Transmission Expansion Advisory Committee (TEAC)

Recommendations to the PJM Board

PJM Staff Whitepaper
July 2017

EXECUTIVE SUMMARY

On February 14, 2017 the PJM Board of Managers approved changes to the Regional Transmission Expansion Plan (RTEP), totaling $1,516.22 million, primarily to resolve baseline reliability criteria violations.

Since that time PJM has identified additional baseline reliability criteria violations within the planning horizon as part of the 2017 RTEP. Transmission upgrades have been identified to resolve these reliability criteria violations. The increase in the RTEP to include the upgrades to resolve the new baseline reliability criteria violations is $368.06 million. In addition, a number of previously approved baseline projects have been cancelled or the cost and scope has changed resulting in a net increase of $48.74 million. The net impact due to baseline reliability changes is an increase of $416.80 million.

With these changes, the RTEP will include over $31,259.33 million of transmission additions and upgrades since the first plan was approved by the Board in 2000.

The additional baseline projects are summarized in the following paper and were presented for the Board Reliability Committee's consideration and for recommendation to the Board for approval. At the July 2017 meeting, the PJM Board approved the updated RTEP as requested.

Summary of Results

2017 Baseline Transmission Upgrades Changes and Additions

One aspect of the development of the Regional Transmission Expansion Plan is an evaluation of the "baseline" system, i.e. the transmission system without any of the generation interconnection requests included in the current planning cycle. This baseline analysis determines the compliance of the existing system with reliability criteria and standards. Transmission upgrades required to maintain a reliable system are identified and reviewed with stakeholders through the Transmission Expansion Advisory Committee (TEAC) and Subregional RTEP Committees. The cost of transmission upgrades to mitigate such baseline reliability criteria violations are the responsibility of the PJM load customers.

Reliability Project Summary

A summary of the more significant baseline projects with estimated costs equal to or greater than $5 million are detailed below. A complete listing of all of the projects that are being recommended along with their associated cost allocations is included as Attachment A to this white paper. The projects with estimated costs less than $5 million include circuit breaker replacements, transmission line re-conductoring, transmission line terminal equipment upgrades, and substation bus modifications.

Mid-Atlantic Region System Upgrades

- PSE&G Transmission Zone
  - Build a new 138/26kV Newark GIS station in a building (located adjacent to the existing Newark Switch) and demolish the existing Newark Switch - $275.0 M

Western Regional System Upgrades

- AEP Transmission Zone
  - Install 300 MVAR reactors at Ohio Central and West Bellaire 345kV substations - $10.0 M

- ATSI Transmission Zone
  - Re-conductor the Avon – Lorain 138 kV line and upgrade the line drop at Avon - $13.5 M
  - Re-conductor the Beaver - Black River 138kV line with 954Kcmil ACSS conductor and upgrade terminal equipment at both stations - $20.0 M

Southern Region System Upgrades

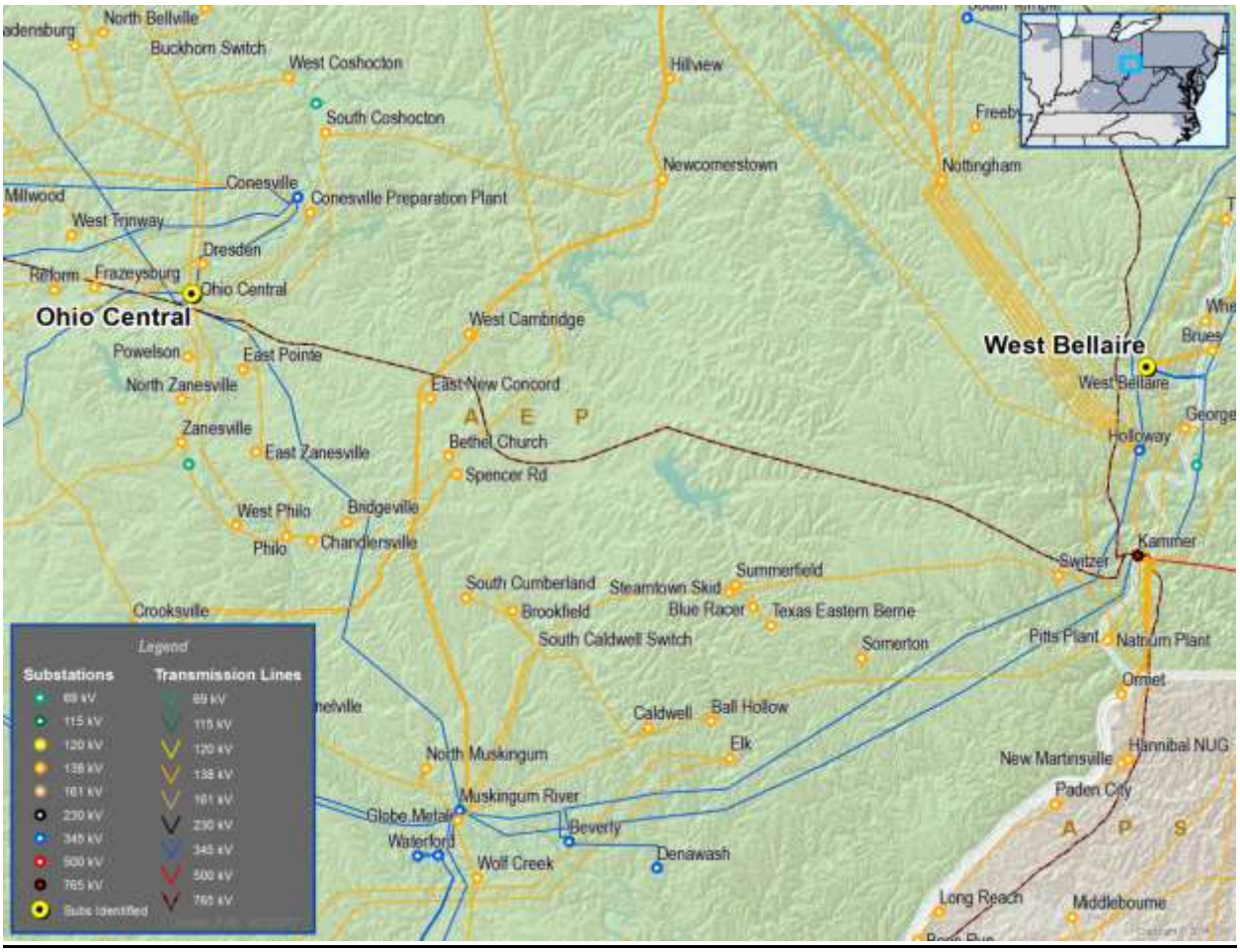
- Dominion Transmission Zone
  - Rebuild 230kV line #247 from Swamp to Suffolk (31 miles) to current standards. - $31.0 M

Following is a more detailed description of the larger scope upgrades that were recommended to the PJM Board for their consideration. A description of the criteria driving the need for the upgrade as well as the required in-service date is provided.

Baseline Project b2826 – New 300 MVAR Reactors at Ohio Central and Bellaire Stations

Background and Need

High voltage conditions on the EHV system have been occurring regularly in AEP and surrounding areas under light load conditions. These conditions are expected to worsen with the recently announced deactivation of the Stuart and Killen units which had helped to control high voltages in the area during light load conditions. PJM planners worked closely with AEP planners to determine operational and planning alternatives to address the issue. In addition, EMS snapshots during high voltage conditions were reviewed. A number of modeling and operational alternatives were considered. Based on these evaluations, PJM staff are recommending to add a 300 MVAR 345 kV reactor at the Ohio Central substation and a 300 MVAR 345 kV reactor at the West Bellaire substation on the AEP system. The estimated cost is $5M for each reactor, for a total project cost of $10M. The expected in-service date is 9/1/2018

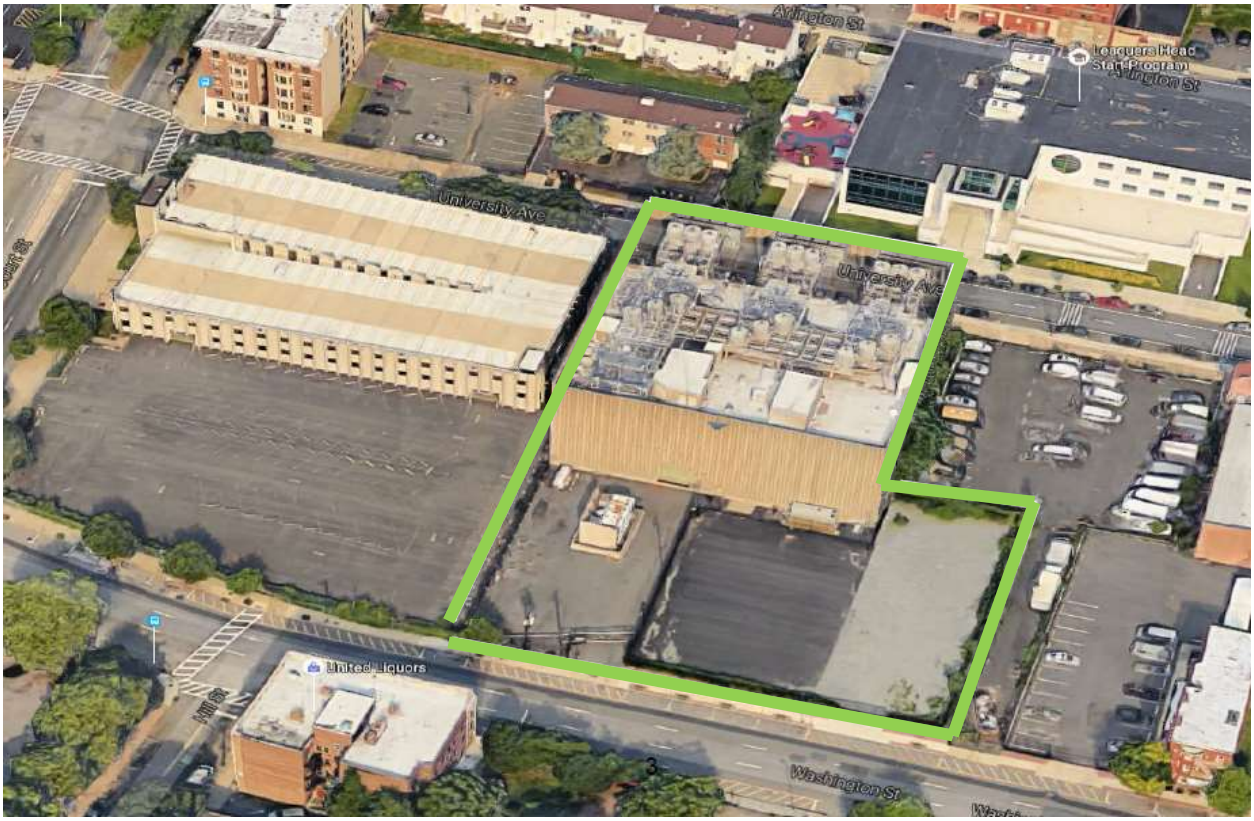


Baseline Project b2870 – Newark GIS Station

Background and Need

The PSEG Newark switch is an aging building type switchyard serving critical loads in downtown Newark, NJ. The building and two of the three transformers were placed in-service in the late 1950's. The site, shown in the picture below consists of 138 kV, 26 kV, and 13 kV feeders, transformers, switchgear, control room and reactors all located inside and on top of a 3 story urban structure. The functional layout of the building is as follows:

- Roof: 138 kV Yard
- 3rd floor: Control room/AUX power rooms
- 2nd floor: Distribution reactors
- 1st Floor: 26 kV switchgear & Transformer vaults
- Basement: Oil rooms, 13 kV & 26 kV feeders & underground 138 kV transmission lines entering the station



There are several critical local load customers supplied by the station including:

- Healthcare buildings
- Schools and churches, including NJIT and Rutgers
- Financial buildings
- Newark City Hall
- Other government buildings
- PATH Train, NJ Transit rail system
- Local 26kV and 13kV distribution source stations
- Several internet network data centers
- Downtown Newark
- Prudential Arena, NJ Performing Arts Center
- United States Citizenship and Immigration Services (USCIS)

Given the age, condition and layout of the equipment there is concern that a transformer fire or catastrophic failure of other equipment in the station would likely result in the destruction of the whole facility and the loss of 300 MVA of critical load for an extended period of time. Several alternatives were evaluated to address this issue.

Three basic alternatives were considered:

1. Build new Newark GIS station in a building (layout #1) located adjacent to the existing Newark Switch and demolish the existing Newark Switch.
2. Build a new Newark GIS station elsewhere in Newark and relocate all transmission and distribution cables and protection equipment.
3. Continue with the status quo, do nothing.

Given the age and condition of the equipment and the critical load served by the Newark Switch, Option 3 is not a viable option. Option 2 was not pursued further due to the lack of available space near the existing substation. Relocating the existing substation would require relocating the existing underground distribution feeders, which would require extended outages to the distribution facilities, involve high risk of customer interruptions and incur significant cost. Initial designs for option 1 also had a number of drawbacks given the limited open space around the station. In the initial design of option 1 a portion of the land where the existing building substation is located was going to be needed to accommodate the new substation. This

would require work around live equipment, long equipment outage durations and result in a high risk system configuration.

PSEG worked closely with equipment manufacturers and consultants to develop a variation of Option 1 which addresses many of the concerns with the original conceptual Option 1 configuration. Specifically, this new solution alternative Option 1A:

- Locates transformers outside of existing building
- Constructs a new three story building separate from the existing building.
- Re-arranges the Gas Insulated Switchgear (GIS) into a more compact layout. The Gas Insulated Bus (GIB) will be located entirely within the new building.
- Reduces transformer outage durations by enabling testing of the GIS/GIB and transformers before cutover.
- Uses conventional demolition methods for the existing building, provides material lay-down area and allows for storm retention requirements.

Option 1A is the least cost and least risk approach. The estimated cost for Option 1A is $275M, which is a reduction of $78M from the original (Option 1) conceptual design.

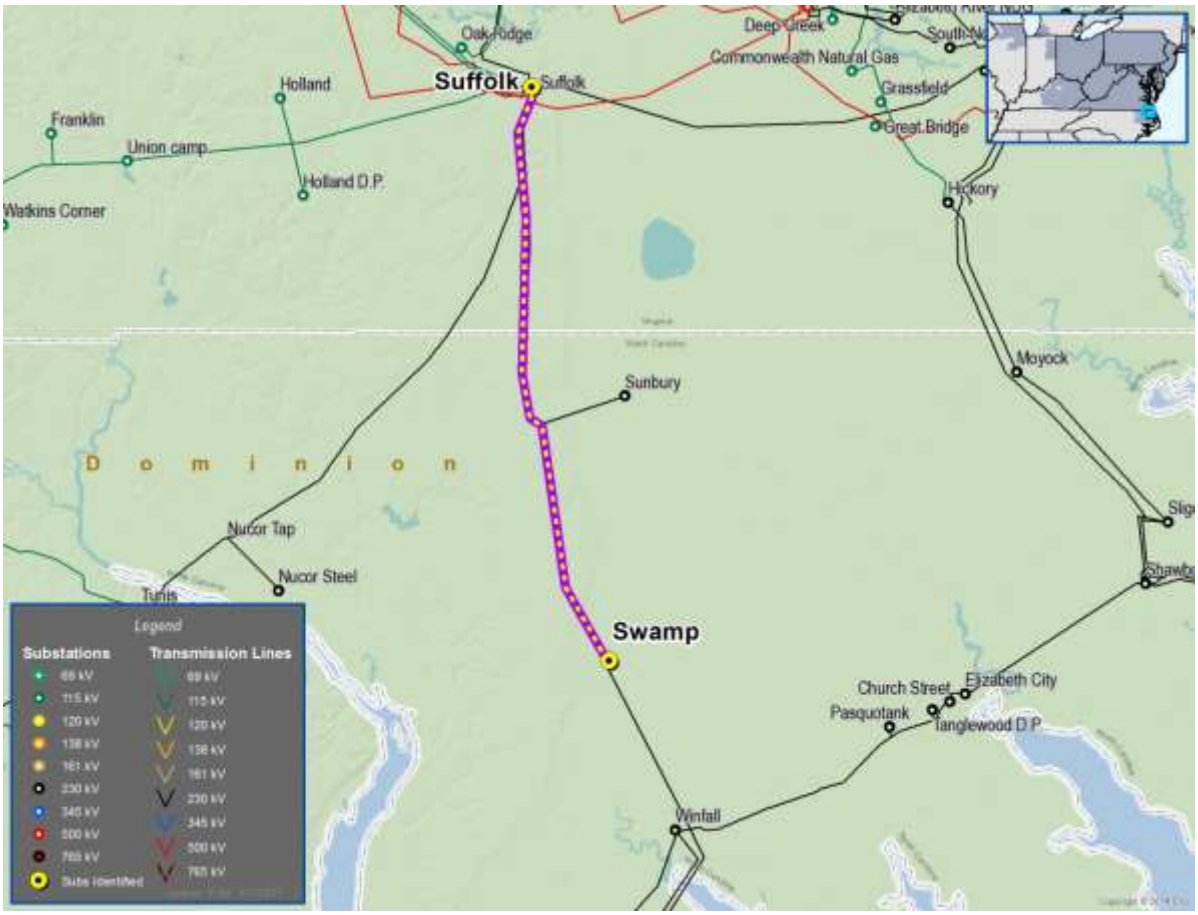
This project was recommended as a baseline RTEP project to address PSEG's FERC-filed local planning criteria related to aging infrastructure. Transmission upgrades required to resolve violations of transmission owner FERC-filed form 715 local planning criteria are included in the RTEP consistent with section 1.2(e) of Schedule 6 of the Operating Agreement. Based on FERC Order regarding 715 local criteria, the cost for transmission upgrades that are driven exclusively by transmission owner FERC-filed form 715 planning criteria are allocated to the local transmission owner zone.

Baseline Project b2871 – Rebuild #247 Swamp to Suffolk 230kV Transmission Line

Background and Need

The Swamp to Suffolk 230kV line (#247) in the Dominion transmission zone is approximately 49 years old, and is built primarily on wood H frame structures. The facility has reached its end of life per Dominion's FERC Form 715 local planning criteria and needs to be replaced.

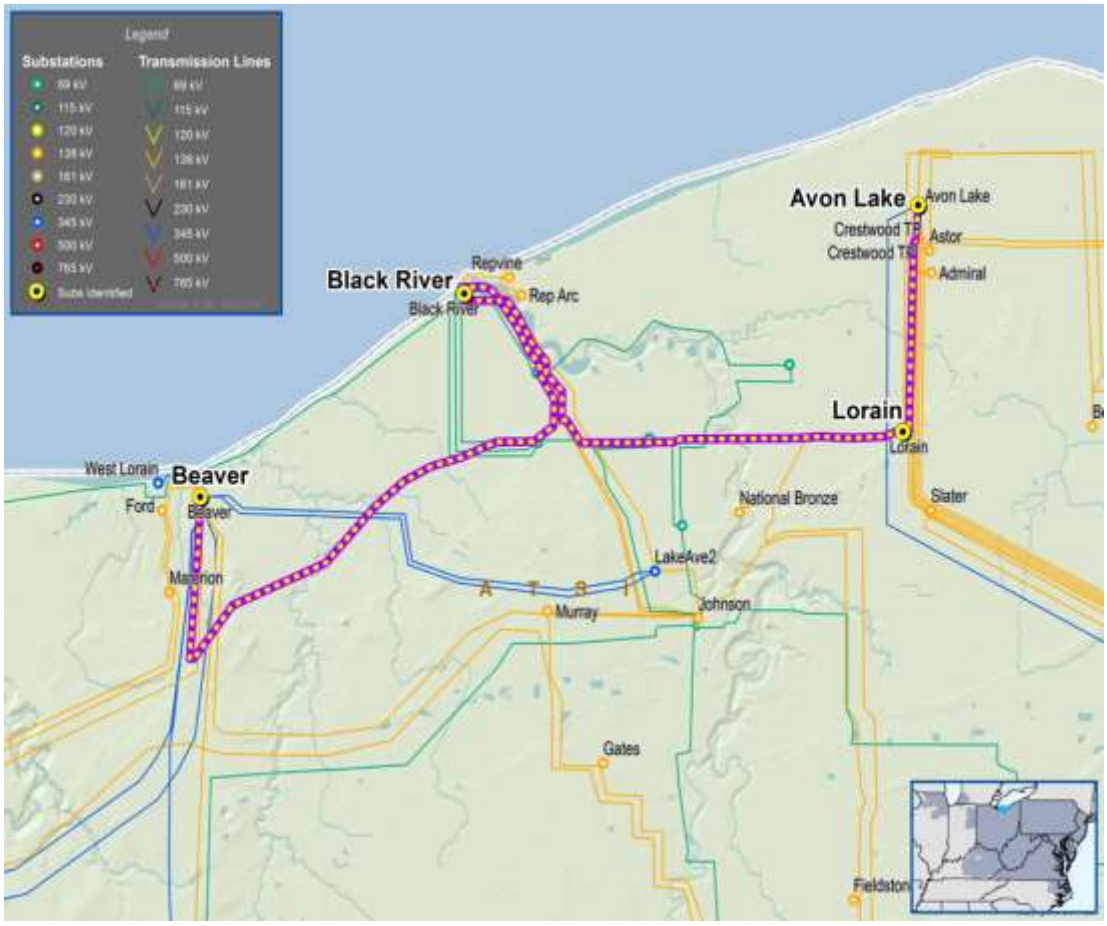
The line serves 21 MW of directly connected load so eliminating the line is not a viable option. Staff is recommending that the line be rebuilt to current standards based on Dominion's "End of Life" criteria. The estimated cost of the project is $31M. As noted, the facility has reached its end of life and should be replaced as soon as practical. The expected in-service date for the rebuilt line is December of 2022.



Baseline Reliability
Baseline Project b2896 – Rebuild / Re-conductor the Black River–Lorain 138 kV line
Baseline Project b2897 – Re-conductor the Avon-Lorain 138kV line
Baseline Project b2898 – Re-conductor the Beaver-Black River 138 kV line

Background and Need

2016 RTEP Proposal window #3 and #3A identified a number of violations in the Beaver / Black River / Avon Lake region of northern Ohio.



A total of 10 flowgate violations were identified due to summer peak and winter peak generator deliverability criteria. Thirteen proposals were received from 3 entities (First Energy, Transource and Northeast Transmission Development) to address some or all of these violations. PJM staff evaluated all of the proposals to determine the most effective solutions. The results of the PJM analysis are summarized in the table below.

Reliability Analysis Result Summary												
	Cost Estimate	FG #	FG #	FG #	FG #	FG #	FG #	FG #	FG #	FG #	FG #	Comment
Project ID	($ Million)	393	490	392	489	400	493	407	504	386	915	
2016_3-2C	44.9	O	O	O	O	O	O	O	O	O	O	Essentially the same as project 2016_3A-1A
2016_3-5B	19	O	O	O	O	O	O	O	O	X	X	
2016_3-5D	35.4	O	O	O	O	O	O	O	O	O	O	New 345 kV circuit overload. Beaver - Carlisle 345 kV (118%) for tower outage
2016_3-5F	12.4	X	X	X	X	X	X	X	X	X	O	
2016_3-6B	13.4	X	X	X	X	O	O	O	O	X	X	Essentially the same as project 2016_3A-3B
2016_3-6C	30.3					O	O	O	O			
2016_3-6D	3.2	O	O	O	O	X	X	X	X	X	X	Essentially the same as project 2016_3A-3C
2016_3A-1A	44.58	O	O	O	O	O	O	O	O	O	O	New 345 kV circuit overload. Beaver - Carlisle 345 kV (118%) for tower outage
2016_3A-1B	50.56											Analysis deferred due to high project cost
2016_3A-2A	62.8											Analysis deferred due to high project cost
2016_3A-3A	19.97	X	X	X	X	X	X	X	X	O	O	
2016_3A-3B	13.46	X	X	X	X	O	O	O	O	X	X	
2016_3A-3C	3.2	O	O	O	O	X	X	X	X	X	X	

Notes:

- **Blue shaded cells indicate the flowgates that were identified by the Proposing Entity as solved by the proposal**
- **'O' means yes, the proposed project solves the flowgate violation**
- **'X' means no, the proposed project doesn't solve the flowgate violation**

Recommended Projects

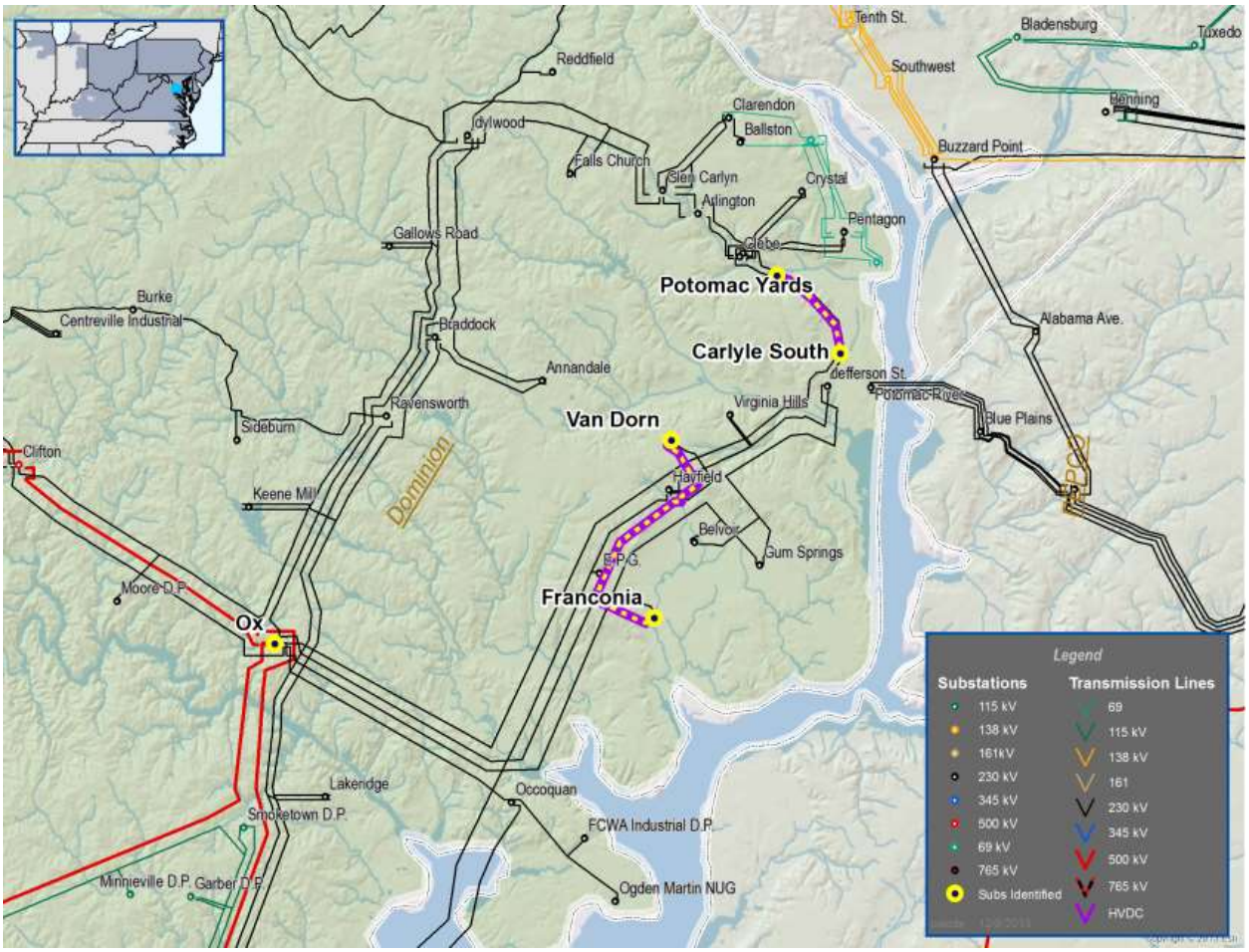
Based on PJM's evaluation, staff is recommending proposals 3A, 3B, and 3C to rebuild or re-conductor the Black River – Lorrain 138 kV line, the Avon Lake – Lorraine 138 kV line and the Beaver – Black River 138 kV line proposals that were submitted by FirstEnergy. The combination of the three proposals resolves all of the identified issue, did not create additional overloads, are the least cost, and have relatively little implementation risk as they are upgrades to existing facilities

The total estimated cost for the combined project is $36.3M and has a required in-service date of 6/1/2021.

Changes to Previously Approved Projects

Cost and scope of a number of previously approved RTEP baseline projects have changed, resulting in a net increase of $48.74M. Seventeen projects, totaling $91.27M, are being cancelled as they are no longer needed to satisfy reliability criteria. Three of these projects totaling $61.6M are upgrades in the PS transmission zone that are no longer required due to the Edison – Metuchen – Burlington rebuild project that was approved by the Board in February. The expected cost of four other projects has increased by a total of $140.01M. All but $7M of this increase is attributed to the b2443 project which is described in more detail below.

Baseline Project b2443 Install Glebe – Station C 230 kV line and Phase Angle Regulator (PAR) in the Dominion and PEPCO transmission zones



The scope of this previously approved RTEP project is to build a new underground 230kV line from Dominion's Glebe station to Station C (a.k.a. PEPCO's Potomac River substation), rebuild the Glebe substation, replace 230kV breakers at Idylwood, Ox, and Blue Plains substations, and rebuild/expand the Potomac River substation to also include a phase angle regulator (PAR). The cost of this project is expected to increase. Approximately 2/3 of the increase in expected cost is due to the need to use micro-tunneling installation methods rather than open trenching to install the underground line. The dense urban

setting (Alexandria, VA), the need to cross a waterway, a busy railroad right of way, and National Parks Service (NPS) property are all drivers in this decision. Acquiring the necessary easements has also been more costly than expected. Also, the limited open space around the Glebe station will require more compact gas insulated switchgear (GIS) equipment, an option which was not considered in the original proposal. Finally, cost estimates for the PEPCO substation work have been refined and increased by $20M. Due to all of the factors above, the original estimate has increased by $133M for a total estimated cost of $299M.

In light of this significant increase, PJM staff working with Dominion, evaluated alternate solutions. The next most feasible alternative included re-conductoring 4.2 miles of overhead and 6.2 miles of underground transmission lines, installing a new transformer and other equipment at the Occoquan substation. Also, rebuilding the Glebe substation and upgrading the North Potomac switchyard would also be required. The projected cost of this alternative is $282M. While this alternative would solve the identified reliability criteria violations at slightly less cost, further study revealed a significant difference in the system resiliency between these two alternatives. The alternative to re-conductor lines and add transformation did not enhance resilience of the electric system in this area whereas the recommended solution provides significantly improved resilience with a modest ($17M) increase in cost. In addition, engineering and development work associated with the approved project is well underway and would be abandoned if an alternative was selected.

Considering all of these issues, staff recommended Dominion and PEPCo continue to implement the previously approved project.

Review by the Transmission Expansion Advisory Committee (TEAC)

The need for the projects was reviewed with stakeholders at several meetings throughout 2017, most recently at the June 2017 TEAC and Sub Regional RTEP Committee meetings. Written comments were requested to be submitted to PJM to communicate any concerns with the recommendations and any alternative transmission solutions for consideration.

Cost Allocation

Preliminary cost allocations for the approved projects are shown in Attachment A.

Cost allocations for the projects were calculated in accordance with the Schedule 12 of the OATT. Baseline reliability project allocations are calculated using a distribution factor methodology that allocates the cost to the load zones that contribute to the loading on the new facility. Baseline projects required exclusively to address local transmission owner FERC Form 715 planning criteria are allocated to the local transmission owner zone. The allocations will be filed at the FERC 30 days following approval by the Board.

Board Approval

The PJM Board Reliability Committee endorsed the new baseline reliability projects and associated cost allocations, and recommend to the PJM Board of Managers, approval of the baseline upgrades to the 2017 RTEP. The PJM Board of Managers approved all recommended changes to the RTEP.

Reliability Project Single Zone Allocations

Upgrade ID	Description	Cost Estimate ($M)	Trans Owner	Cost Responsibility	Required IS Date
b2826.1	Install 300 MVAR reactor at Ohio Central 345 kV substation	$5.00	AEP	AEP	6/1/2018
b2826.2	Install 300 MVAR reactor at West Bellaire 345 kV substation	$5.00	AEP	AEP	6/1/2018
b2839	Replace the Sickler 69kV 'H' breaker with 63kA breaker	$0.32	AEC	AEC	6/1/2019
b2840	Replace the Sickler 69kV 'M' breaker with 63kA breaker	$0.32	AEC	AEC	6/1/2019
b2841	Replace the Sickler 69kV 'A' breaker with 63kA breaker	$0.32	AEC	AEC	6/1/2019
b2842	Update the nameplate for Mount Storm 500kV "57272" to be 50kA breaker	$0.00	Dominion	Dominion	6/1/2019
b2843	Replace the Mount Storm 500kV "G2TY" with 50kA breaker	$0.90	Dominion	Dominion	6/1/2019
b2844	Replace the Mount Storm 500kV "G2TZ" with 50kA breaker	$0.90	Dominion	Dominion	6/1/2019
b2845	Update the nameplate for Mount Storm 500kV "G3TSX1" to be 50kA breaker	$0.00	Dominion	Dominion	6/1/2019
b2846	Update the nameplate for Mount Storm 500kV "SX172" to be 50kA breaker	$0.00	Dominion	Dominion	6/1/2019
b2847	Update the nameplate for Mount Storm 500kV "Y72" to be 50kA breaker	$0.00	Dominion	Dominion	6/1/2019
b2848	Replace the Mount Storm 500kV "Z72" with 50kA breaker	$0.90	Dominion	Dominion	6/1/2019
b2850	Replace the Waneeta 230kV "285" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2851	Replace the Eddystone 230kV "305" & "405" with 63kA breaker	$0.75	Exelon Generation	Exelon Generation	6/1/2019
b2852	Replace the Chichester 230kV "195" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2853	Replace the Eddystone 230kV "345" with 63kA breaker	$0.37	Exelon Generation	Exelon Generation	6/1/2019
b2854	Replace the North Philadelphia 230kV "CS 775" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2855	Replace the North Philadelphia 230kV "CS 885" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2856	Replace the Parrish 230kV "CS 715" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2857	Replace the Parrish 230kV "CS 825" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2858	Replace the Parrish 230kV "CS 935" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2859	Replace the Plymouth Meeting 230kV "215" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2860	Replace the Plymouth Meeting 230kV "235" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2861	Replace the Plymouth Meeting 230kV	$0.38	PECO	PECO	6/1/2019

Upgrade ID	Description	Cost Estimate ($M)	Trans Owner	Cost Responsibility	Required IS Date
	"325" with 63kA breaker				
b2862	Replace the Grays Ferry 230kV "705" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2863	Replace the Grays Ferry 230kV "985" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2864	Replace the Grays Ferry 230kV "775" with 63kA breaker	$0.38	PECO	PECO	6/1/2019
b2865	Replace Seward 115kV breaker "Jackson Road" with 63kA breaker	$0.30	PENELEC	PENELEC	6/1/2019
b2866	Replace Seward 115kV breaker "Conemaugh N." with 63kA breaker	$0.30	PENELEC	PENELEC	6/1/2019
b2867	Replace Seward 115kV breaker "Conemaugh S." with 63kA breaker	$0.30	PENELEC	PENELEC	6/1/2019
b2868	Replace Seward 115kV breaker "No.8 Xfmr" with 63kA breaker	$0.30	PENELEC	PENELEC	6/1/2019
b2869	Replace the Crossland 138 kV breaker "B-16" with a 40 kA breaker	$0.25	ATSI	ATSI	6/1/2019
b2870	Build new 138/26 kV Newark GIS station in a building (layout #1A) located adjacent to the existing Newark Switch and demolish the existing Newark Switch	$275.00	PSEG	PSEG	6/1/2017
b2871	Rebuild 230kV line #247 from Swamp to Suffolk (31 miles) to current standards with a summer emergency rating of 1047 MVA at 230kV.	$31.00	Dominion	Dominion	12/30/2022
b2875	Relocate the Richland to Ridgeville 138KV line from Richland J bus to K, extend the K bus and install a new breaker.	$1.70	ATSI	ATSI	6/1/2019
b2878	Upgrade the Clifty Creek 345 kV risers	$0.10	AEP	AEP	6/1/2018
b2879.1	Replace wavetrap at the Stuart 345 kV substation	$0.90	Dayton	Dayton	6/1/2018
b2879.2	Re-conductor EKPC portion of the Stuart - Spurlock 345 kV line	$1.60	EKPC	EKPC	6/1/2018
b2896	Rebuild/Re-conductor the Black River – Lorain 138 kV circuit	$3.20	ATSI	ATSI	6/1/2021
b2897	Re-conductor the Avon – Lorain 138 kV section and upgrade line drop at Avon	$13.46	ATSI	ATSI	6/1/2021
b2898	Re-conductor the Beaver - Black River 138kV) with 954Kcmil ACSS conductor and upgrade terminal equipment on both stations	$19.97	ATSI	ATSI	6/1/2021

Reliability Project Multiple Zone Allocations

None.