Market Efficiency Update

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2020/21 Long-Term Window 1

2020/21 Long-Term Window 1 - Retooled ME Base Case

- The retooled Market Efficiency economic model for the 2020/21 Long-Term Window 1 has been posted on the Market Efficiency secure page.
  - Retooled market efficiency base case files for all study years, (XML format compatible with PROMOD 11.3).
  - Updated FSA sensitivity.

- Retooled data include
  - Updated Generation Expansion Plan
    - Recently requested generator deactivations, including the deactivation withdrawals of Byron and Dresden units.
    - Updated queued generator status changes (withdrawals, suspension or execution of Interconnection Service Agreements).
  - Powerflow Updates
    - Implemented network upgrades associated with the changes to the Generation Expansion Plan.
  - Event file Updates
    - Updated reactive interface ratings based on PV Analysis on the 2026 RTEP load flow cases.
    - Added couple of flowgates identified during analysis of proposals.

Cluster Analysis Status

- Cluster No. 1 (APS) - French's Mill to Junction 138 kV
  - Analysis in progress.
- 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, 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, 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, selected as the preferred solution.

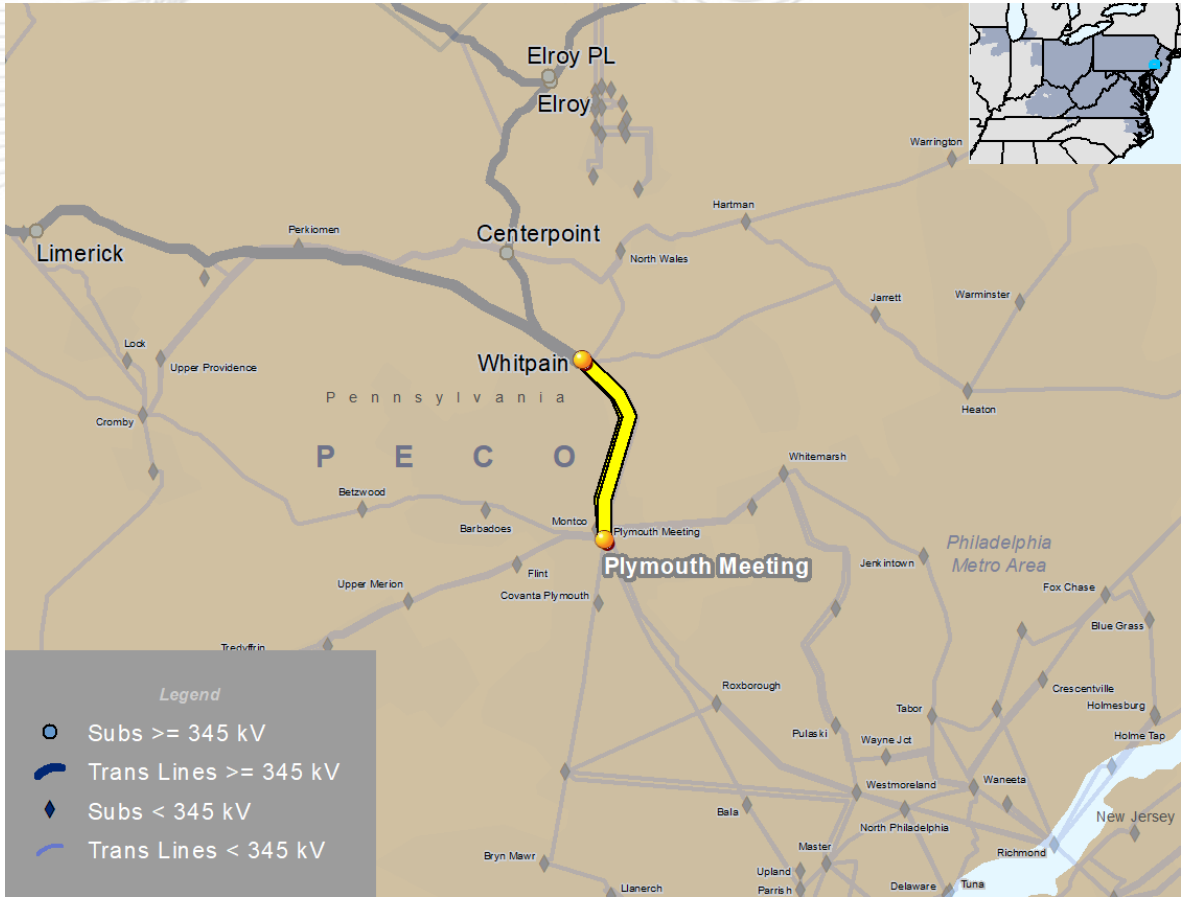
2020/21 Long-Term Window
1st Read

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

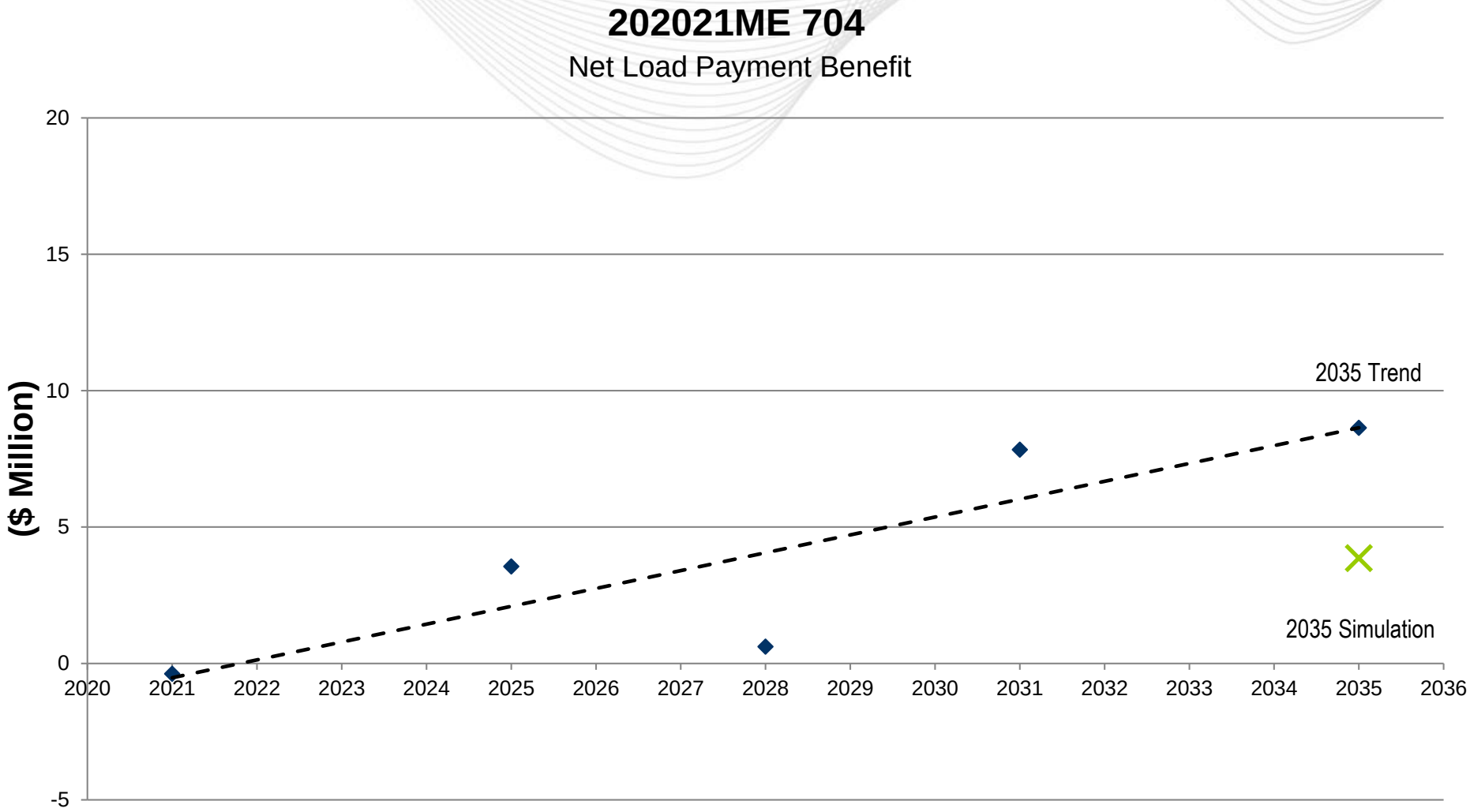
- Completed comprehensive analysis considering economic benefits, reliability and operational impacts of the proposals.
- Proposal 704, terminal equipment upgrades at the Plymouth Meeting and Whitpain 230 kV substations, selected as the preferred solution:
  - Highest B/C Ratio: 75.30
  - Lowest Cost: $0.62 million
  - Addresses the target congestion
  - Passes all PROMOD sensitivity scenarios
  - Reliability analysis has been completed and no reliability violations identified
- 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 Year: 2025
B/C Ratio = 75.30
Target Zone: PECO
ME Constraints: Plymouth Meeting to Whitpain 230 kV
Notes: Redacted Public Proposal 704



Proposal 704 - Trend for Net Load Benefits

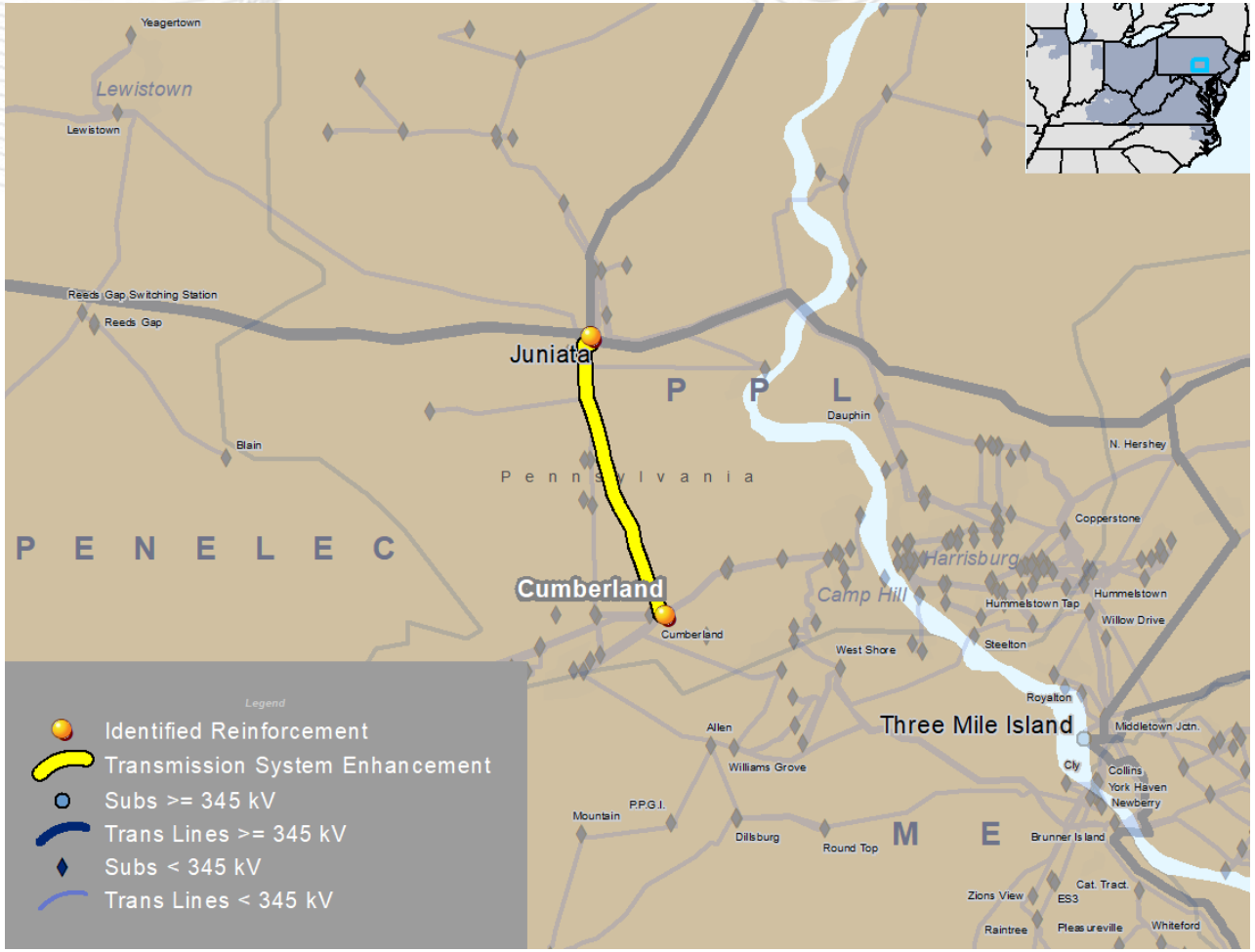


Cluster 3: Juniata-Cumberland 230 kV (PPL)

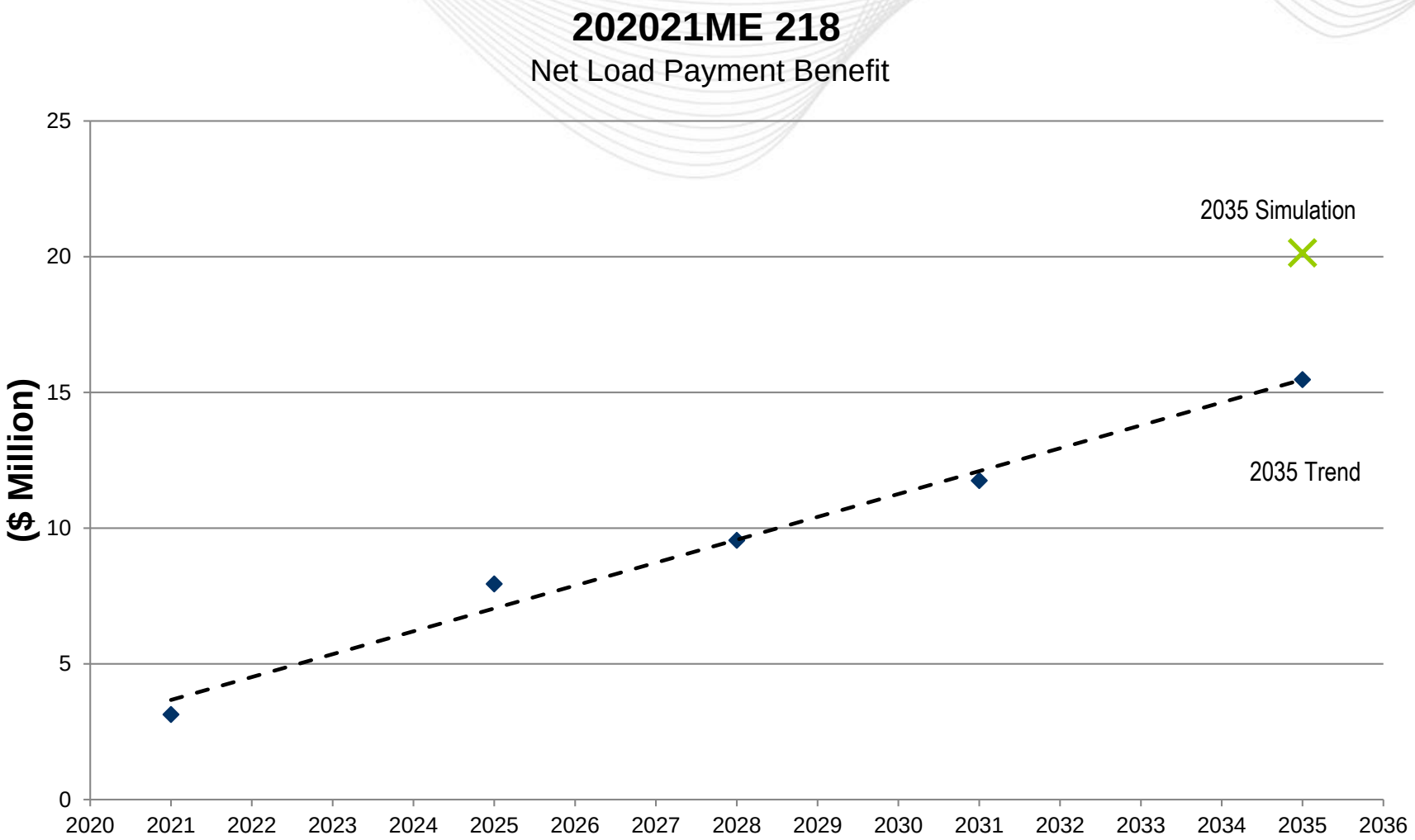
- Completed comprehensive analysis considering economic benefits, reliability and operational impacts of the proposals.
- Proposal 218, reconductor the Juniata-Cumberland 230 kV line, selected as the preferred solution:
  - High B/C Ratio: 11.28
  - Low Cost: $9.00 million
  - Fully addresses the target congestion driver Juniata-Cumberland 230 kV
  - Passes all PROMOD sensitivity scenarios
  - Reliability analysis has been completed and no reliability violation identified
- 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 Year: 2023
B/C Ratio = 11.28
Target Zone: PPL
ME Constraints: Cumberland to Juniata 230 kV
Notes: Redacted Public Proposal 218



Proposal 218 - Trend for Net Load Benefits

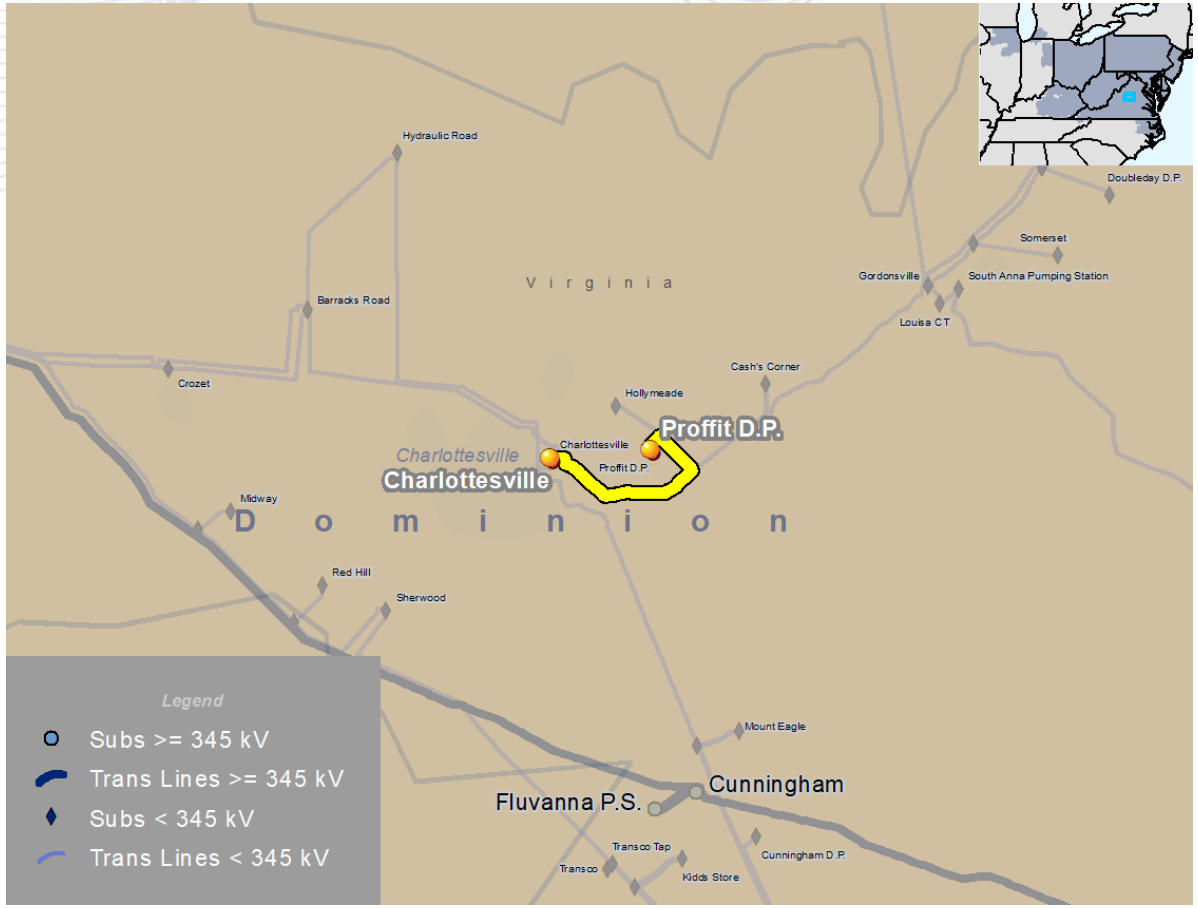


Cluster 4: Charlottesville-Proffit 230 kV (DOM)

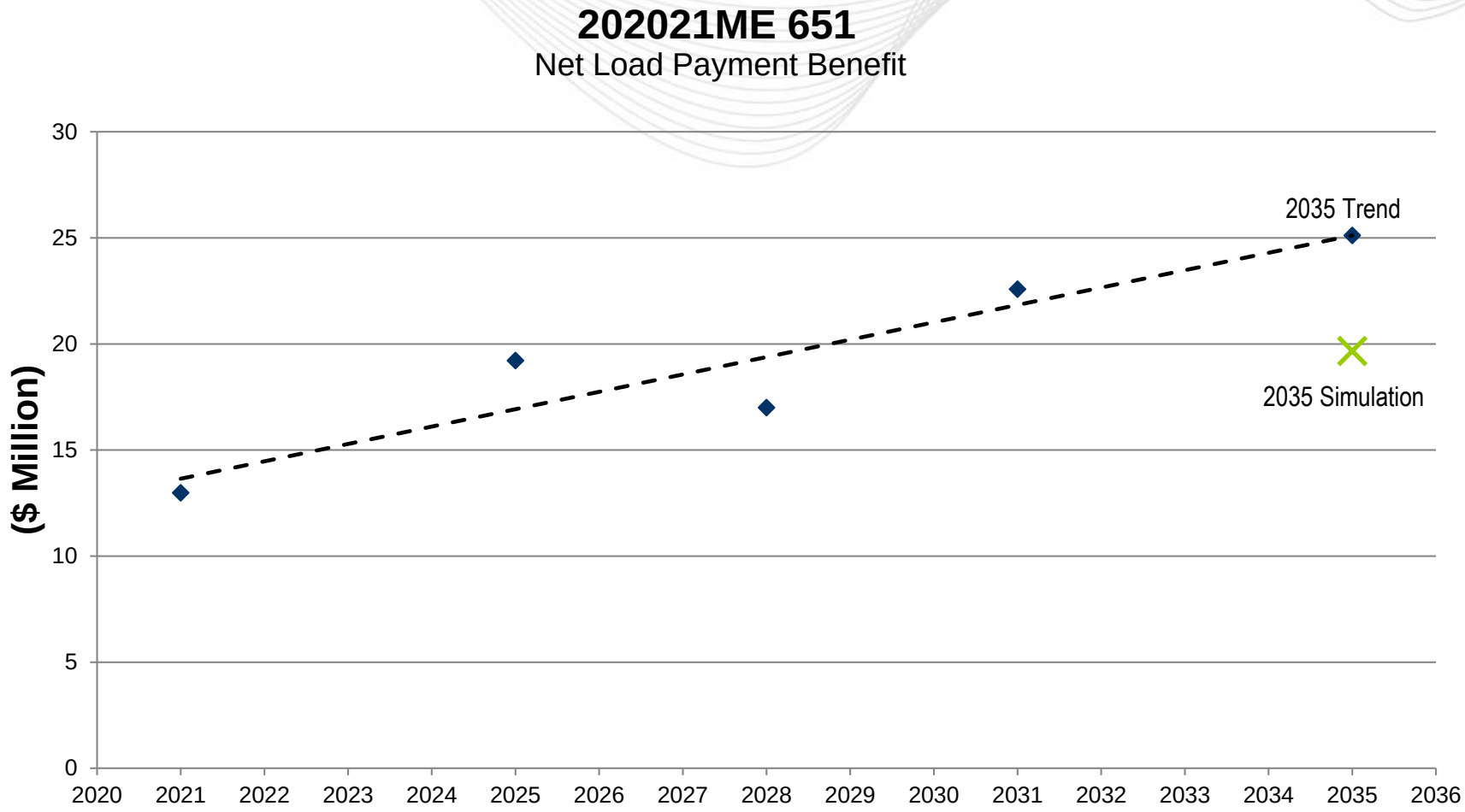
- Completed comprehensive analysis considering economic benefits, reliability and operational impacts of the proposals.
- Proposal 651, series reactor on the Charlottesville-Proffit 230 kV line, selected as the preferred solution:
  - High B/C Ratio: 16.05
  - Low Cost: $11.38 million
  - Fully addresses target congestion driver Charlottesville-Proffit 230 kV
  - Passes all PROMOD sensitivity scenarios
  - Reliability analysis has been completed and no reliability violation identified
- 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 Year: 2023
B/C Ratio = 16.05
Target Zone: DOM
ME Constraints: Charlottesville to Proffit Rd Del Pt 230 kV
Notes: Redacted Public Proposal 651



Proposal 651 - Trend for Net Load Benefits



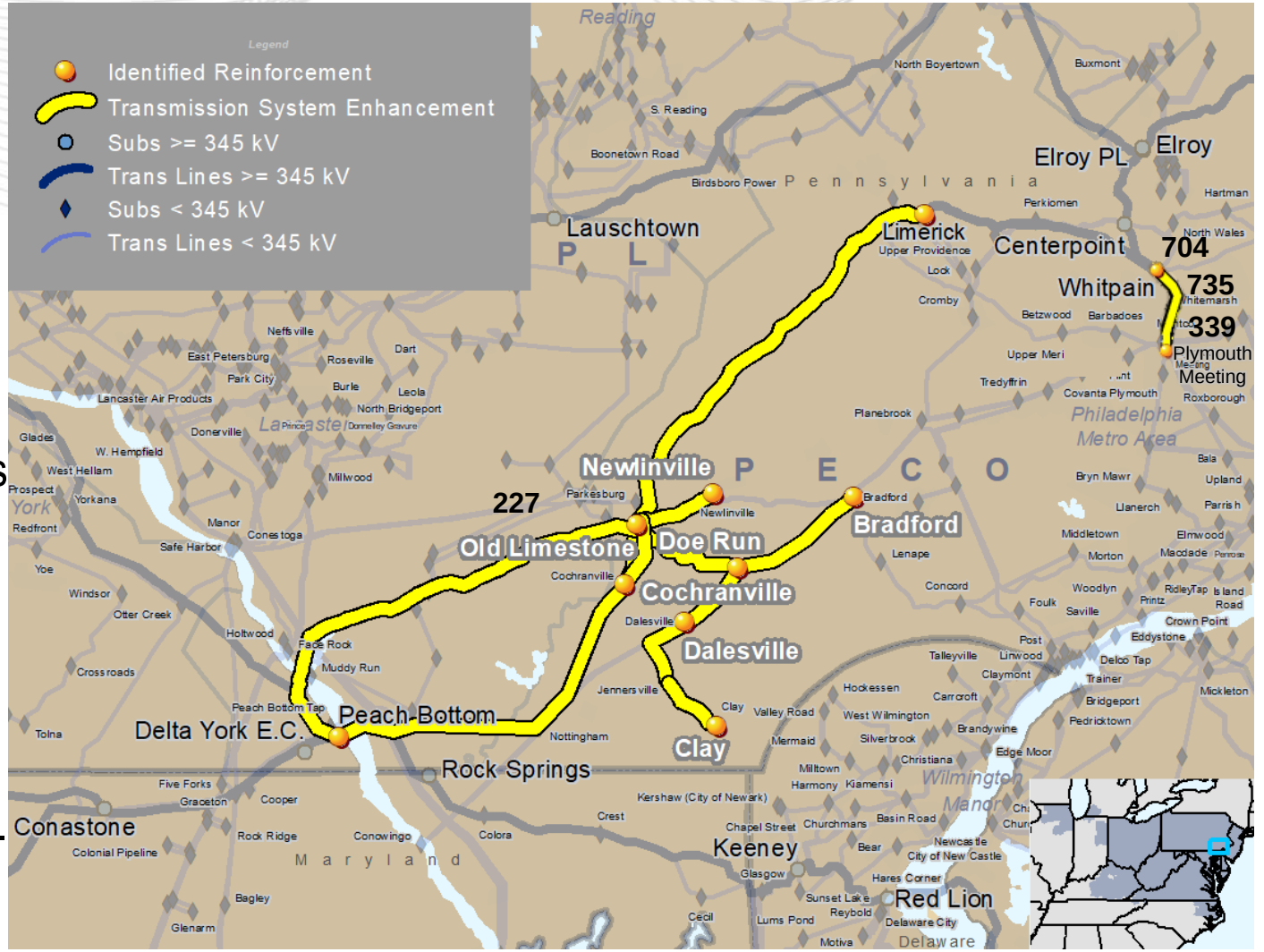
Next Steps

- Finalize analysis for Cluster No. 1 (APS) - French's Mill to Junction 138 kV.
- 2nd read for Clusters No. 2 (PECO), No. 3 (PPL), and No. 4 (DOM).
- Final recommendation to the PJM Board for review and approval.

Appendix A
2020/21 Long Term Window 1
B/C Ratios
Clusters No. 2 (PECO), No. 3 (PPL), and No.4 (DOM)

Cluster No. 2 (PECO) - Market Efficiency Proposals

- 227: Interconnect Peach Bottom - Limerick 500kV and Cochranville - Newlinville 230kV lines via new Old Limestone 500/230 kV substation. Build new 230 kV Doe Run substation and interconnect Daleville - Bradford and Clay Tap - Bradford 230kV lines. Build new Old Limestone to Doe Run line.
- 399: Install Smart Wires device in series with the 220-13 and 220-14 Whitpain-Plymouth 230 kV lines and upgrade terminal equipment at Whitpain and Plymouth substations.
- 704: Upgrade terminal equipment at Whitpain and Plymouth substations.
- 735: Reconductor the 220-13 and 220-14 Whitpain-Plymouth 230 kV lines.

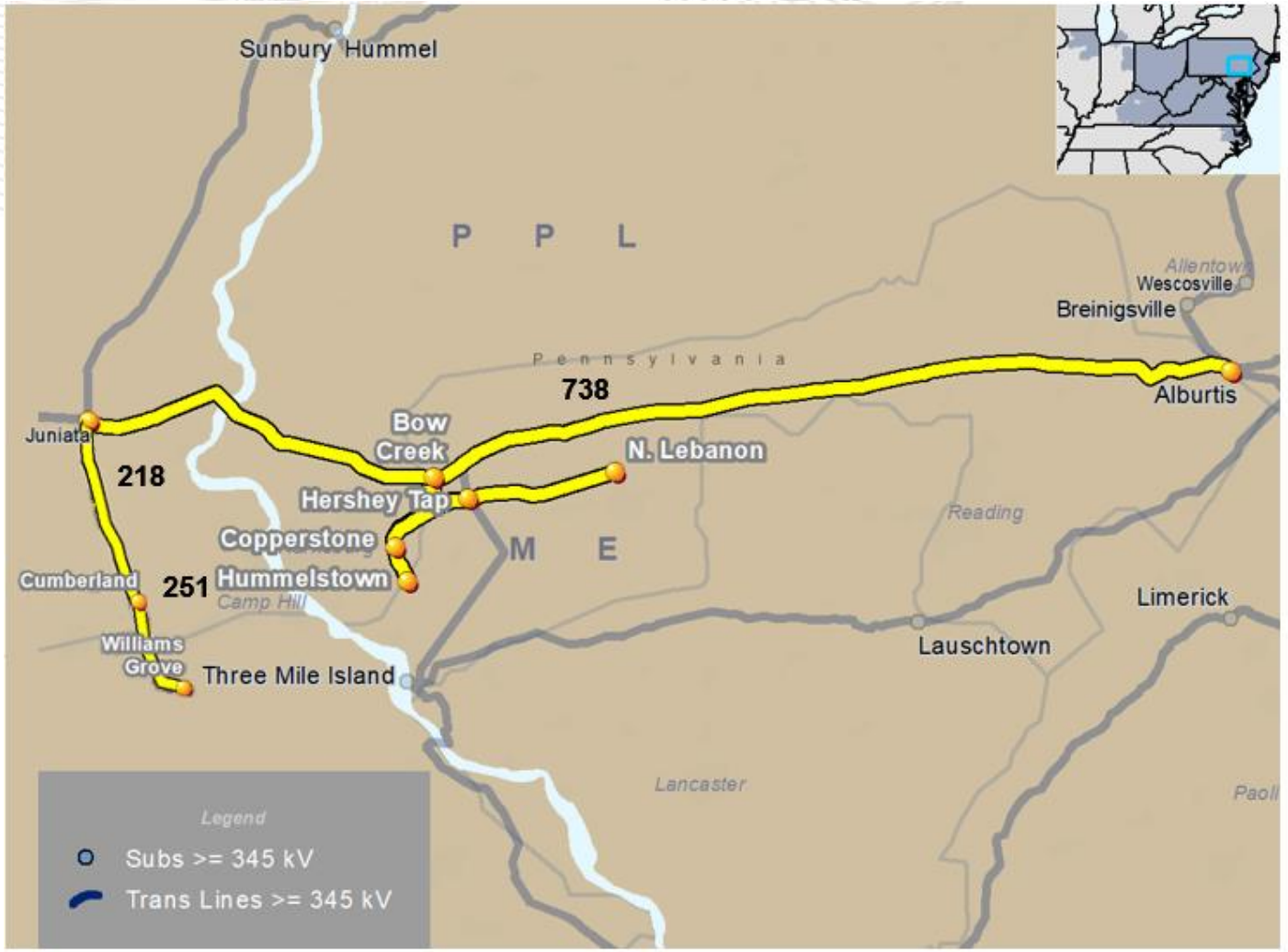


Cluster No. 2 (PECO) - Final B/C Ratios: Base Case and Sensitivities

Proposal ID	227	399	704	735
Proposal Description	Old Limestone - Doe Run 500/230kV New line	Plymouth-Whitpain 220-13, 220-14 SmartWires	Plymouth-Whitpain 220-13, 220-14 Terminal Upgrades	Rebuild Plymouth-Whitpain 220-13, 220-14 Circuits
Project Type	Greenfield	Upgrade	Upgrade	Upgrade
B/C Ratio Metric	Lower Voltage	Lower Voltage	Lower Voltage	Lower Voltage
In-Service Cost ($MM)	$73.51	$8.42	$0.62	$14.98
Cost Containment	Yes	No	No	No
In-Service Year	2025	2025	2025	2025
% Cong Driver Mitigated	99.80%	100%	99.91%	100%
2025 Shifted Cong ($MM)	No significant shift	No significant shift	No significant shift	No significant shift
15-Yr NPV NLP Benefit ($MM)	$85.09	$47.49	$49.41	$51.23
Base Case B/C Ratio	1.09	5.33	75.30	3.23
No9A Sens. B/C Ratio	N/A	6.21	72.73	3.08
FSA Sens. B/C Ratio	N/A	1.58	17.76	0.56
Low Load B/C Ratio	N/A	3.97	63.33	2.64
High Load B/C Ratio	N/A	9.18	111.17	5.00
Low Gas B/C Ratio	N/A	3.36	43.33	2.20
High Gas B/C Ratio	N/A	3.01	36.75	1.53

Cluster No. 3 (PPL) - Market Efficiency Proposals

- 102*: Capacitor bank at Reston 230 kV substation
- 218: Reconductor the Juniata - Cumberland 230 kV line.
- 251: Rebuild the existing single circuit Juniata - Cumberland 230 kV section to double circuit. Upgrade the Cumberland to William Grove 230 kV line.
- 540*: Capacitor bank at Bull Run 230 kV substation
- 738: Build new 500/230 kV Bow Creek tap substation on Juniata – Alburtis 500kV line to interconnect North Hershey - Hummelstown and North Lebanon – Copperstone 230kV lines.



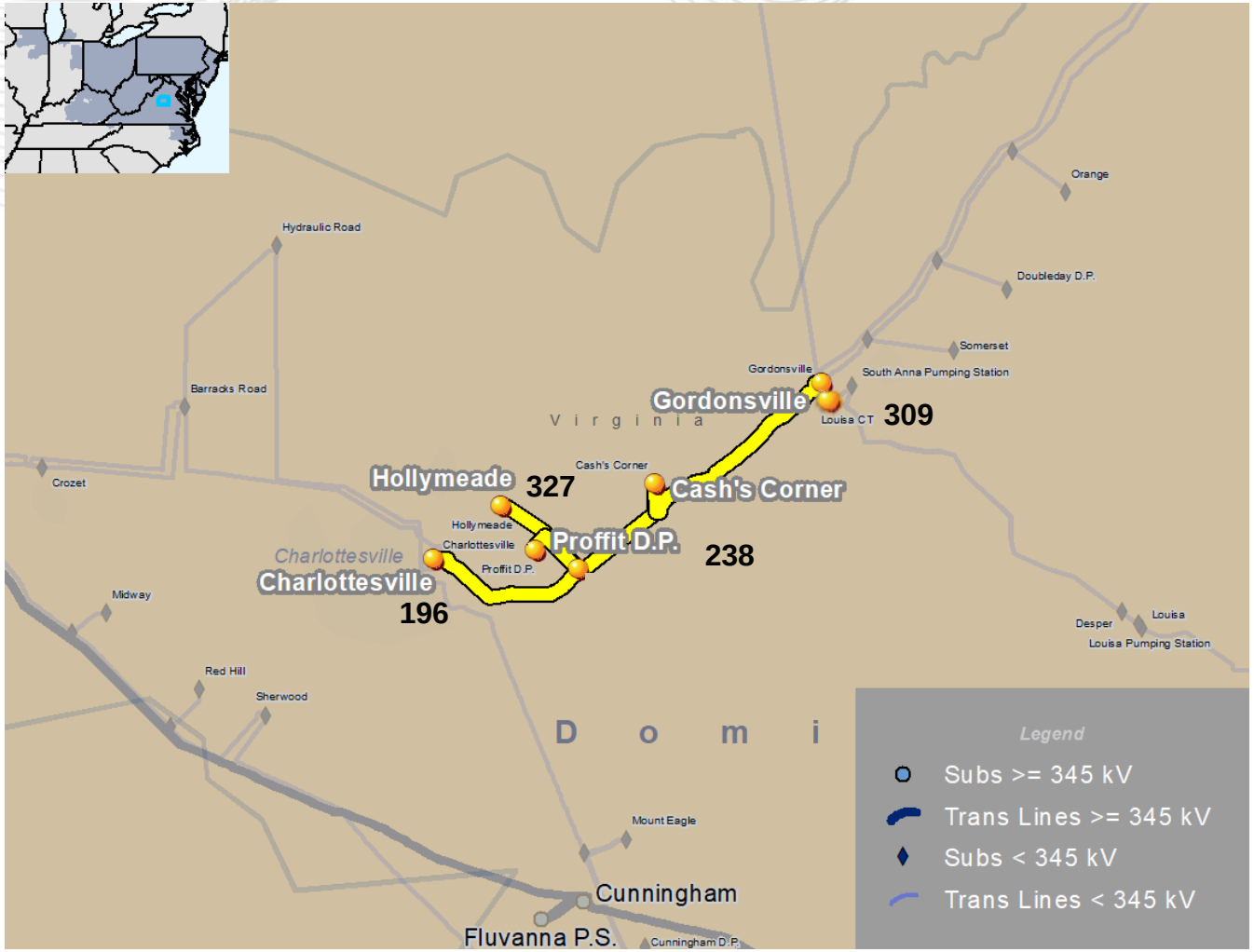
** Proposals 102 and 540, capacitor banks at Reston and Bull Run 230 kV, are not show on the map*

Cluster No. 3 (PPL) - Final B/C Ratios: Base Case and Sensitivities

Proposal ID	102	218	251	540	738
Proposal Description	Reston 230kV Capacitor	Juniata - Cumberland 230 kV Line Reconductor	Juniata - Cumberland 230 kv Double Circuit Rebuild	Bull Run 230kV Capacitor	Bow Creek 500/230kV Project
Project Type	Upgrade	Upgrade	Upgrade	Upgrade	Greenfield
B/C Ratio Metric	Lower Voltage	Lower Voltage	Lower Voltage	Lower Voltage	Lower Voltage
In-Service Cost ($M)	$1.89	$9.00	$49.05	$5.73	$55.05
Cost Containment	No	Yes	No	No	Yes
In-Service Year	2022	2023	2024	2023	2025
% Cong Driver Mitigated	0%	100%	100%	0%	97.83%
2025 Shifted Cong ($MM)	N/A	No significant shift	No significant shift	N/A	No significant shift
15-Yr NPV NLP Benefit ($MM)	N/A	$107.41	$106.57	N/A	$125.03
Base Case B/C Ratio	N/A	11.28	2.05	N/A	2.15
No9A Sens. B/C Ratio	N/A	10.65	2.28	N/A	2.48
FSA Sens. B/C Ratio	N/A	15.22	3.07	N/A	3.19
Low Load B/C Ratio	N/A	6.48	1.34	N/A	1.13
High Load B/C Ratio	N/A	18.10	3.43	N/A	3.15
Low Gas B/C Ratio	N/A	14.71	3.19	N/A	3.00
High Gas B/C Ratio	N/A	13.17	2.80	N/A	2.15

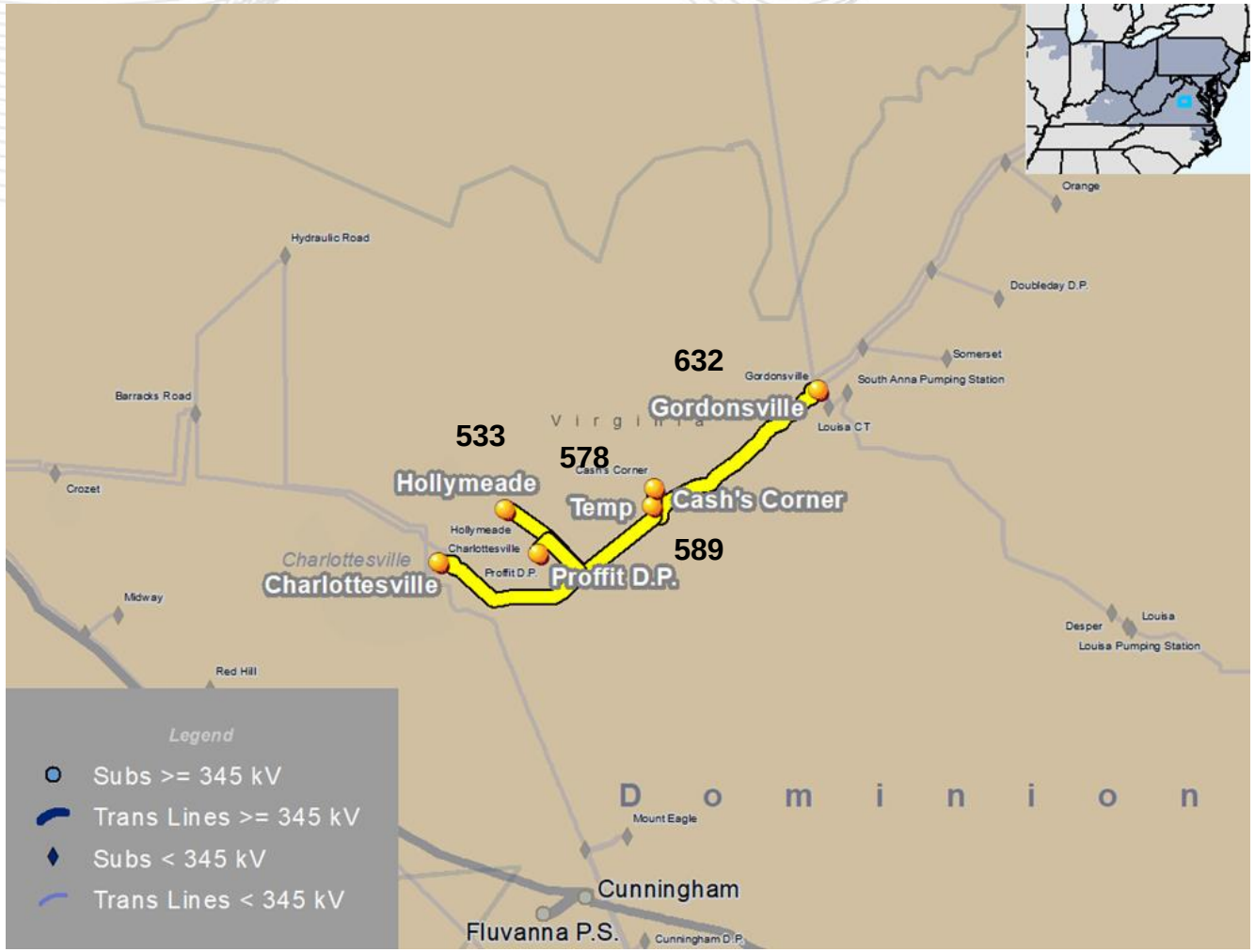
Cluster No. 4 (DOM) - Market Efficiency Proposals

- 196: Charlottesville-Proffit 230kV Line Rebuild.
- 238: Charlottesville-Gordonsville 230kV Greenfield Line.
- 309: 5 MW Battery Energy Storage System at Louisa CT substation.
- 327: New Hollymeade Tap 230kV Substation. Charlottesville-Hollymeade Tap-Cash's Corner-Gordonsville 230kV Line Rebuild.



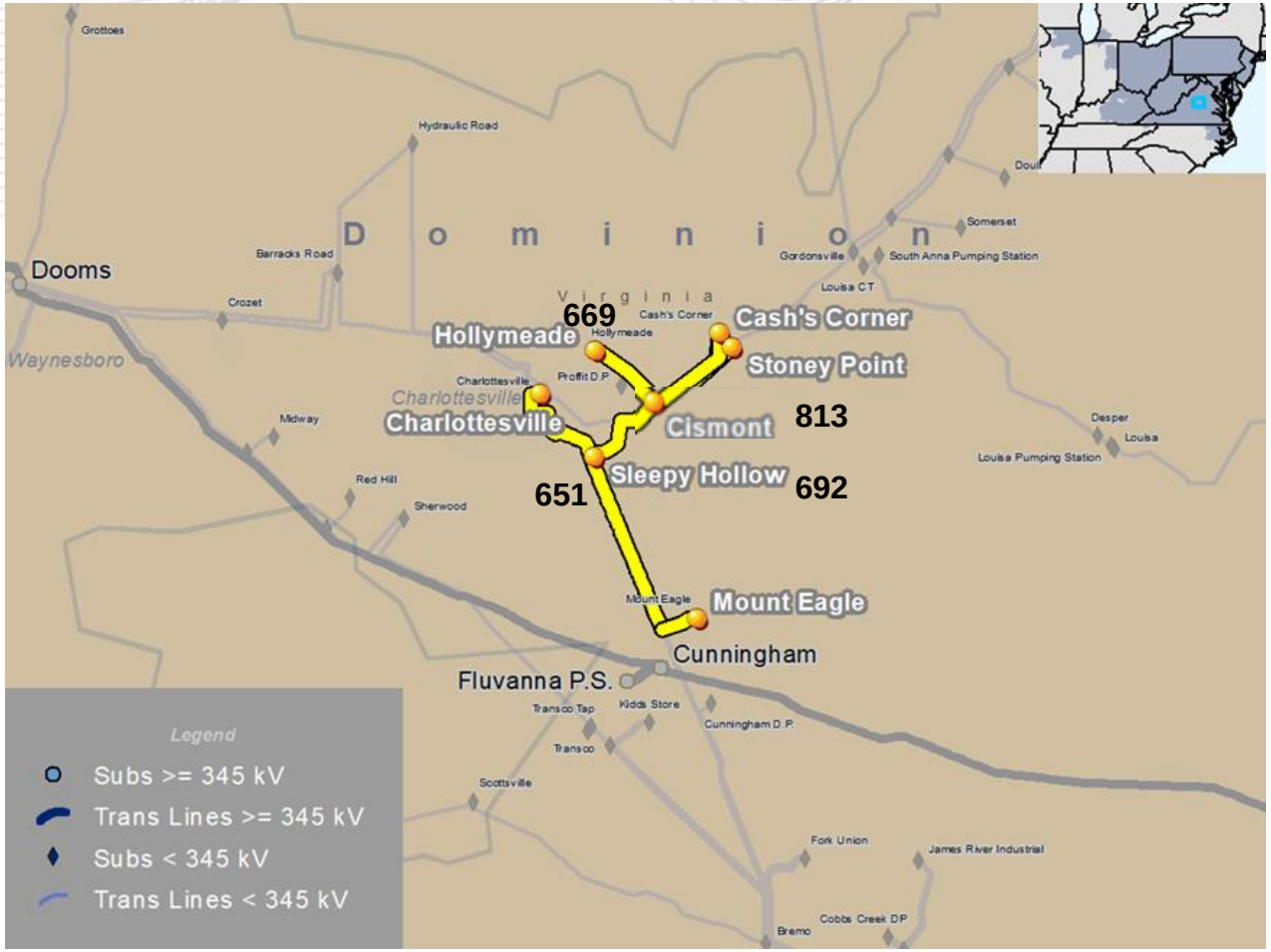
Cluster No. 4 (DOM) - Market Efficiency Proposals (cont.)

- 533: 10 MW Battery Energy Storage System at Hollymeade substation.
- 578: New Hollymeade Tap 230kV Substation.
- 589: Build Second Charlottesville-Gordonsville 230kV Line. Upgrade terminal equipment from Hollymeade to Gordonsville 230 kV.
- 632: 5 MW Battery Energy Storage System at Gordonsville Substation.



Cluster No. 4 (DOM) - Market Efficiency Proposals (cont.)

- 651: Charlottesville-Proffit 230kV Line Series Reactor.
- 669: 5 MW Battery Energy Storage System at Hollymeade Substation.
- 692: Sleepy Hollow-Stoney Point 230kV Greenfield Project.
- 813: New Cismont 230kV Substation. Charlottesville-Hollymeade Tap-Cash's Corner-Gordonsville 230kV Line Rebuild.



2021 Window 1 Reliability Proposals Charlottesville-Proffit 230kV

- 6: Charlottesville-Proffit 230kV Line Rebuild.
  - Proposal does not clear congestion on the Charlottesville-Proffit 230 kV driver.
- 26: 16 MW Battery Energy Storage System at Hollymeade substation.
  - Proposal does not clear congestion on the Charlottesville-Proffit 230 kV driver.
- 38: Sleepy Hollow-Gordonsville 230kV Greenfield Project.
  - Proposal clears congestion on the driver and yields a B/C Ratio of 3.97 (see details on slide 28).
- 111: Build Second Charlottesville-Gordonsville 230kV Line.
  - This proposal is identical to the Market Efficiency Proposal 589.
- 170: Hollymeade 230kV Line Series Reactor.
  - The series reactor in this proposal has a lower reactance than the Market Efficiency Proposal No. 651.
  - Proposal does not clear congestion on the Charlottesville-Proffit 230 kV driver.

2021 Window 1 Reliability Proposals Charlottesville-Proffit 230kV (cont.)

- 182: Charlottesville-Gordonsville 230kV Greenfield Line.
  - This proposal is identical to the Market Efficiency Proposal 238.
- 268: New Hollymeade Tap 230kV Substation.
  - This proposal is identical to the Market Efficiency Proposal 327.
- 298: Lee District 500/230kV Greenfield Project.
  - Proposal does not clear congestion on the Charlottesville-Proffit 230 kV driver.
- 385: New Cismont 230kV Substation. Charlottesville-Hollymeade Tap-Cash's Corner-Gordonsville 230kV Line Rebuild.
  - This proposal is identical to the Market Efficiency Proposal 813.
- 624: Charlottesville-Proffit 230kV Line Rebuild.
  - This proposal is identical to the Market Efficiency Proposal 196.

Cluster No. 4 (DOM) - Final B/C Ratios

Proposal ID	196	238	309	327
Proposal Description	Charlottesville-Proffit 230kV Line Rebuild	Charlottesville-Gordonsville 230kV Greenfield Line	5 MW Battery Energy Storage System at Louisa CT substation	New Hollymeade Tap 230kV Substation. Charlottesville-Hollymeade Tap-Cash's Corner-Gordonsville 230kV Line Rebuild.
Project Type	Upgrade	Greenfield	Upgrade	Greenfield
B/C Ratio Metric	Lower Voltage	Lower Voltage	Lower Voltage	Lower Voltage
In-Service Cost ($MM)	$19.49	$45.83	$25.98 [1)]	$35.93
Cost Containment	No	Yes	No	No
In-Service Year	2024	2025	2023	2025
% Cong Driver Mitigated	100%	100%	0.87%	99.48%
2025 Shifted Cong ($MM)	Hollymeade-Cash's Corner [2)]	No significant shift	N/A	No significant shift
15-Yr NPV NLP Benefit ($MM)	$137.63	$146.48	N/A	$151.68
Base Case B/C Ratio	N/A	3.02	N/A	3.99
No9A Sens. B/C Ratio	N/A	3.75	N/A	5.66
FSA Sens. B/C Ratio	N/A	0.87	N/A	2.22
Low Load B/C Ratio	N/A	3.52	N/A	4.62
High Load B/C Ratio	N/A	4.93	N/A	6.67
Low Gas B/C Ratio	N/A	3.54	N/A	4.33
High Gas B/C Ratio	N/A	3.20	N/A	4.37

Notes: [1)] Corrected BESS cost includes augmentation, replacement and recycling (disposal) expenses.
[2)] Rebuilding only the Charlottesville-Proffit segment shifts congestion to the next segment, Hollymeade-Cash's Corner.

Cluster No. 4 (DOM) - Final B/C Ratios (cont.)

Proposal ID	533	578	589	632
Proposal Description	10 MW Battery Energy Storage System at Hollymeade substation	New Hollymeade Tap 230kV Substation	Build Second Charlottesville-Gordonsville 230kV Line. Upgrade terminal equipment from Hollymeade to Gordonsville 230 kV.	5 MW Battery Energy Storage System at Gordonsville Substation
Project Type	Upgrade	Greenfield	Greenfield	Greenfield
B/C Ratio Metric	Lower Voltage	Lower Voltage	Lower Voltage	Lower Voltage
In-Service Cost ($MM)	$40.45 [1)]	$10.02	$25.97	$29.15 [1)]
Cost Containment	No	No	Yes	No
In-Service Year	2023	2023	2025	2023
% Cong Driver Mitigated	7.82%	0%	100%	4.57%
2025 Shifted Cong ($MM)	N/A	N/A	Hollymeade-Cash's Corner-Gordonsville [2)]	N/A
15-Yr NPV NLP Benefit ($MM)	N/A	N/A	N/A	N/A
Base Case B/C Ratio	N/A	N/A	N/A	N/A
No9A Sens. B/C Ratio	N//A	N/A	N/A	N/A
FSA Sens. B/C Ratio	N/A	N/A	N/A	N/A
Low Load B/C Ratio	N/A	N/A	N/A	N/A
High Load B/C Ratio	N/A	N/A	N/A	N/A
Low Gas B/C Ratio	N/A	N/A	N/A	N/A
High Gas B/C Ratio	N/A	N/A	N/A	N/A

Notes: [1)] Corrected BESS cost includes augmentation, replacement and recycling (disposal) expenses.
[2)] Proposed terminal equipment upgrades not enough to achieve proposed ratings on Hollymeade-Cash's Corner-Gordonsville.

Cluster No. 4 (DOM) - Final B/C Ratios (cont.)

Proposal ID	651	669	692	813
Proposal Description	Charlottesville-Proffit 230kV Line Series Reactor	5 MW Battery Energy Storage System at Hollymeade Substation	Sleepy Hollow-Stoney Point 230kV Greenfield Project	New Cismont 230kV Substation. Line Rebuild Charlottesville - Gordonsville 230kV.
Project Type	Upgrade	Upgrade	Greenfield	Greenfield
B/C Ratio Metric	Lower Voltage	Lower Voltage	Lower Voltage	Lower Voltage
In-Service Cost ($MM)	$11.38	$25.95 [1)]	$36.07	$73.64
Cost Containment	No	No	Yes	No
In-Service Year	2023	2023	2025	2025
% Cong Driver Mitigated	99.52%	6.46%	100%	100%
2025 Shifted Cong ($MM)	No significant shift	N/A	Stoney Point – Cash's Corner [2)]	No significant shift
15-Yr NPV NLP Benefit ($MM)	$193.24	N/A	N/A	$168.88
Base Case B/C Ratio	16.05	N/A	N/A	2.17
No9A Sens. B/C Ratio	12.21	N/A	N/A	2.64
FSA Sens. B/C Ratio	8.13	N/A	N/A	1.01
Low Load B/C Ratio	15.06	N/A	N/A	2.19
High Load B/C Ratio	18.86	N/A	N/A	3.04
Low Gas B/C Ratio	11.39	N/A	N/A	2.28
High Gas B/C Ratio	17.96	N/A	N/A	2.17

Notes: [1)] Corrected BESS cost includes augmentation, replacement and recycling (disposal) expenses.
[2)] Proposal shifts a significant portion of the congestion to Stoney Point – Cash's Corner.

Cluster No. 4 (DOM) - Reliability Proposal No. 38

Proposal ID	Reliability Prop. 38
Proposal Description	Sleepy Hollow-Gordonsville 230kV Greenfield Project
Project Type	Greenfield
B/C Ratio Metric	Lower Voltage
In-Service Cost ($MM)	$40.17
Cost Containment	Yes
In-Service Year	2026
% Cong Driver Mitigated	100%
2025 Shifted Cong ($MM)	No significant shift
15-Yr NPV NLP Benefit ($MM)	$151.02
Base Case B/C Ratio	3.97
No9A Sens. B/C Ratio	4.50
FSA Sens. B/C Ratio	1.76
Low Load B/C Ratio	3.86
High Load B/C Ratio	5.38
Low Gas B/C Ratio	4.04
High Gas B/C Ratio	3.56

Revision History

- V1 – 10/28/2021 – Original slides posted