



# Transmission Expansion Advisory Committee Market Efficiency Update

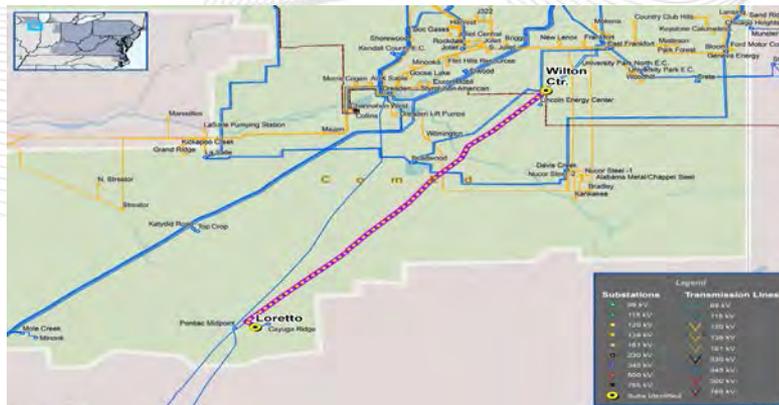
March 10, 2016



# Market Efficiency 2014/15 Long Term Proposal Window Update

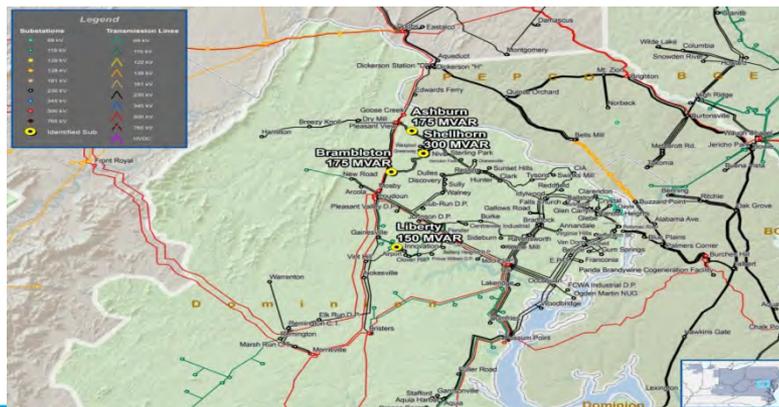
## RPM project in ComEd Area

- Mitigate sag limitations on Loretto-Wilton Center line and replace station conductor at Wilton Center.



## Optimal Capacitor configuration for ApSouth/AEP-DOM Reactive Interfaces

- Brambleton substation: 175 MVAR
- Ashburn substation: 175 MVAR
- Shelhorn substation: 300 MVAR
- Liberty substation: 150 MVAR



- The Market Efficiency base case was updated to include:
  - 2016 load forecast
  - 2016 February Board approved projects
  
- PJM performed additional Market Efficiency Analysis on transmission projects proposed to address ApSouth congestion.
  - Included projects that passed the original B/C tests conducted in 2015 under multiple sensitivities.
  - Ten projects qualified for additional analysis.

## Project ID: 201415\_1-6D Modified

Proposed by: Dominion

Proposed Solution: build a new 500 kV station (Palmyra) by connecting at the intersection of the North Anna – Midlothian 500 kV line and Cunningham – Elmont 500 kV line. ~~Build five capacitor banks in Dominion Area.~~

kV Level: 500

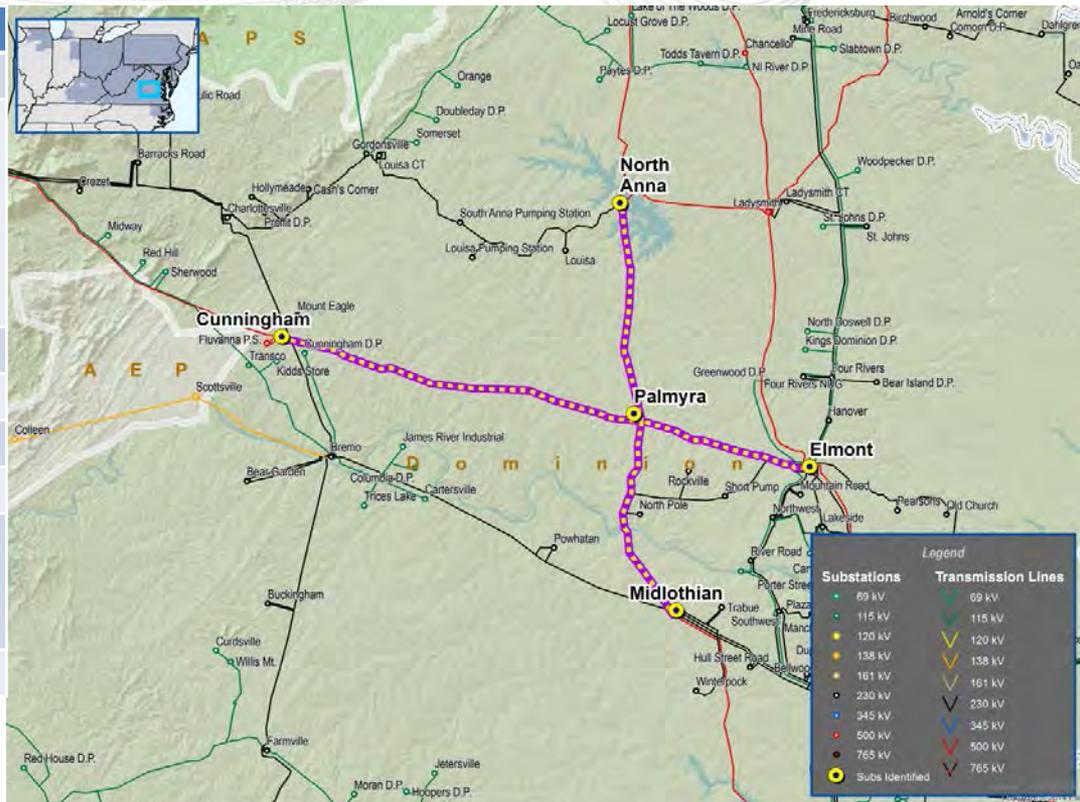
Cost (\$M): 28.7

IS Date: 2019

Target Zone: Dominion

Results: B/C=0.22

Notes: Minimal impact on congestion



**Project ID: 201415\_1-7A Modified**

Proposed by: Transource

Proposed Solution: Construct a double circuit 230 kV line between AEP's Axton Station to AEP's East Danville Station. Install breakers and a transformer at Axton and East Danville Station. A total of 1,550 MVARs of new capacitance will also be installed at Brambleton, Ashburn, Lexington, Doods, Jackson's Ferry and Broadford substations.

kV Level: 765

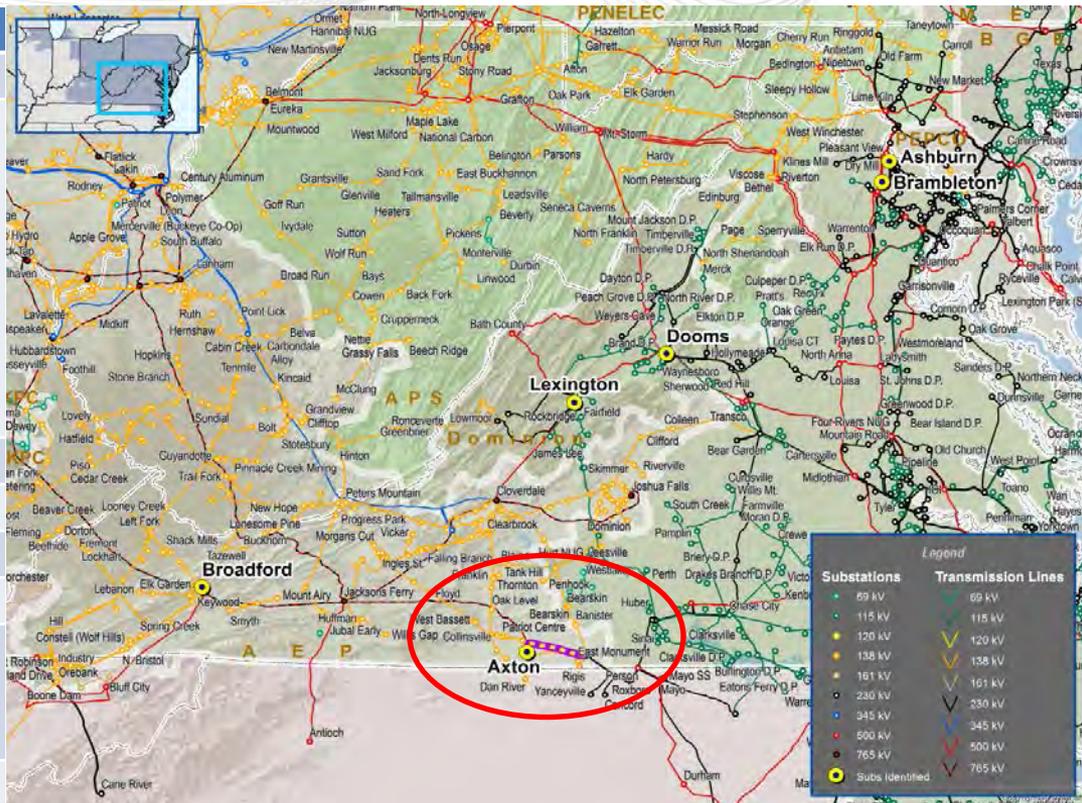
Cost (\$M): 122

IS Date: 2020

Target Zone: AEP

Results: B/C=.02

Notes: Increases total PJM congestion



## Project ID: 201415\_1-7B Modified

Proposed by: Transource

Proposed Solution: Construct a double circuit 230 kV line between Meadow Brook Station and Doubs Station. Additional upgrades in AEP will also be included in this proposal. A total of ~~1,550 MVARs of new capacitance~~ will also be installed at Brambleton, Ashburn, Lexington, Dooms, Jackson's Ferry and Broadford substations.

kV Level: 230

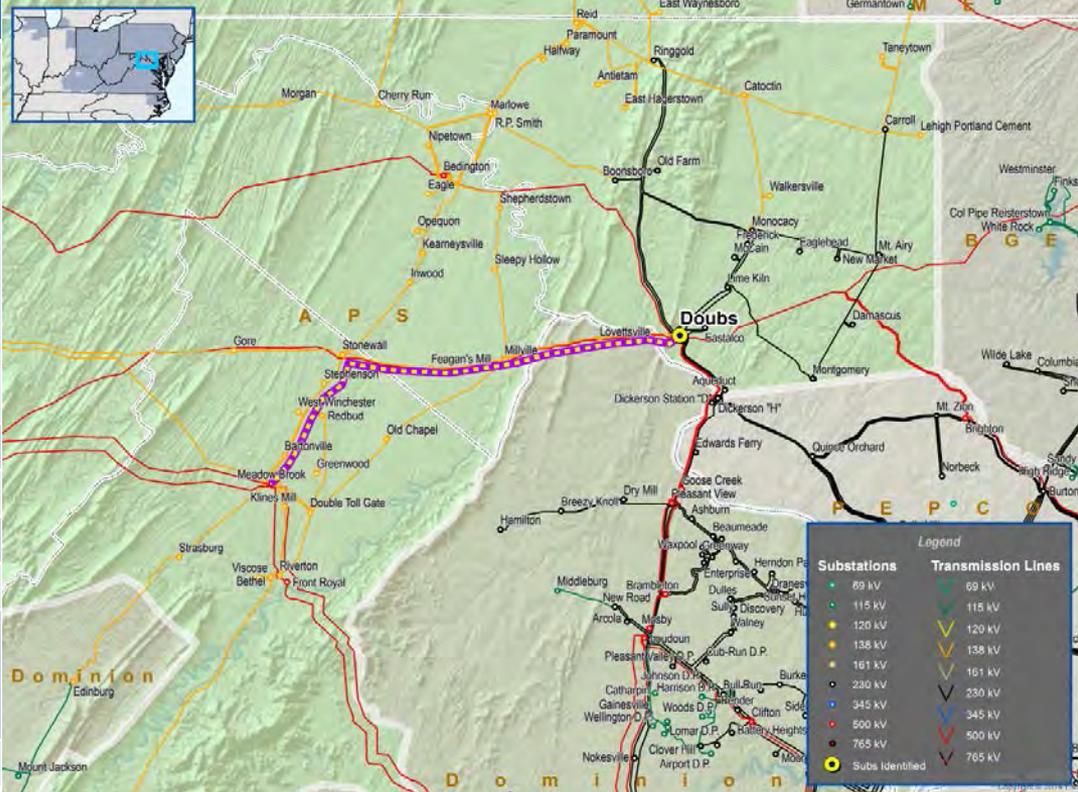
Cost (\$M): 222

IS Date: 2021

Target Zone: AEP

Results: B/C=0.46

Notes: Increases total PJM congestion



## Project ID: 201415\_1-7C Modified

Proposed by: Transource

Proposed Solution: Construct a new 500 kV line from Meadow Brook to Doubs. Install a single 500 kV breaker in the existing ring arrangement at Meadow Brook Station. Additional upgrades in AEP will also be included in this proposal. ~~1,750 MVARs of new capacitance will also be installed with 350 MVAR of capacitor banks each at Brambleton, Loudoun, Lexington, Jackson's Ferry and Broadford substations.~~

kV Level: 500

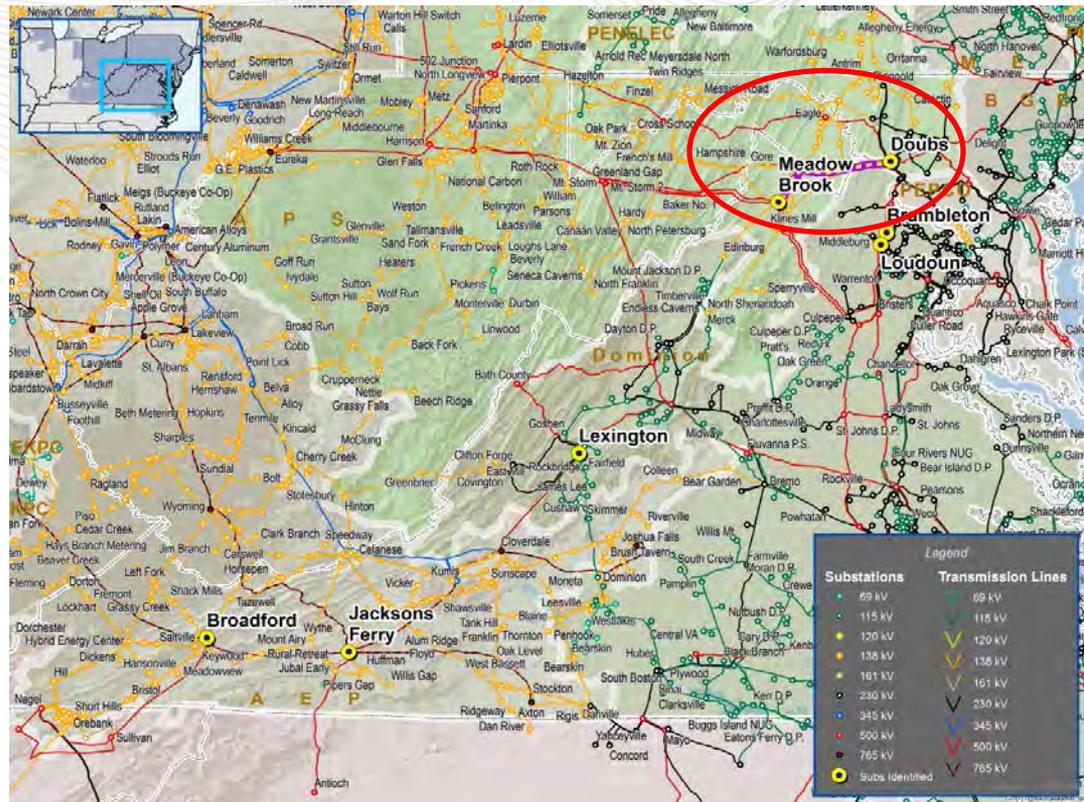
Cost (\$M): 196

IS Date: 2021

Target Zone: AEP

Results: B/C = 0.46

Notes: Increases total PJM congestion



## Project ID: 1-9A Modified

Proposed by: DOM High Voltage / Transource

Proposed Solution: Tap the Conemaugh - Hunterstown 500 kV line and build new 230 kV double circuit line between Rice and Ringgold. Build new 230 kV double circuit line between Furnace Run and Conastone. Rebuild the Conastone - Northwest 230 kV line. Add cap banks to Jackson's Ferry, Broadford, Lexington, Dooms, Ashburn and Brambleton stations. **Additional upgrades required at Ringgold transformers.**

kV Level: 230

Cost (\$M): 292.1

IS Date: 2020

Target Zone: Multiple

Results : B/C = 2.66

Notes: Major congestion reductions on ApSouth and other PJM facilities



## Project ID: 1-9A-2

Proposed by: DOM High Voltage / Transource

Proposed Solution: Tap the Conemaugh - Hunterstown 500 kV line and build new 230 kV double circuit line between Rice and Ringgold. **Additional upgrades required at Ringgold transformers.**

kV Level: 230

Cost (\$M): 143.6

IS Date: 2020

Results: B/C = 1.85

Notes: Major congestion reductions on ApSouth and other PJM facilities. Increases congestion on eastern area constraints near Conastone.



**Project ID: 1-9A-3**

Proposed by: DOM High Voltage / Transource

Proposed Solution: Build new 230 kV double circuit line between Furnace Run and Conastone. Rebuild the Conastone - Northwest 230 kV line.

kV Level: 230

Cost (\$M): 148.5

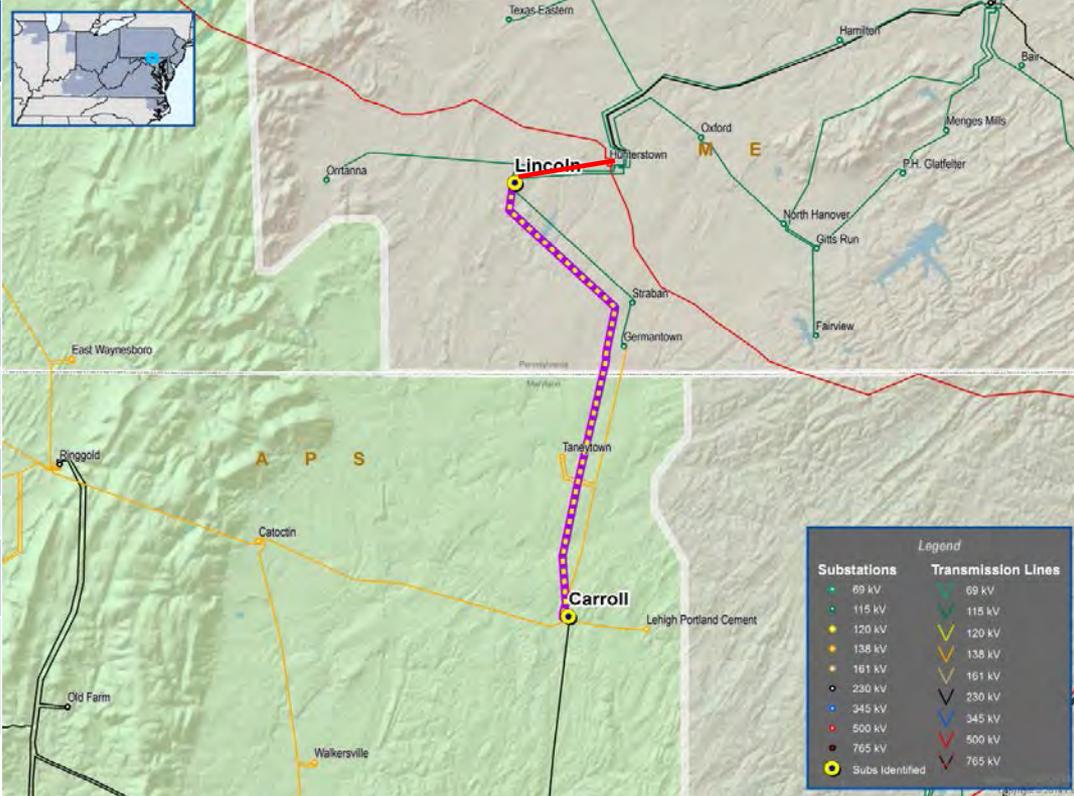
IS Date: 2020

Results: B/C= 1.05

Notes: Moderate congestion reductions on ApSouth. Increases congestion on Graceton-Bagley and Germantown-Straban



## Project ID: 201415\_1-18H Modified



Proposed by: FirstEnergy

Proposed Solution: Rebuild and reconductor the Lincoln - Carroll 115/138kV path.

**Added: Path will be converted to 230kV operation. Rebuild Hunterstown-Lincoln.**

kV Level: 138

Cost (\$M): 72 (Does not include upgrade for TMI-Jackson 230 kV line)

IS Date: 2019

Target Zone: APS/Meted

Results: B/C= 2.11 (Does not include upgrade for TMI-Jackson 230 kV line)

Notes: Moderate congestion reduction on ApSouth. Increased congestion on TMI-Jackson 230 kV line would need to be addressed.

## 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.**

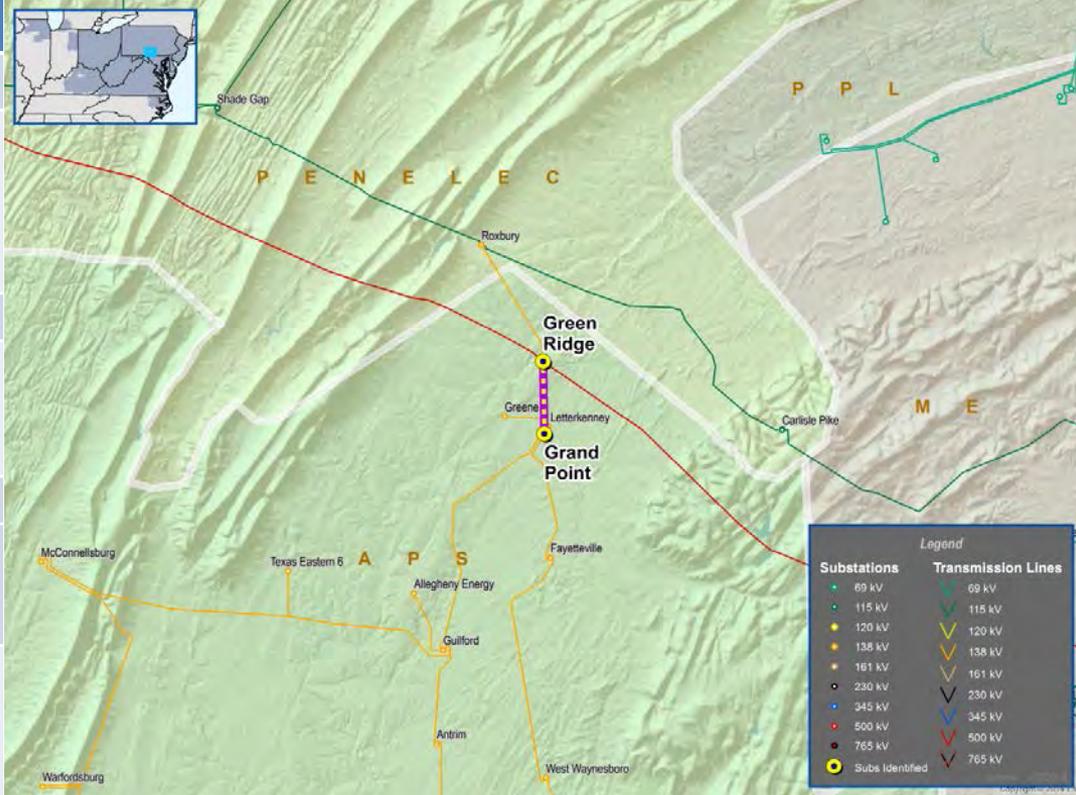
kV Level: 138

Cost (\$M): \$50.3-\$63.7 (Does not include upgrades at Otter Creek-Conastone and Peachbottom-Conastone)

IS Date: 2020

Results: B/C= 2.92-3.69 (Does not include upgrades at Otter Creek-Conastone and Peachbottom-Conastone)

Notes: Increases congestion on eastern area constraints near Conastone. Additional upgrades would be required at Otter Creek-Conastone and Peachbottom-Conastone. Moderate congestion reduction on ApSouth.



Project ID: 201415\_1-19D

Proposed by: Northeast Transmission Development

Proposed Solution: Approximately 26-mile 230 kV Line from Ringgold to a new 500/230 kV substation on the Conemaugh-Hunterstown 500 kV Line ("Green Ridge").  
**Additional upgrades required at Ringgold transformers.**

kV Level: 230

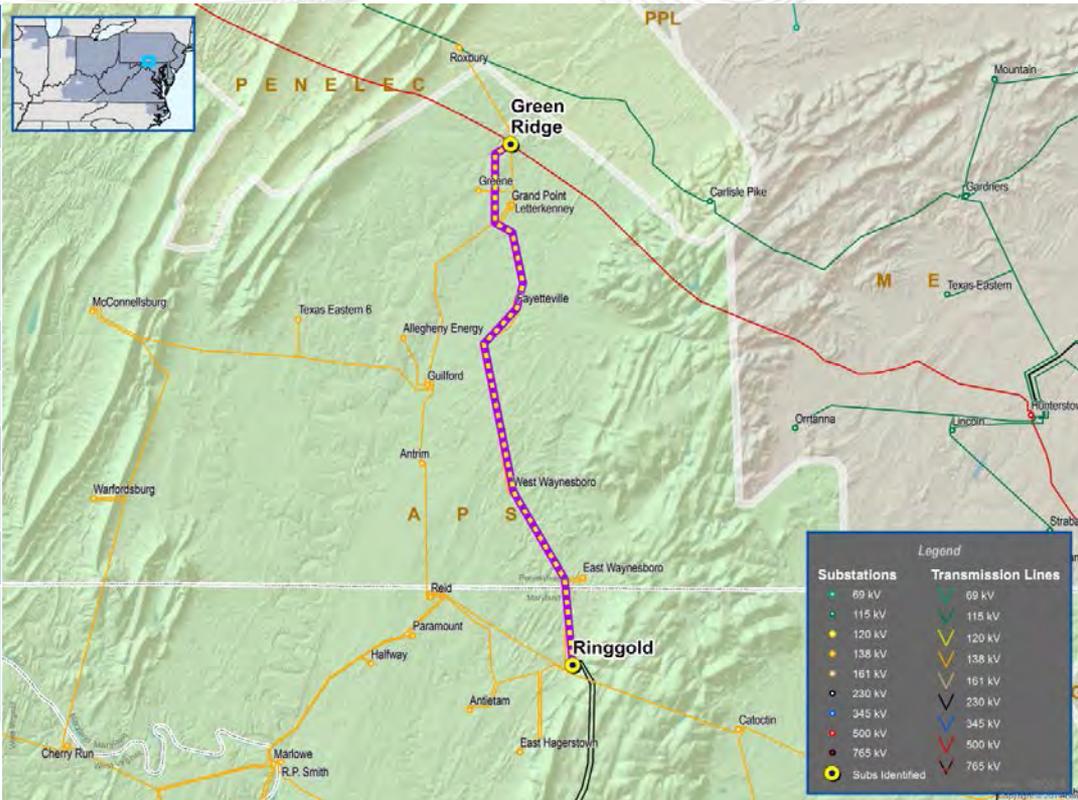
Cost (\$M): 115

IS Date: 2020

Target Zone: Meted/Penelec

Results: B/C= 2.0

Notes: Major congestion reductions on ApSouth and other PJM facilities. Increases congestion on eastern area constraints near Conastone.



**Project ID: 201415\_1-19F**

Proposed by: Northeast Transmission Development

Proposed Solution: Approximately 99-mile 500 kV Line from Harrison to Bath County.

kV Level: 500

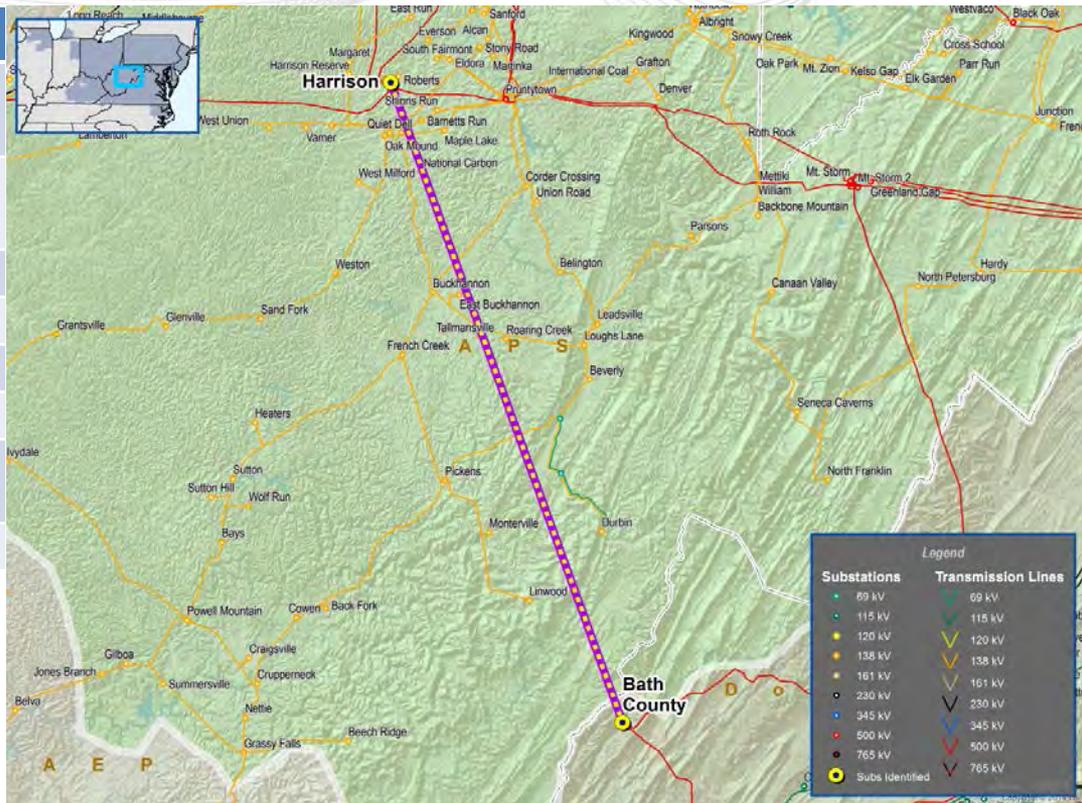
Cost (\$M): 432.5

IS Date: 2019

Target Zone: APS/Dominion

Results: B/C=0.76

Notes: Significant congestion reduction on ApSouth



**Project ID: 201415\_1-19G**

**Proposed by: Northeast Transmission Development**

**Proposed Solution: Build 500/230 kV Substation (Keysers Run) Interconnecting Conastone-Brighton 500 kV Line to Northwest 230 kV Substation.**

**kV Level: 230**

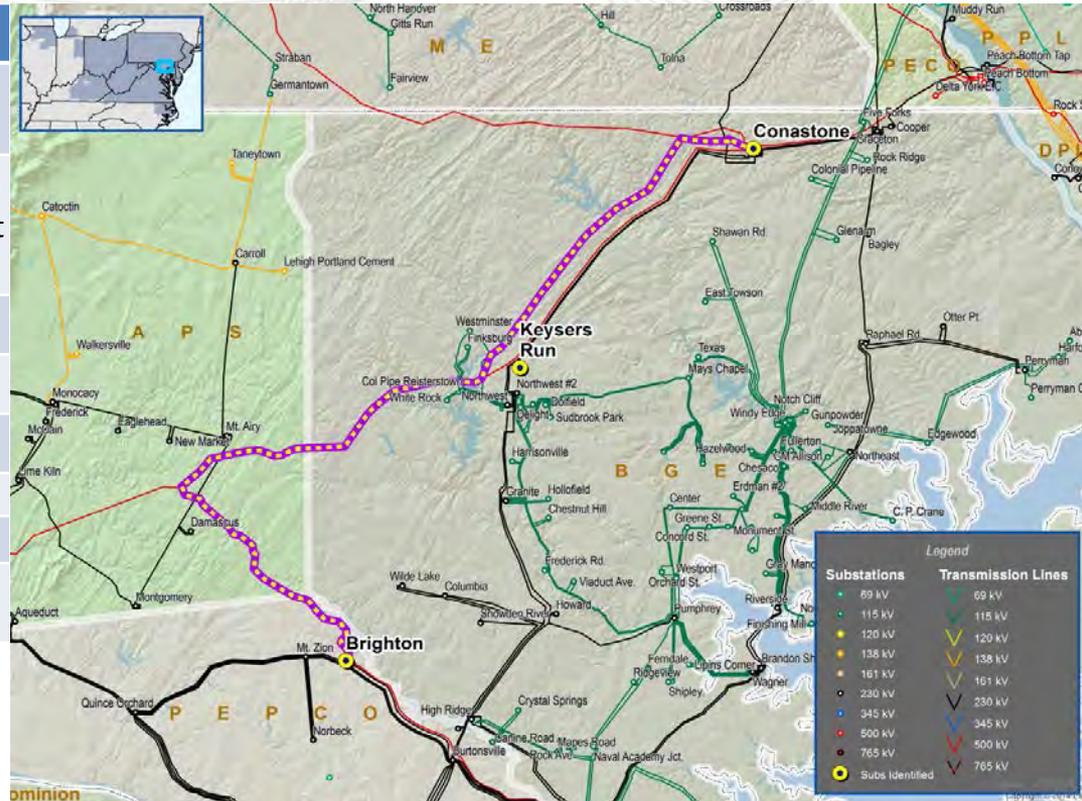
**Cost (\$M): 48.6**

**IS Date: 2020**

**Targeted Zone: Pepco/BGE**

**Results: B/C = 2.85**

**Notes: Minimal congestion reduction on ApSouth. Major increase in total PJM congestion.**





# Summary of Results

	18H	19B	19D	19G	9A-2 West	9A-3 East	9A
Sponsor	First Energy	Northeast Transmission Development	Northeast Transmission Development	Northeast Transmission Development	Transource /DOM HV	Transource /DOM HV	Transource /DOM HV
Project Cost	\$58.00	\$38.90	\$104.50	\$48.60	\$130.00	\$152.00	\$282.00
Additional Upgrades Description	Replace Germantown Transformer, Rebuild Hunterstown-Lincoln, Convert to 230 kV (Lincoln-Carroll)	Upgrade Fayette to Grand Point to Guilford Path	Ringgold Transformers		Ringgold Transformers		Ringgold Transformers
Additional Upgrades Cost	\$14.00	\$11.40 - \$24.80	\$10.50	-	\$10.50	-	\$10.50
Total Cost (w Upgrd)	\$72.00	\$50.30 – \$63.70	\$115.00	\$48.60	\$143.60	\$148.50	\$292.10
ISD	2019	2020	2020	2020	2020	2020	2020
Delta in AEP-DOM L/O BED-BLA	-\$2	-\$4	-\$3	-\$2	-\$7	-\$1	-\$4
Delta in AP SOUTH L/O BED-BLA	-\$11	-\$25	-\$30	-\$5	-\$39	-\$13	-\$49
Delta in Total Interfaces Cong	-\$12	-\$29	-\$33	-\$8	-\$45	-\$14	-\$54
Delta in Total PJM Cong	-\$14	-\$32	-\$41	\$51	-\$50	-\$13	-\$83
B/C Ratio	2.11	2.92 – 3.69	2.00	2.85	1.85	1.05	2.66
Delta in Gross Load Payment	-\$9	-\$23	\$2	\$25	-\$1	-\$4	-\$30
Delta in Production Cost	-\$9	-\$13	-\$18	-\$4	-\$22	-\$5	-\$31
Comments	Modified to tap into Hunterstown. Moderate congestion reduction on ApSouth. Increased congestion on the TMI-Jackson 230 kV line would need to be addressed.	Increases congestion on eastern area constraints near Conastone. Additional upgrades would be required at Otter Creek-Conastone and Peachbottom-Conastone.	Major congestion reductions on ApSouth and other PJM facilities. Increases congestion on eastern area constraints near Conastone.	Minimal congestion reduction on ApSouth. Major increase in total PJM congestion.	Major congestion reductions on ApSouth and other PJM facilities. Increases congestion on eastern area constraints near Conastone.	Moderate Congestion reductions on ApSouth. Increases congestion on Gracetown-Bagley and Germantown-Straban	Major congestion reductions on ApSouth and other PJM facilities

\*Deltas represent totals of 2019 and 2022 study years



# Summary of Results

	19F	6D	7A	7B	7C
Sponsor	Northeast Transmission Development	Dominion	Transource	Transource	Transource
Project Cost	\$432.50	\$28.67	\$122.00	\$222.00	\$196.00
ISD	2023	2019	2020	2021	2021
Delta in AEP-DOM L/O BED-BLA	-\$29	\$1	\$21	-\$1	-\$3
Delta in AP SOUTH L/O BED-BLA	-\$172	\$1	-\$12	\$33	\$49
Delta in Total Interfaces Cong	-\$201	\$2	\$10	\$32	\$46
Delta in Total PJM Cong	-\$194	\$1	\$8	\$24	\$36
B/C Ratio	0.76	0.22	0.02	0.46	0.46
Delta in Gross Load Payment	\$77	\$13	\$20	\$21	\$26
Delta in Production Cost	-\$97	-\$3	-\$6	-\$2	\$2

\*Deltas represent totals of 2019 and 2022 study years

- The inclusion of the approved optimal capacitors reduces the benefits for the majority of projects.
- Several projects that pass the B/C test increase PJM congestion or have minimal impacts on ApSouth congestion.
- Several projects required additional upgrades because they caused additional congestion on existing facilities.
- Most benefits provided by projects that diverted flow from ApSouth area to the central Pennsylvania area.
  - Projects that tapped off the Conemaugh-Hunterstown 500 kV line provided larger benefits but increased congestion in eastern areas.
  - Optimal solution requires multiple upgrades
    - Transmission line that taps the Conemaugh-Hunterstown 500 kV line
    - Transmission upgrades in Conastone area



# Combination Projects



	9A	Combo 18H+(9A-3 East)	Combo 19B+(9A-3 East)	Combo 19D+(9A-3 East)
Sponsor	Transource /DOM HV	First Energy /Transource /DOM HV	NTD/Transource/DOM HV	NTD/Transource/DOM HV
Project Cost	\$281.6	\$72.0	\$187.4	\$252.99
Additional Upgrades Description	Ringgold Transformers		Upgrade Fayette to Grand Point to Guilford Path	Ringgold Transformers
Additional Upgrades Cost	\$10.5	\$0.00	\$11.4 - \$24.8	\$10.5
Total Cost (w Upgrd)	\$292.1	\$220.5	\$198.8 - \$212.2	\$263.5
ISD	2020	2020	2020	2020
Delta in AEP-DOM L/O BED-BLA	-\$4	-\$5	-\$4	-\$7
Delta in AP SOUTH L/O BED-BLA	-\$49	-\$19	-\$26	-\$31
Delta in Total Interfaces Cong	-\$54	-\$24	-\$31	-\$38
Delta in Total PJM Cong	-\$83	-\$41	-\$44	-\$61
B/C Ratio	2.66	2.46	2.22 – 2.36	2.33
Delta in Gross Load Payment	-\$30	-\$9	-\$33	-\$13
Delta in Production Cost	-\$31	-\$16	-\$17	-\$25
Comments		Additional congestion will require upgrade(s) in BGE Area	Additional congestion will require upgrade(s) in BGE Area	Additional congestion will require upgrade(s) in BGE Area

\*Deltas represent totals of 2019 and 2022 study years

- Each combination project provides significant market benefits
  - Combinations with 18H, 19B, and 19D increase congestion in BGE area and additional upgrade(s) will be necessary.
  
- 9A project consistently ranked highest in most categories
  - B/C ratio, ApSouth and PJM total congestion reduction, and production cost reduction
  
- Project Combination of 9A-3 (East) + 19D is similar to project 9A
  - 19D is a single circuit and 9A is a double circuit for western portion.
  - Double circuit provides additional \$22 million in PJM congestion reductions, \$18 million in ApSouth congestion reductions, and higher B/C ratio.

## Project ID: 1-9A

Proposed by: DOM High Voltage / Transource

Proposed Solution:

9A Project without capacitors: Tap the Conemaugh - Hunterstown 500 kV line and build new 230 kV double circuit line between Rice and Ringgold. Build new 230 kV double circuit line between Furnace Run and Conastone. Rebuild of the Conastone - Northwest 230 kV line.

Additional Upgrades: Replace the Ringgold #3 and #4 transformers with 230/138 kV autotransformers

kV Level: 230

Cost (\$M): \$292.1\*

IS Date: 2020

Notes:

- Recommendation Pending Reliability Analysis and Sensitivity Analysis.
- Board recommendation in April 2016
- Constructability analysis complete
- Designated Entities: TBD



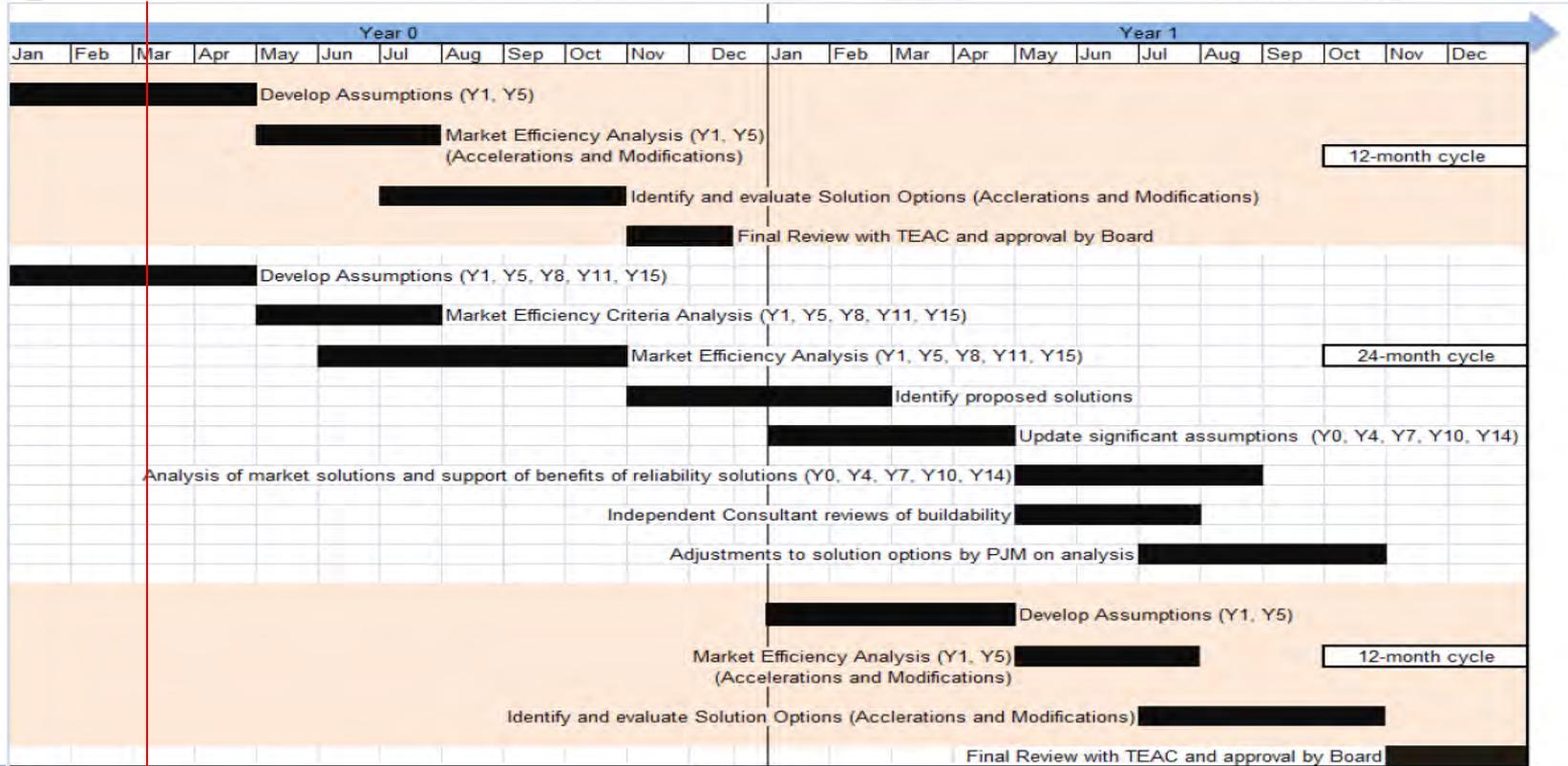
\*Ringgold transformers estimate does not include work on the 230 kV side.

- **WebEx Session on Thursday, 3/17**
  - Reliability Analysis results on project 9A
  - Sensitivity Analysis results on combination projects
  - Identify Designated Entities
  
- **Recommendation to the PJM Board in April**



# Market Efficiency 2016/17 Long Term Proposal Window Update

# Market Efficiency Timeline





# 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

- 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

- 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, April 2016

## PJM zonal peak and energy forecast from 2016 Load Forecast Report

2016 PJM Peak Load and Energy Forecast

Load	2017	2021	2024	2027	2031
Peak (MW)	154,149	157,358	159,991	162,988	167,469
Energy (GWh)	821,812	843,262	862,838	879,605	906,168

Notes: 1.) Peak and energy values from PJM Load Forecast Report Table B-1 and Table E-1, respectively.

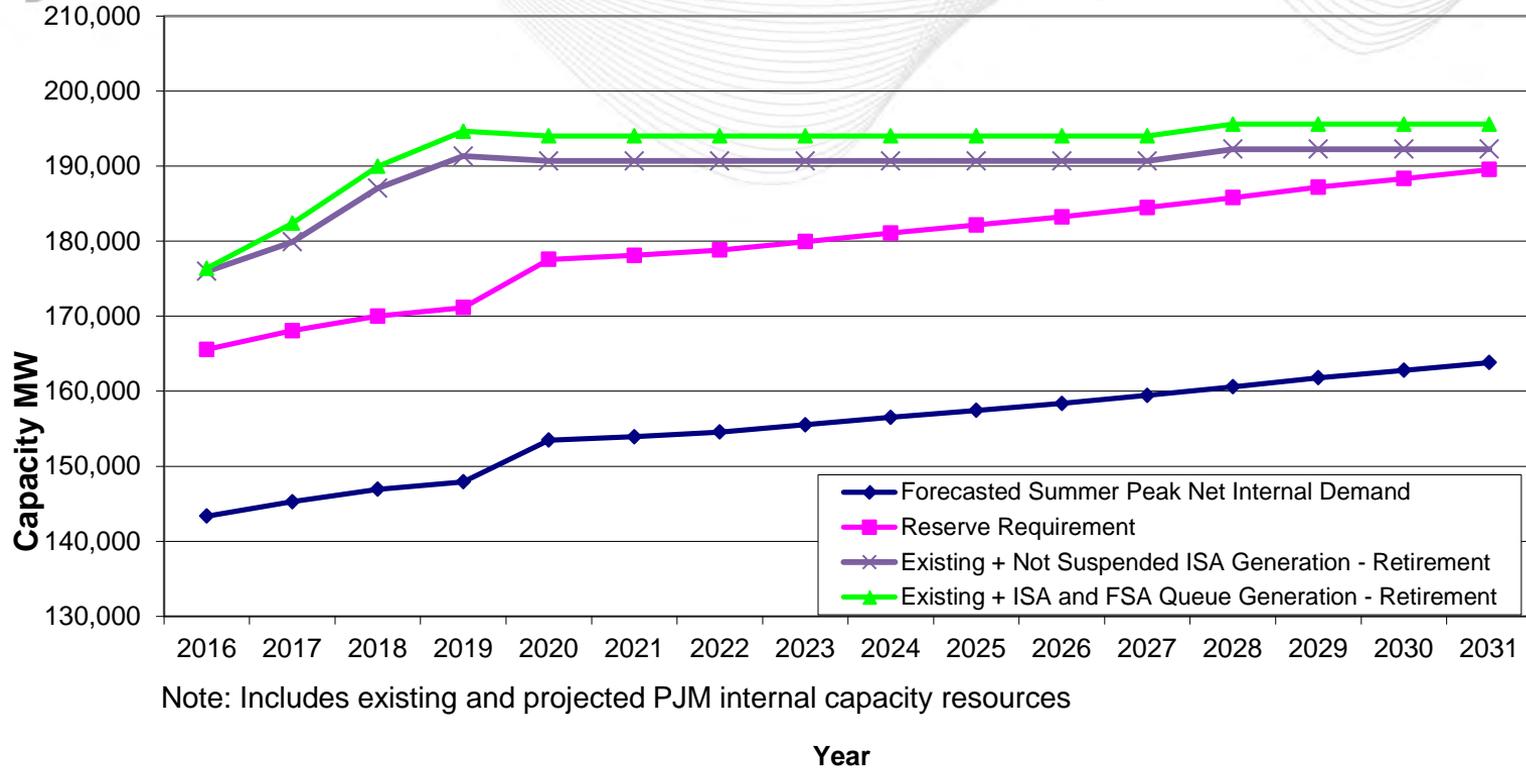
2.) Model inputs are at the zonal level, to the extent zonal load shapes create different diversity - modeled PJM peak load may vary.

Model zonal demand resources consistent with Table B-7 of the 2016 Load Forecast Report.

2016 PJM Demand Resource Forecast

	2017	2021	2024	2027	2031
Demand Resource (MW)	8,883	3,424	2,478	3,543	3,651

### PJM Market Efficiency Reserve Margin - Preliminary



- 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>

- 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) <sup>[1]</sup>
- 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%

[1] <http://www.pjm.com/markets-and-operations/billing-settlements-and-credit/formula-rates.aspx>

Market Efficiency Inputs:

- Fuel Prices
- Emissions Prices

April

April

Board Review of Market Efficiency Input Assumptions

May

Market Efficiency Preliminary Results:

- Stakeholder feedback on model:
- PJM review for acceleration candidates:
- Proposal window opens:

June

June-September

June-September

November

Questions?

Email: [RTEP@pjm.com](mailto:RTEP@pjm.com)