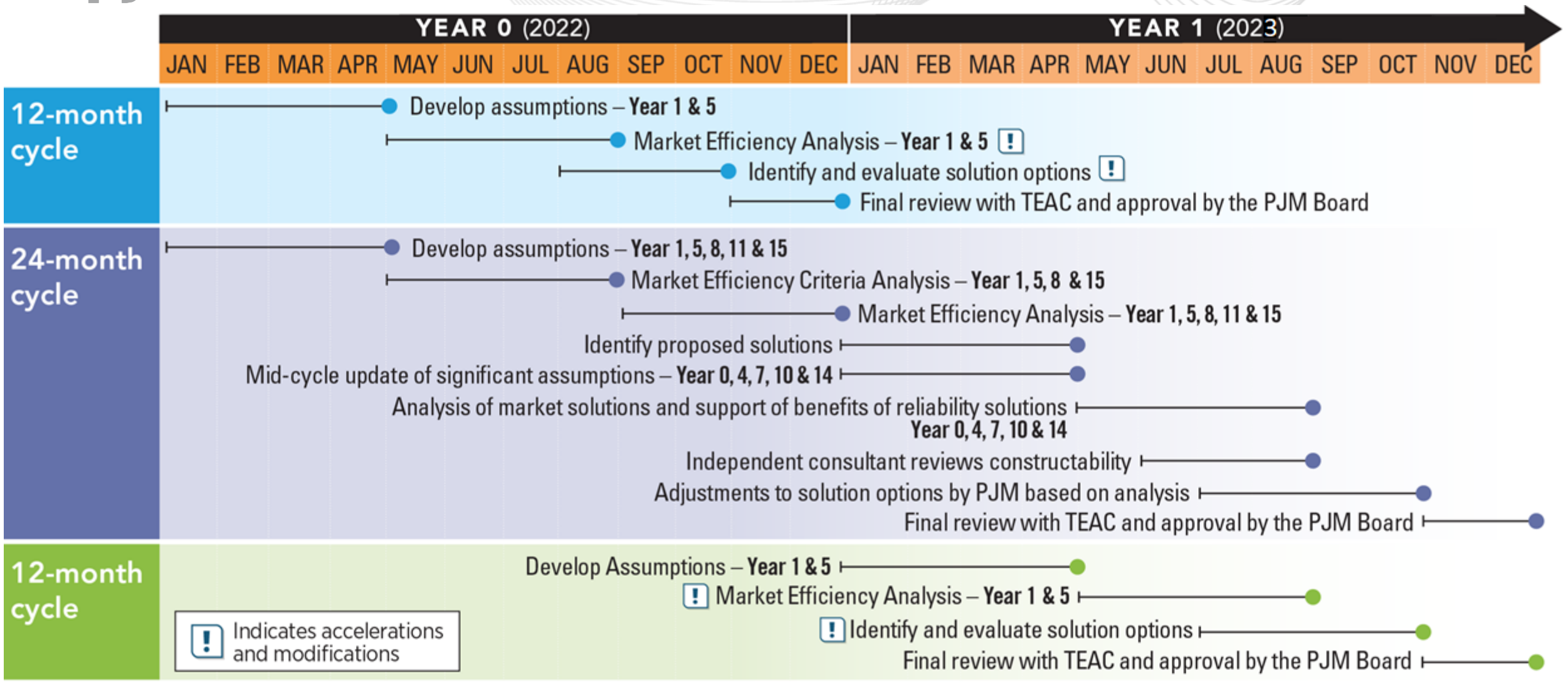
2021 Re-evaluation Results

Re-evaluation	Benefit / Cost Ratio (sunk costs excluded*)	Benefit / Cost Ratio (full in-service cost*)
Project 9A Base Case Analysis	1.44	1.00
Sensitivity scenario with higher load growth	2.08	1.44
Sensitivity scenario with additional coal retirements	2.00	1.39

Sunk costs represent $131.88 million incurred spend ($428.76 million in-service cost)

2022/23 Market Efficiency Cycle

2022/23 Market Efficiency Timeline



2022 Market Efficiency Assumptions

- Hitachi Energy PROMOD Database – Spring 2022.
- Powerflow consistent with the 2027 RTEP powerflow.
- Load Forecast and Demand Response based on PJM 2022 Load Forecast Report.
- Generation Expansion consistent with the machine list included in the Planning RTEP Powerflow.
- Fuel and Emissions Price forecasts provided by Hitachi Energy.
- Financial parameters Discount Rate and Carrying Charge, based on the Transmission Cost Information Center spreadsheet.

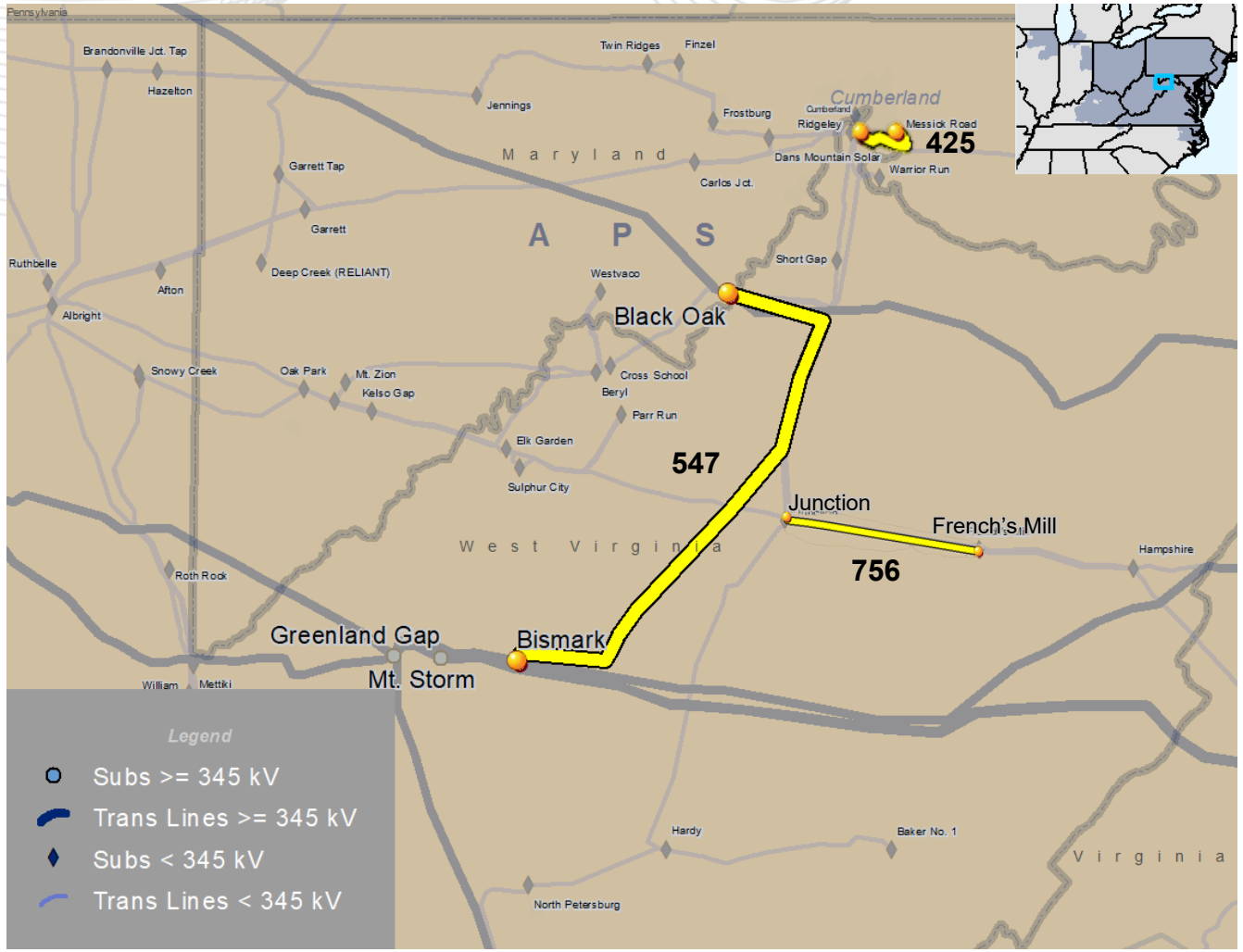
2022/23 Market Efficiency Next Steps

Step	Target Date
Post Preliminary Base Case	July 2022
Stakeholders Feedback	September 2022
Identify Congestion Drivers	September – November 2022
2022 Reevaluation Analysis	September – November 2022
2022 Acceleration Analysis	September – November 2022
Post Final Base Case and Target Congestion Drivers	January 2023
Long Term Proposal Window	January - May 2023
Analysis of Proposed Solutions	May – September 2023
TEAC Reviews and Board Approval	October - December 2023

Appendix A
2020/21 Long Term Window 1
B/C Ratios
Cluster No.1 (APS)

Cluster No. 1 (APS) - Market Efficiency Proposals

- 102*: Capacitor bank at Reston 230 kV substation
- 425: Replace terminal equipment on the French's Mill-Junction 138 kV line. Reconductor Messick Road-Ridgeley 138 kV line.
- 540*: Capacitor bank at Bull Run 230 kV substation
- 547: Build 500 kV transmission line connecting Black Oak Substation and Bismark Substation.
- 756: Replace terminal equipment on the French's Mill-Junction 138 kV line.



** Proposals 102 and 540, capacitor banks at Reston and Bull Run 230 kV, are not show on the map*

Cluster No. 1 (APS) - Final B/C Ratios: Base Case and Sensitivities

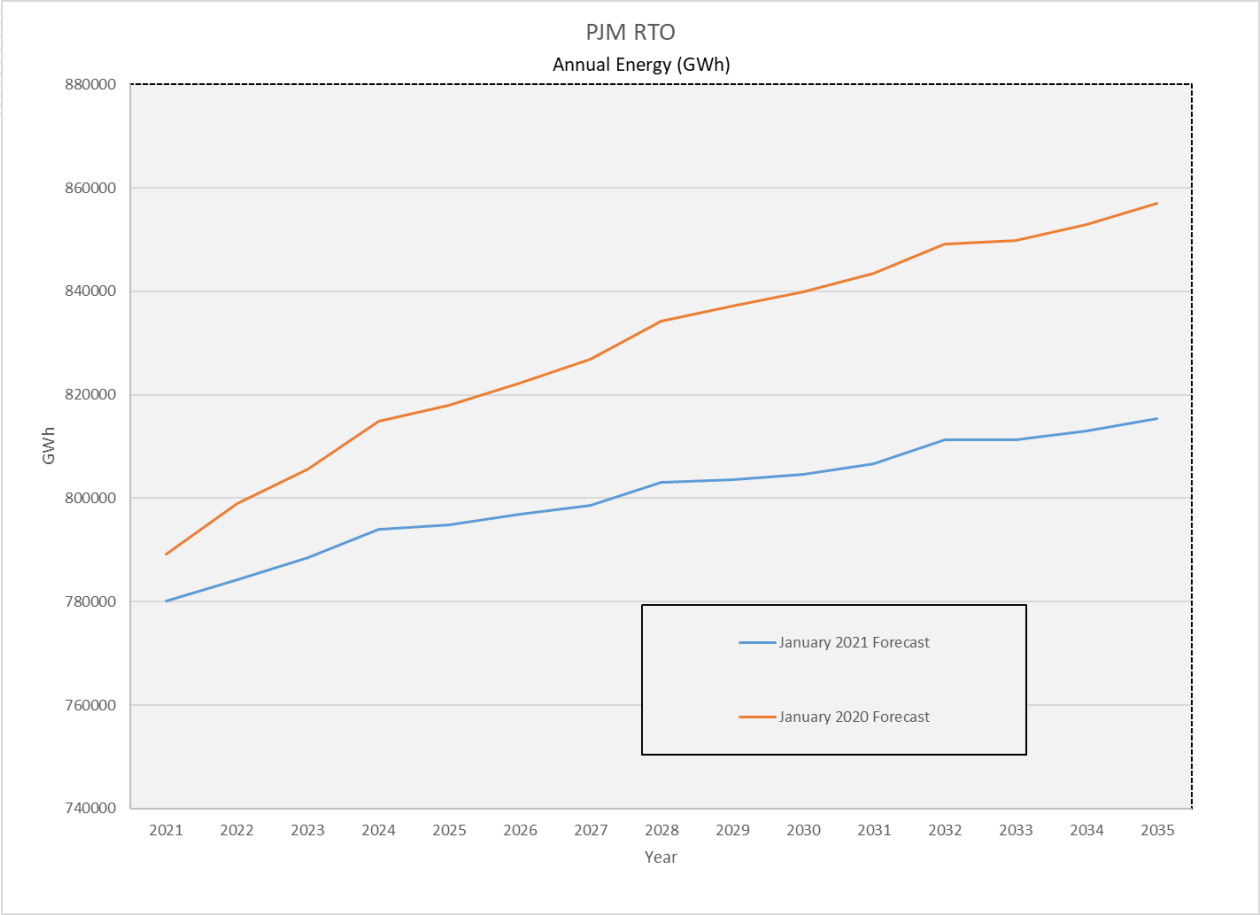
Proposal ID	102	425	540	547	756
Proposal Description	Reston 230kV Capacitor	Reconductor Messick Rd-Ridgeley	Bull Run 230kV Capacitor	Black Oak to Bismark 500kV Line	French's Mill - Junction Terminal Upgrades
Project Type	Upgrade	Upgrade	Upgrade	Greenfield	Upgrade
B/C Ratio Metric	Lower Voltage	Lower Voltage	Lower Voltage	Regional	Lower Voltage
In-Service Cost ($MM)	$1.89	$11.99	$5.73	$128.75	$0.77
Cost Containment	No	No	No	Yes	No
In-Service Year	2022	2025	2023	2025	2022
% Cong Driver Mitigated	0%	100%	0%	99.97%	100%
2025 Shifted Cong ($MM)	N/A	Bla-Bed Interface	N/A	Bla-Bed Interface	Messick Rd-Ridgeley, Bla-Bed Interface
15-Yr NPV NLP Benefit ($MM)	N/A	$99.64	N/A	$136.07	$97.45
Base Case B/C Ratio	N/A	7.86	N/A	0.60	119.03
No9A Sens. B/C Ratio	N/A	15.86	N/A	1.45	193.19
FSA Sens. B/C Ratio	N/A	N/A	N/A	N/A	N/A
Low Load B/C Ratio	N/A	N/A	N/A	N/A	N/A
High Load B/C Ratio	N/A	N/A	N/A	N/A	N/A
Low Gas B/C Ratio	N/A	N/A	N/A	N/A	N/A
High Gas B/C Ratio	N/A	N/A	N/A	N/A	N/A

Appendix B
Transource IEC (9A) Project
Sensitivity Scenarios Details

Sensitivity – Previous 2020 Load Forecast (Higher Load Growth)

2021 PJM load forecast assumes lower growth than the previous 2020 PJM load forecast, especially in the long term years.

- Load Sensitivity B/C ratios
  - Project 9A (Sunk costs excluded) = 2.08
  - Project 9A (In-Service Cost) = 1.44



Sensitivity – Additional Coal Retirements

Talen Energy Corporation announced that their Montour generation facility located in Pennsylvania and its Brandon Shores and H.A. Wagner coal generation facilities located in Maryland will cease coal-fired operations by the end of 2025 and repower pending approvals by state agencies.*

- Total >3,500 MW
- Official retirement notice not submitted to PJM

Sensitivity B/C ratios

- Project 9A (Sunk costs excluded) = 2.0
- Project 9A (In-Service Cost) = 1.39

*https://talenenergy.investorroom.com/2020-11-10-Talen-Energy-Announces-Transformational-Move-Toward-a-Sustainable-ESG-Focused-Future

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Market Efficiency Update

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Revision History

- V1 – 11/23/2021 – Original slides posted
- V2 – 12/15/2021
  - Slides 3, 7, 11, 13, 15: Added month, day to the in-service year
  - Slide 6: Corrected zone in the slide title
  - Slides 6, 10, 12, 14: Added projected in-service date