Transmission Expansion Advisory Committee (TEAC) Recommendations to the PJM Board

PJM Staff Whitepaper
Jul. 2019

For Public Use

Executive Summary

On February 11, 2019, the PJM Board of Managers approved changes to the Regional Transmission Expansion Plan (RTEP), totaling $271.92 million, primarily to resolve baseline reliability criteria violations.

Since then, PJM has identified additional baseline reliability criteria violations and the transmission system enhancements needed to solve them, at an estimated cost of $400.08 million. In addition, 6 previously approved baseline projects have been canceled resulting in a net cost decrease of $121.9 million. Scope changes to existing projects will result in a net increase of $49.62 million. This yields an overall RTEP net increase of $327.8 million for which PJM is recommending Board approval. With these changes, RTEP projects will total $38,832.96 million since the first Board approvals in 2000.

PJM seeks Board Reliability Committee consideration and full Board approval of the additional RTEP baseline projects summarized in this white paper.

July 2019 Baseline Reliability Recommendations

A key dimension of PJM's RTEP process is baseline reliability evaluation, necessary before subsequent interconnection requests can be analyzed. Baseline analysis identifies system violations to reliability criteria and standards. PJM then develops transmission system enhancements to solve identified violations and reviews them with stakeholders through the Transmission Expansion Advisory Committee (TEAC) and Subregional RTEP committees prior to recommendation to the Board. Baseline reliability transmission enhancement costs are allocated to PJM load.

Baseline Reliability Projects Summary

A summary of baseline projects with estimated costs equal to or greater than $5 million is provided below. A complete listing of all recommended projects and their associated cost allocations is included in Attachment A (for allocation to a single zone) and Attachment B (for allocation to multiple zones). Projects with estimated costs less than $5 million typically include transformer replacements, line reconductoring, breaker replacements, and upgrades to terminal equipment, including relay and wave trap replacements.

Deactivation Driven Enhancements

AEP Transmission Zone:

- Rebuild the Delaware – Hyatt 138 kV line and replace conductors at Delaware and Hyatt substations: $16M

FERC Form No. 715 Transmission Owner Criteria Driven Enhancements

AEP Transmission Zone:

- Hartford City, IN area improvements, which includes the Royerton 138 kV, Bosman/Strawboard 69 kV, and Jay 138 kV station rebuilds, the Hartford City – Jay and Delaware – Bosman 69 kV line rebuilds, and new 138/69 kV transformer installations at the Royerton and Jay stations: $70.75M
- Construct the Amlin – Dublin 138 kV line, convert Dublin station from a straight bus into a ring configuration, and re-terminate the Britton underground cable to Dublin station: $39.29M
- Chadwick station area improvements, which includes the expansion of Chadwick station, installation of second 138/69 kV transformer, conversion of the 69 kV bus into a ring configuration, and reconductoring of the Chadwick – Leach and Chadwick – England Hill 69 kV lines: $16.9M
- Retire a large portion of the Clifford – Scottsville 46 kV circuit, and build new 138 kV infrastructure to two new distribution stations to serve load, along with required station upgrades to the Joshua Falls, Riverville, and Gladstone stations to accommodate the new 138 kV circuits: $85M
- Rebuild Berne – South Decatur 69 kV line: $16.6M

Dominion Transmission Zone:

- Rebuild Clifton – Ox 230kV and part of Clifton – Keene Mill 230kV lines: $22M
- Rebuild Chesterfield – Centralia 115kV line: $7M
- Rebuild Balcony Falls – Skimmer 115kV and Balcony Falls – Cushaw 115 kV lines: $20M

- Rebuild Loudoun – Dulles Junction 230 kV line, retire Loudoun – Bull Run 115 kV line, cut and loop Clifton – Sully 230 kV into Bull Run Substation, and required breaker additions and replacements: $14.54M
- Rebuild Carolina – South Justice Branch 115 kV line: $25M

Baseline Load Growth Deliverability & Reliability Driven Enhancements

AEP Transmission Zone:

- Rebuild 5.2 mile Bethel-Sawmill 138 kV line: $34.5M

Operational Performance Driven Enhancements

Dayton Transmission Zone:

- Install 100 MVAR reactors at Miami, Sugarcreek, and Hutchings 138 kV stations: $15M

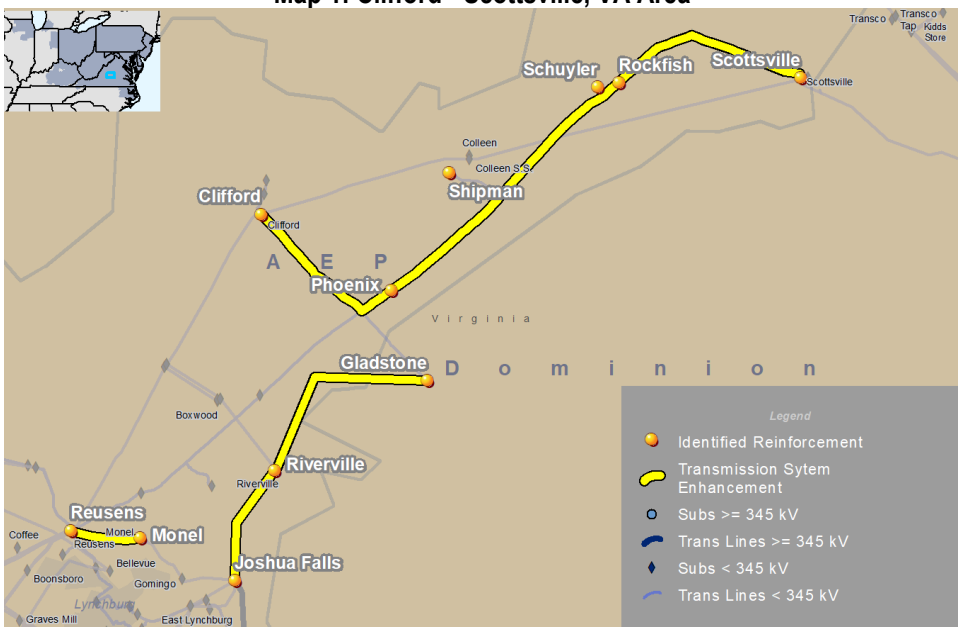
PJM is also recommending 10 projects totaling $17.5 million that include transformer replacements, minor rebuilds, and terminal equipment work whose individual cost estimates are less than $5 million each.

A more detailed description of the larger-scope projects that PJM is recommending to the Board is provided below: Descriptions include criteria driving the project need and required in-service date.

Baseline Project b3208: Clifford – Scottsville, VA Area
AEP Transmission Zone

In the 2022 PJM Winter RTEP case, PJM identified both thermal and voltage violations of AEP's Transmission Owner criteria. For the loss of both 138/46 kV transformers at Scottsville, the Clifford 138/69-46 kV transformer; the Clifford – Gladstone Tap 46 kV and the Gladstone Tap - Phoenix 46 kV line sections exceed their emergency ratings. In addition, all the 46 kV busses served by the Clifford-Scottsville 46 kV circuit experience extreme low voltage magnitude and drop violations resulting in a voltage collapse scenario. The 46 kV bus voltage violations include Scottsville, Esmont, Rockfish, Schuyler, Shipman, Phoenix, Gladstone, Clifford, and Piney River. Additionally, for the loss of both Clifford 138/69-46 kV transformers the Scottsville 138/46 kV transformer No. 5 exceeds its emergency rating and the same 46 kV bus voltages served by the Clifford – Scottsville 46 kV circuit experience extreme low voltage magnitude and drop violations.

Map 1: Clifford - Scottsville, VA Area



The recommended solution – Baseline Project b3208 – to address the Transmission Owner planning criteria violations has several components. The solution retires approximately 38 miles of the 44 mile long Clifford – Scottsville 46 kV circuit and builds two new distribution stations, along the Clifford-Scottsville line to serve the load formerly served by Phoenix, Shipman, Schuyler (AEP), and Rockfish stations. Additional components of this solution include new 138 kV lines from Joshua Falls to Riverville (approximately 10 miles) and Riverville to Gladstone (approximately 5 miles), and associated terminal equipment at Joshua Falls, Riverville, and Gladstone stations to accommodate the new 138 kV circuits. The project also includes the rebuild of Reusen – Monroe 69 kV (approximately 4 miles).

There are also supplemental needs in the area that were evaluated together with the baseline violations. The supplemental needs in the area are driven by equipment condition for the Amherst – Clifford 69 kV and Clifford – Scottsville 46 kV circuits. The lines were built in 1960 and 1926 respectively, on wood pole structures and have many open conditions due to rot, woodpecker/insect damage, split poles, broken insulators, and damaged shield wire. The recommended solution addresses both the baseline and supplemental needs in the area and is the most

cost effective. The estimated cost for this project is $85 million, and the required in-service date is December, 2022. Based on their FERC 715 TO Criteria, the local transmission owner, AEP, will be designated to complete this work.

Increased Real-Time Operational Capability
AEP and Dayton Transmission Zones

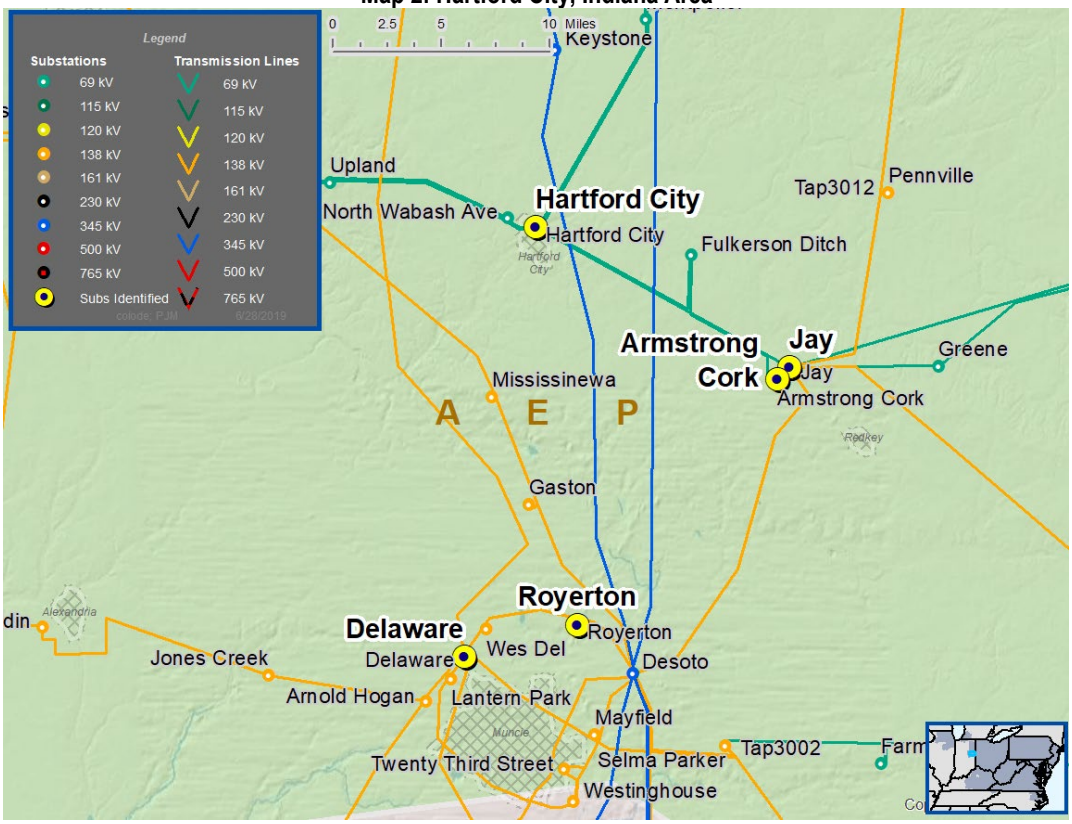
PJM worked closely with the AEP and Dayton to develop the following baseline upgrades to address operational performance and increase real-time operational capability:

- Baseline upgrade b3103 (Hartford City, IN area improvements) in AEP
- Baseline upgrade b3108 (Install 100 MVAR reactors at Miami, Sugarcreek, and Hutchings 138 kV stations) in Dayton

Baseline Project b3103: Hartford City, IN Area Improvements

In the 2022 and 2023 Summer RTEP case, following the correction of the Armstrong Cork load model (increase of approximately 10MW), PJM identified thermal violations of AEP's Transmission Owner criteria. For the loss of the Jay and Deer Creek 138/69/34.5kV banks, the Delaware – Bosman 34.5kV and Bosman – Hartford 34.5kV circuits are overloaded. Additionally, for the loss of the Deer Creek 138/69/34.5kV transformer and Bosman – Delaware 34.5kV line, the Armstrong Cork – Fulkerson 69kV and Fulkerson – 3M 69 kV circuits are overloaded. These issues were validated by the high number of Post Contingency Local Load Relief Warnings (PCLLRWs) in the area. This area has received PCLLRW's on February 26, 2018 (two different instances on this day due to Deer Creek 138/69/34.5kV transformer being out of service); February 6, 2018; January 9, 2018; July 24, 2017; and July 14, 2017 for the loss of Jay transformer with several of these PCLLRW's lasting multiple days. PJM worked closely with AEP and Operations to review the issues to develop the recommended solution.

Map 2: Hartford City, Indiana Area



The recommended solution – Baseline Project b3103 – to address the Transmission Owner planning criteria violations and real-time operational issues has several components that affect the following stations and lines:

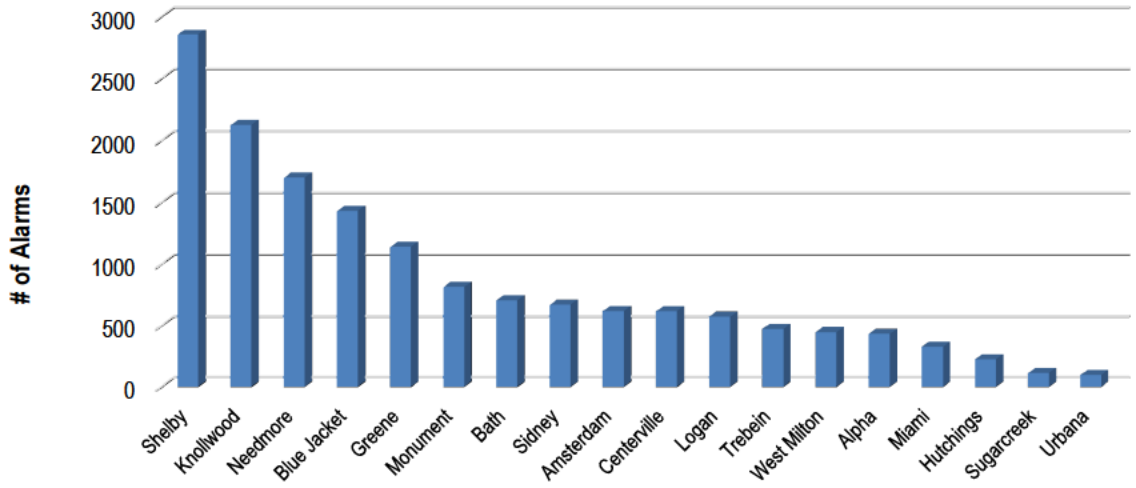
- Royerton: Install a 138/69kV transformer. Install a 69kV bus with one 69kV breaker toward Bosman station. Rebuild the 138kV portion into a ring bus configuration built for future breaker and a half with 4 138kV breakers.
- Bosman/Strawboard: Rebuild this station in the clear across the road to move it out of the flood plain and bring it up to 69kV standards.
- Delaware: Retire Breaker L and re-purpose M for the Jay line.
- Hartford City: Retire all 34.5kV equipment. Re-purpose breaker M for the Bosman line 69kV exit.
- Jay: Rebuild the 138kV portion of this station as a 6 breaker, breaker and a half station re-using the existing breakers "A", "B" and "G". Rebuild the 69kV portion of this station as a 6 breaker ring bus re-using the 2 existing 69kV breakers. Install a new 138/69kV transformer.
- Hartford City – Jay: Rebuild the 69kV Hartford City – Armstrong Cork line but instead of terminating it into Armstrong Cork, terminate it into Jay station.
- Armstrong Cork – Jay #2: Build a new 69kV line from Armstrong Cork – Jay station.
- Delaware – Bosman: Rebuild the 34.5kV Delaware – Bosman line as the 69kV Royerton – Strawboard line. Retire from Royerton – Delaware station

The recommended solution addresses AEP Transmission Owner planning criteria violations and is expected to improve real-time operational capability. The estimated cost for this project is $70.75 million, with a required in-service date of June, 2022. Based on their FERC 715 TO Criteria, the local transmission owner, AEP, will be designated to complete this work.

Baseline Project b3108: Installation of Reactors at Miami, Sugarcreek, and Hutchings 138 kV stations

Dayton has been experiencing an excessive amount of high voltage alarms during light load periods, amounting to approximately 19,000 operational alarms which were logged in 2017 and 2018, including 327 alarms at 345 kV buses. It appears the number of the high voltage alarms has been trending up, as more alarms were logged in 2018 with fewer minimum load hours in comparison to 2017. The high voltage alarms to minimum load hour ratio almost doubled from 2017 to 2018. Figure 1 below shows the number of alarms by 138 kV station, starting in January, 2017 through December, 2018:

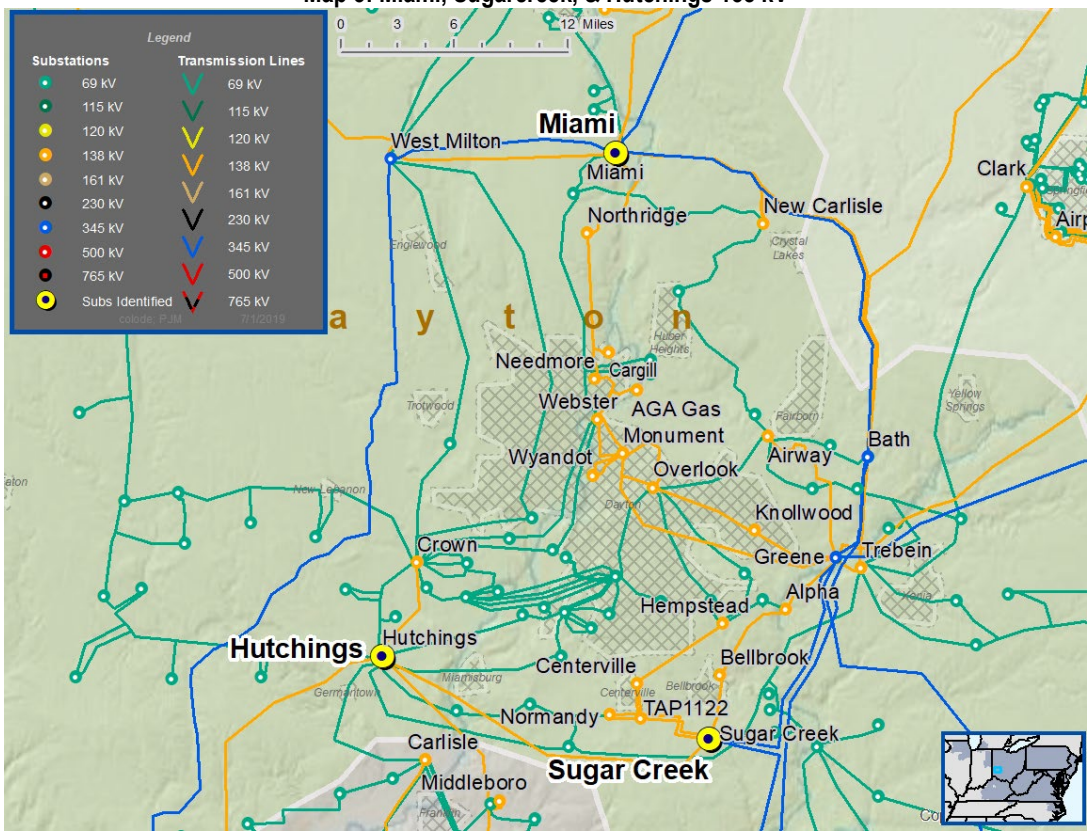
Figure 1: Alarms by 138 kV Substation 1/2017 - 12/2018



Dayton also has limited means to control high voltage due to the Killen and Stuart generator retirements in 2018 and the Hutchings retirements in 2015, which resulted in a total loss of approximately 600 MVAR of reactive absorption

capability. After exhausting all typical operating procedures, Dayton is frequently forced to switch out equipment to avoid long-term damage from high voltage exposure. This practice of switching out equipment is not a sustainable operating practice and does not effectively solve the high voltage issues. As a result of the retirements, there are only peaking plants left in the Dayton transmission zone, and there are no existing or planned devices such as SVC's, Statcoms, or reactors.

Map 3: Miami, Sugarcreek, & Hutchings 138 kV



PJM worked closely with Dayton to determine what operational and planning changes are available, including the review of EMS snapshots to confirm the high voltage issues experienced during light load periods, and examining impacts of planned, approved reactive upgrades. The outcome of the investigation resulted in the recommended solution, which is to install a total of three 100 MVAR reactors, one each at the Miami, Sugarcreek, and Hutchings 138 kV substations. The estimated cost for this project is $15 million, and it is an immediate need project with a projected in-service date of December, 2021. Dayton will be designated to complete this work.

Dominion Transmission Zone End-of-life Rebuilds

There are six baseline projects recommended for approval in the Dominion Transmission zone, which include complete and partial rebuilds of 230 kV and 115 kV lines, due to violation of Dominion's FERC Form No. 715 filed "End of Life Criteria", Section C.2.9 regarding age and facility condition. All of the projects are immediate need, and the projected in-service date is provided below. Industry guidelines indicate the following equipment life:

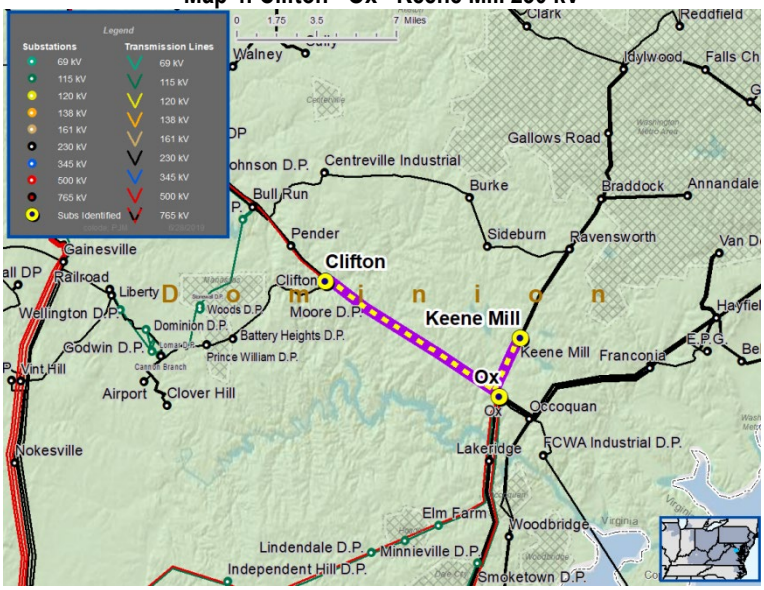
- wood structures: 35-55 years
- conductor and connectors: 40-60 years
- porcelain insulators: 50 years

The lines and structures identified under Dominion's "End of Life Criteria" show sufficient deterioration, indicating they have reached the end of their useful service life.

Baseline Project b3096: Rebuild Clifton – Ox 230kV and Part of Clifton – Keene Mill 230kV Lines

The Clifton – Ox 230kV line is about 7.16 miles long and was constructed on Cor-ten lattice-type double circuit towers in the 1960s. Roughly 7.1 mile long section from Clifton – Keene Mill 230kV is on the same structures. These towers have inherent corrosion problems that continuously deteriorate the steel members. Clifton – Keene Mill 230kV is also part of the network feed to Idylwood substation supplying over 100 MW of load required to meet Dominion's Transmission planning criteria.

Map 4: Clifton - Ox - Keene Mill 230 kV



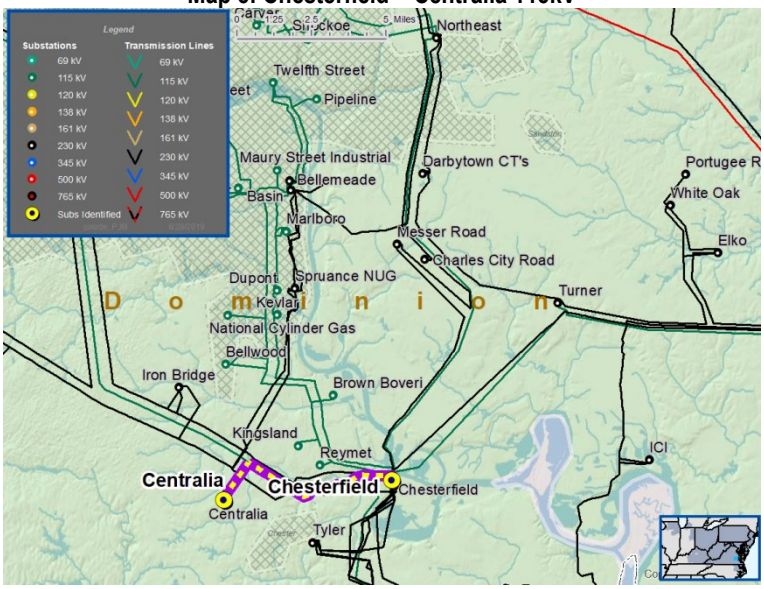
The recommended solution is to rebuild the Clifton – Ox 230kV and part of Clifton – Keene Mill 230kV lines with double circuit steel structures, using double circuit conductor at current 230kV northern Virginia standards, with a minimum rating of 1200 MVA. The estimated cost for this project is $22 million, and the projected in-service date is December, 2024. Dominion will be designated to complete this work.

Baseline Project b3097: Rebuild Chesterfield – Centralia 115kV Line

The line section from Chesterfield – Centralia 115kV, approximately 4 miles long, was constructed on wood H-frame structures in 1951. Additionally, the circuit provides service to River Road, Stratford Hills and Centralia substation

with a total load of 50 MWs. Removing Chesterfield – Centralia 115kV section from service creates a 20.7-mile radial line from Northwest to Centralia with 50 MWs, which is a violation of Dominion's 700 MW-Mile planning criteria[1].

Map 5: Chesterfield – Centralia 115kV



The recommended solution is to rebuild Chesterfield – Centralia 115kV to current standards with a minimum summer emergency rating of 393 MVA. The estimated cost for this project is $7 million, and the projected in-service date is May, 2020. Dominion will be designated to complete this work.

Baseline Project b3098: Rebuild Balcony Falls – Skimmer 115kV and Balcony Falls – Cushaw 115 kV Lines

The Balcony Falls – Skimmer 115kV circuit extends 9.8 miles, and shares structures with a secondary line, Balcony Falls – Cushaw 115 kV, which is 3.8 miles in length. The lines were constructed in the 1920's on a combination of double circuit Blaw Knox structures and single circuit wood H-frame structures. Removing Balcony Falls – Skimmer 115kV from service creates a 29 mile radial line from Skimmer to Altavista that violates Dominion's 700 MW-Mile planning criteria. The secondary line Balcony Falls – Cushaw 115 kV connects to a radial hydroelectric generator, and not rebuilding the line strands the generation at Cushaw 115 kV.

[1] C.2.6. Radial transmission lines

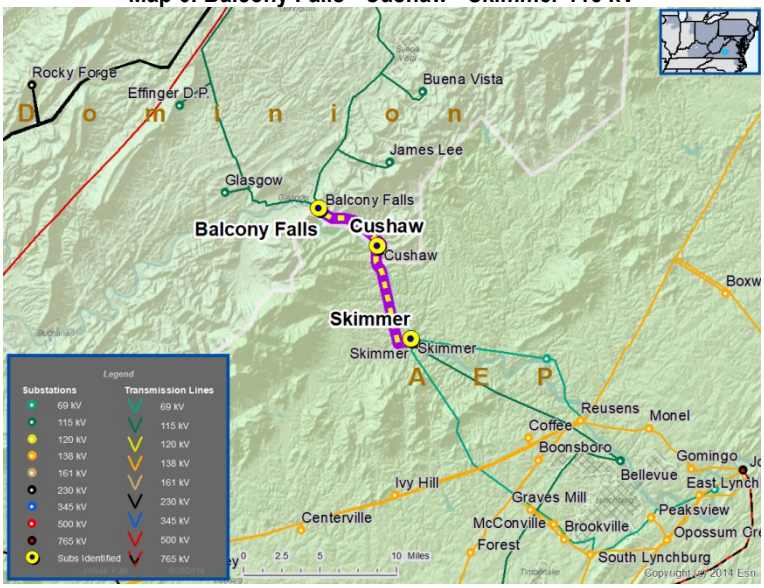
A Radial transmission line is defined as a single line that has one transmission source, serves load, and does NOT tie to any other transmission source (line or substation). Dominion Energy – Electric Transmission Planning Criteria Version 16 Effective 3/15/2019 Page 17 of 32 Unlike load served from a network transmission line having two sources where a downed conductor or structure can be sectionalized for load to be served before repairs are completed, load served from a single source radial transmission line cannot be reenergized until all repairs to the line are completed. Accordingly, loading on single source radial transmission lines will be limited to the following:

- 100 MW Maximum
- 700 MW-Mile Exposure (MW-Mile = Peak MW X Radial Line Length)

Once a radial loading limit exceeds any of these thresholds, an additional transmission source is required. Acceptable transmission source includes but is not limited to the following:

- Network from a separate transmission substation source (Preferred)
- Loop back to same transmission substation source
- Normally open network or loop transmission source

Map 6: Balcony Falls - Cushaw - Skimmer 115 kV

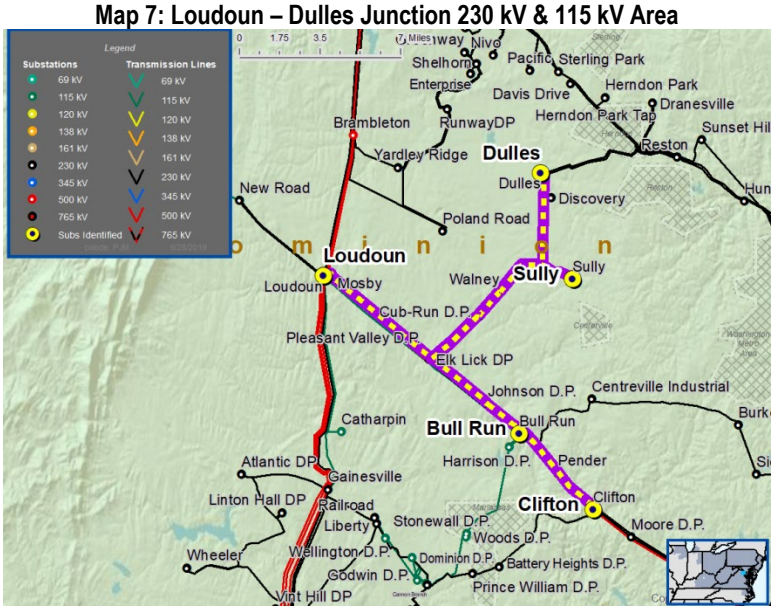


The recommended solution is to rebuild 9.2 miles of Balcony Falls – Skimmer 115kV and 3.8 miles of Balcony Falls – Cushaw 115 kV to current standards with a minimum rating of 261 MVA. The estimated cost for this project is $20 million, and the projected in-service date is December, 2023. Dominion will be designated to complete this work.

Baseline Project b3110: Rebuild Loudoun – Dulles Junction 230 kV Line

The 4.4 mile long section between Loudoun – Dulles Junction 115kV and 230kV circuits were constructed on Cor-ten lattice-type double circuit towers. These towers have inherent corrosion problems that continuously deteriorate the steel members, and have been identified to be rebuilt or retired as part of Dominion's "End of Life Criteria". Removing the section of Loudoun – Dulles Junction 230 kV would cause over 241 MWs of load, including the whole Dulles Substation, to be radial. Additionally, a failed breaker contingency at Reston Substation would lead to over 311 MW of load to be dropped, which are required to meet Dominion's Transmission planning criteria.

Map 7: Loudoun – Dulles Junction 230 kV & 115 kV Area

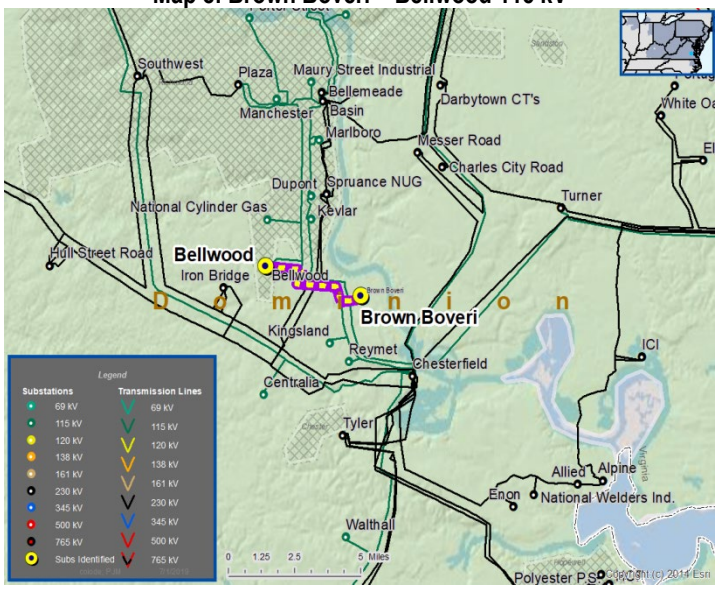


The recommended solution is to rebuild Loudoun – Dulles Junction 230 kV using single circuit conductor with minimum summer ratings of 1200 MVA. The project also includes the retirement of the Loudoun – Bull Run 115 kV line, which is approximately 8.44 miles, and to cut and loop Clifton – Sully 230 kV into Bull Run Substation. The solution adds three 230kV breakers at Bull Run to accommodate the new line and upgrade the substation, and replaces the Bull Run 230kV breakers "200T244" and "200T295" with 63kA breakers, which were identified in short circuit analysis during the evaluation of this project. The estimated cost for this project is $14.54 million, and the projected in-service date is December, 2023. Dominion will be designated to complete this work.

Baseline Project b3113: Rebuild Plaza – Chesterfield and Kevlar – Chesterfield 115 kV Lines

Approximately 1 mile of Plaza – Chesterfield 115 kV and Kevlar – Chesterfield 115 kV lines were constructed in 1956 on double circuit 3 pole wood H-frame structures, which had been identified to be rebuilt or retired as part of Dominion's "End of Life Criteria". Plaza – Chesterfield 115 kV provides service to National Cylinder Gas, Bellwood, Brown Boveri, Kingsland and Reymet substations with a total load of 21.5 MWs. Brown Boveri substation is tapped from the identified 1 mile line section to be rebuilt.

Map 8: Brown Boveri – Bellwood 115 kV

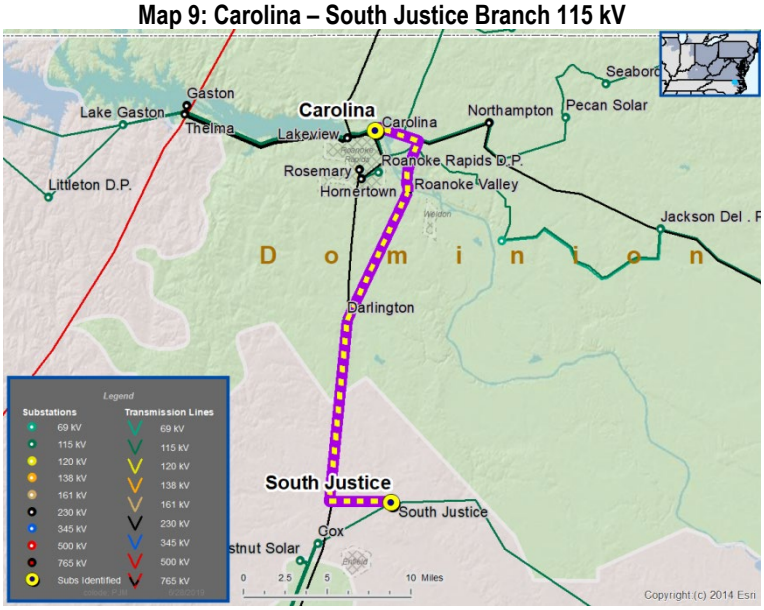


The recommended solution is to rebuild approximately 1 mile of Plaza – Chesterfield 115 kV and Kevlar – Chesterfield 115 kV to current standards with a minimum summer emergency rating of 393 MVA. The resulting summer emergency rating of Plaza – Chesterfield 115 kV segment from Brown Boveri to Bellwood is 180 MVA. There is no change to the Kevlar – Chesterfield 115 kV ratings. The estimated cost for this project is $3 million, and the projected in-service date is December, 2019. Dominion will be designated to complete this work.

Baseline Project b3114: Rebuild Carolina – South Justice Branch 115 kV Line

The Carolina – South Justice Branch 115 kV, which is 21.6 miles, serves 3 delivery points: Roanoke Rapids DP, Darlington DP, and Hornertown. The majority of the circuit is wood H-frames, constructed in 1959. There are two sections, 1.7 miles total, within the 18.6 mile section, which has 115 kV and 230 kV double circuit structures that are V series Corten. The remaining 3 mile 115 kV double circuit tap to South Justice Branch was constructed in 2015 and does not require replacement.

Map 9: Carolina – South Justice Branch 115 kV



The recommended solution is to rebuild the 18.6 mile section of Carolina – South Justice Branch 115 kV which includes 1.7 miles of double circuits. This segment of Carolina – South Justice Branch 115 kV will be rebuilt to current standards with a minimum rating of 261 MVA. The secondary circuit rating will not change. The estimated cost for this project is $25 million, and the projected in-service date is December, 2025. Dominion will be designated to complete this work.

Transmission Owner Criteria Projects

Of the $400.08 million of the new recommended baseline transmission system enhancements, approximately $331.54 million is driven by Transmission Owner planning criteria, which makes up almost 83% of the new project cost estimates. All but one of the detailed project descriptions provided above are driven by the local Transmission Owner planning criteria.

Changes to Previously Approved Projects

PJM recommends that the Board cancel the following projects:

- Baseline project b1690 (Build a new third 230 kV line into the Red Bank 230 kV substation) is recommended for cancellation due to recent proceedings. PJM and First Energy are working on alternative solutions to address the reliability violations.
- Baseline project b2676 (Install one 72 MVAR fast switched capacitor at the Englishtown 230 kV substation) is recommended for cancellation due to a lower load forecast and other area upgrades.
- Baseline projects b2843, b2844, and b2848 (Replace the Mount Storm 500kV "G2TY," "G2TZ," and "Z72" with 50kA breakers) are recommended for cancellation due to the manufacturer identifying the existing breakers are capable of 44 kA, mitigating the over duty condition.
- Baseline project b2966 (Reconductor the Yukon - Smithton - Shepler Hill Jct 138 kV line and replace line disconnect switch at Yukon) is recommended for cancellation due to scope change for b3012, which eliminates the need for this project.

These changes yield a net RTEP decrease of $121.9 million.

PJM is modifying the scope/cost of the following projects:

- Baseline project b1570.4 (Add a 345 kV breaker at Marysville station and a 0.1 mile 345 kV line extension from Marysville to the new 345/69 kV Dayton transformer) was added to the project to clarify the AEP portion of the scope of work. The total project cost has also increased from $16M to $20.1M based on updated engineering estimates.
- Baseline project b2626 (Rebuild the 2.5 mile tap line to Fort Eustis as double circuit line to loop the line in and out of Fort Eustis station to current standard with a summer emergency rating of 393 MVA at 115 kV. Install a 115 kV breaker in line No.34 at Fort Eustis station) has had an increase in scope based on Dominion's Facility Interconnection Requirements for tap lines longer than 1 mile. The project cost has increased from $24M to $35.7M.
- Baseline project b2686.4 (Replace the Remington CT 230kV breaker "2114T2155" with a 63kA breaker) was added to the project due to the overdutied breaker identified in short circuit analysis. The total project cost has increased from $103.7M to $104M.
- Baseline project b2761.1 (Replace and relocate the Hazard 161/138 kV transformer and circuit breaker 'M'. Upgrade protection scheme on the new transformer including installation of low side breaker) and b2761.3 (Rebuild the Hazard – Wooton 161 kV line utilizing 795 26/7 ACSR conductor with 300 MVA rating. Replace line relaying and associated termination equipment) have been updated to provide clarification to the existing project scope. The total project cost has also increased from $18.78M to $20.6M primarily due to the transformer needing to be relocated because of space limitations and the removal of the original transformer.
- Baseline project b2833 (Reconductor the Maddox Creek – East Lima 345 kV circuit with two 954 ACSS Cardinal conductor) cost has increased from $18.2M to $30.5M due to a couple of factors. The first factor is resulting from a detailed access plan review, which showed a much higher cost expected if traditional access roads were used to perform the construction, and as a result, helicopter construction will be used as a more cost-effective approach, increasing cost by $6M. The second factor was labor and material costs for tower and hardware assemblies which were updated, resulting in a $6.3M cost increase.
- Baseline project b2970.5 (Convert Garfield 138/12.5 kV substation to 230/12.5 kV) cost has increased from $13.33M to $15.53M due to addition work required at Garfield 138/12.5 kV station to convert to 230/12.5 kV,

which would allow the connection to the Ring Gold – Catoctin 138 kV circuit that will be converted to 230 kV as part of the b2970 project.

- Baseline project b2981 (Rebuild Fredericksburg – Aquia Harbor 115kV line segment to current 230kV standards, utilizing steel H-frame structures with two 636 ACSR conductor to provide a normal continuous summer rating of 524 MVA at 115kV) cost has increased from $12.5M to $20M due to detailed cost estimate compared to the conceptual cost estimate previously provided.
- Baseline project b3011.7 (Replace the line terminal equipment and line breaker #85 at Dravosburg 138 kV substation in the Elwyn Z-70 line position/bay, with the breaker duty as 63KA) was added to the project due to the overdutied breaker identified in short circuit analysis. The total project cost has increased from $27.6M to $28.5M.
- Baseline project b3012 (Construct two new 138 kV ties between Elrama – Route 51 using double circuit construction, and a new Elrama - Route 51 138 kV No.3 line) has experienced a scope change which eliminates the need for baseline project b2966 (which decreases the transmission enhancement costs in the area) and increases the transmission capability in the area. The total project cost has increased from $41.1M to $46.8M.
- Baseline project b3064.2 (Replace the West Mifflin 138 kV breakers “Z-94”, “Z-74”, “Z-14” and “Z-13” with 63kA breakers) was added to the project due to the overdutied breakers identified in short circuit analysis. The total project cost has increased from $8.75M to $11.85M.

These changes yield a net RTEP increase of $49.62 million, which represents approximately a 17.5% cost increase for these projects.

Review by the Transmission Expansion Advisory Committee (TEAC)

Project needs and recommended solutions as discussed in this report were reviewed with stakeholders during 2019, most recently at the June 2019 TEAC and Subregional RTEP Committee meetings. Written comments were requested to be submitted to PJM to communicate any concerns with project recommendations. No comments have been received as of this white paper publication date.

Cost Allocation

Cost allocations for recommended projects are shown Attachment A (for allocation to a single zone) and Attachment B (for allocation to multiple zones).

Cost allocations were calculated in accordance with Schedule 12 of the Open Access Transmission Tariff (OATT). Baseline reliability project allocations are calculated using a distribution factor methodology that allocates 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 No. 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 was requested to endorse the new baseline reliability projects and associated cost allocations and recommend to the full Board approval of the projects in this white paper to be included in PJM's RTEP. The baseline projects will be incorporated into the published RTEP after approval by the PJM Board. The RTEP will be published on PJM's website.

Attachment A - Reliability Project Single Zone Allocations

Upgrade ID	Description	Cost Estimate ($M)	Trans Owner	Cost Responsibility	Required IS Date
b1570.4	Add a 345 kV breaker at Marysville station and a 0.1 mile 345 kV line extension from Marysville to the new 345/69 kV Dayton transformer.	$4.10	AEP	AEP	6/1/2021
b2686.4	Replace the Remington CT 230 kV breaker "2114T2155" with a 63 kA breaker	$0.30	Dominion	Dominion	6/1/2019
b2970.5	Convert Garfield 138/12.5 kV substation to 230/12.5 kV	$2.20	APS	APS	6/1/2020
b3011.7	Replace the line terminal equipment and line breaker #85 at Dravosburg 138 kV substation in the Elwyn Z-70 line position/bay, with the breaker duty as 63KA	$0.90	DL	DL	6/1/2021
b3012.3	Construct a new Elrama - Route 51 138 kV No.3 line: reconductor 4.7 miles of the existing line, and construct 1.5 miles of a new line to the reconductored portion. Install a new line terminal at APS Route 51 substation.	$18.10	APS	DL	6/1/2020
b3012.4	Establish the new tie line in place of the existing Elarama - Mitchell 138 kV line	$1.00	DL	DL	6/1/2021
b3064.2	Replace the West Mifflin 138 kV breakers "Z-94", "Z-74", "Z14", and "Z-13" with 63 kA breakers	$3.10	DL	DL	6/1/2021
b3096	Rebuild 230 kV Line #2063 and Partial 230 kV Line #2164 with double circuit steel structures using double circuit conductor at current 230 kV northern Virginia standards with a minimum rating of 1200 MVA.	$22.00	Dominion	Dominion	6/1/2019
b3097	Rebuild 4 miles of 115kV Line #86 between Chesterfield and Centralia to current standards with a minimum summer emergency rating of 393 MVA.	$7.00	Dominion	Dominion	6/1/2019
b3098	Rebuild 9.8 miles of 115kV Line #141 between Balcony Falls and Skimmer and 3.8 miles of 115kV Line #28 between Balcony Falls and Cushaw to current standards with a minimum rating of 261 MVA.	$20.00	Dominion	Dominion	6/1/2019
b3099	Install a 138 kV 3000 A 40 kA circuit switcher on the high side of the existing 138/34.5 kV transformer No.5 at Holston station.	$0.70	AEP	AEP	6/1/2022
b3100	Replace 138 kV MOAB switch "YY" with a new 138 kV circuit switcher on the high side of Chemical transformer No.6.	$0.70	AEP	AEP	12/1/2022
b3101	Rebuild the 1/0 Cu. conductor sections (~1.5	$3.00	AEP	AEP	12/1/2023

	miles) of the Fort Robinson - Moccasin Gap 69 kV line section (~5 miles) utilizing 556 ACSR conductor and upgrade existing relay trip limit (WN/WE: 63 MVA , line limited by remaining conductor sections).				
b3102	Replace existing 50 MVA 138/69 kV transformers #1 and #2 (both 1957 vintage) at Fremont station with new 130 MVA 138/69 kV transformers.	$4.10	AEP	AEP	12/1/2022
b3103.1	Install a 138/69 kV transformer at Royerton station. Install a 69 kV bus with one 69 kV breaker toward Bosman station. Rebuild the 138 kV portion into a ring bus configuration built for future breaker and a half with four 138 kV breakers.	$10.25	AEP	AEP	6/1/2022
b3103.2	Rebuild the Bosman/Strawboard station in the clear across the road to move it out of the flood plain and bring it up to 69kV standards.	$4.47	AEP	AEP	6/1/2022
b3103.3	Retire 138 kV breaker L at Delaware station and re-purpose 138 kV breaker M for the Jay line.	$0.18	AEP	AEP	6/1/2022
b3103.4	Retire all 34.5 kV equipment at Hartford City station. Re-purpose breaker M for the Bosman line 69 kV exit.	$0.88	AEP	AEP	6/1/2022
b3103.5	Rebuild the 138 kV portion of Jay station as a 6 breaker, breaker and a half station re-using the existing breakers “A”, “B” and “G”. Rebuild the 69 kV portion of this station as a 6 breaker ring bus re-using the 2 existing 69 kV breakers. Install a new 138/69kV transformer.	$18.73	AEP	AEP	6/1/2022
b3103.6	Rebuild the 69 kV Hartford City – Armstrong Cork line but instead of terminating it into Armstrong Cork, terminate it into Jay station.	$21.12	AEP	AEP	6/1/2022
b3103.7	Build a new 69 kV line from Armstrong Cork – Jay station.	$2.35	AEP	AEP	6/1/2022
b3103.8	Rebuild the 34.5 kV Delaware – Bosman line as the 69 kV Royerton – Strawboard line. Retire the line section from Royerton to Delaware stations.	$12.78	AEP	AEP	6/1/2022
b3104	Perform a sag study on the Polaris - Westerville 138 kV line (~ 3.6 miles) to increase the Summer Emergency rating to 310 MVA.	$0.50	AEP	AEP	6/1/2020
b3105	Rebuild the Delaware – Hyatt 138 kV line (~ 4.3 miles) along with replacing conductors at both Hyatt and Delaware substations.	$16.00	AEP	AEP	6/1/2020

b3106	Perform a sag study on the Hyatt - Maliszewski 138 kV line (~ 6.8 miles) to increase the Summer Emergency rating.	$0.50	AEP	AEP	6/1/2020
b3108.1	Install 100 MVAR reactor at Miami 138 kV substation	$5.00	Dayton	Dayton	1/0/1900
b3108.2	Install 100 MVAR reactor at Sugarcreek 138 kV substation	$5.00	Dayton	Dayton	1/0/1900
b3108.3	Install 100 MVAR reactor at Hutchings 138 kV substation	$5.00	Dayton	Dayton	1/0/1900
b3109	Rebuild 5.2 mile Bethel-Sawmill 138 kV line including ADSS.	$34.50	AEP	AEP	6/1/2019
b3110.1	Rebuild Line #2008 between Loudoun to Dulles Junction using single circuit conductor at current 230 kV northern Virginia standards with minimum summer ratings of 1200 MVA. Cut and loop Line #265 (Clifton – Sully) into Bull Run Substation. Add three (3) 230 kV breakers at Bull Run to accommodate the new line and upgrade the substation.	$14.00	Dominion	Dominion	6/1/2019
b3110.2	Replace the Bull Run 230 kV breakers "200T244" and "200T295" with 50 kA breakers.	$0.54	Dominion	Dominion	6/1/2019
b3111	Install high-speed backup clearing scheme on the E. Frankfort – Matteson 138 kV line (L6603)	$0.50	ComEd	ComEd	6/1/2020
b3112	Construct a single circuit 138 kV line (~3.5 miles) from Amlin to Dublin using 1033 ACSR Curlew (296 MVA SN), convert Dublin Station into a ring configuration, and re-terminating the Britton UG cable to Dublin Station.	$39.29	AEP	AEP	6/1/2020
b3113	Rebuild approximately 1 mile of 115 kV Line #72 and #53 to current standards with a minimum summer emergency rating of 393 MVA. The resulting summer emergency rating of Line #72 segment from Brown Boveri to Bellwood is 180 MVA. There is no change to Line #53 ratings.	$3.00	Dominion	Dominion	6/1/2019
b3114	Rebuild the 18.6 mile section of 115 kV Line #81 which includes 1.7 miles of double circuit Line #81 and 230 kV Line #2056. This segment of line of 81 will be rebuilt to current standards with a minimum rating of 261 MVA. Line 2056 rating will not change.	$25.00	Dominion	Dominion	6/1/2019
b3115	- Provide new station service to control building from 230 kV bus (served from plant facilities presently).	$1.50	ME	ME	9/30/2019

b3116	Replace existing Mullens 138/46 kV 30 MVA transformer No.4 and associated protective equipment with a new 138/46 kV 90 MVA transformer and associated protective equipment.	$3.00	AEP	AEP	12/1/2022
b3118.1	Expand existing Chadwick station and install a second 138/69 kV transformer at a new 138 kV bus tied into the Bellefonte – Grangston 138 kV circuit. The 69 kV bus will be reconfigured into a ring bus arrangement to tie the new transformer into the existing 69 kV via installation of four 3000A 63 kA 69 kV circuit breakers.	$9.30	AEP	AEP	6/1/2022
b3118.10	Replace 69 kV line risers (towards Chadwick) at Leach station	$0.10	AEP	AEP	6/1/2022
b3118.2	Perform 138 kV remote end work at Grangston station.	$0.50	AEP	AEP	6/1/2022
b3118.3	Perform 138 kV remote end work at Bellefonte station.	$0.50	AEP	AEP	6/1/2022
b3118.4	Relocate the Chadwick – Leach 69 kV circuit within Chadwick station.	$0.50	AEP	AEP	6/1/2022
b3118.5	Terminate the Bellefonte – Grangston 138 kV circuit to the Chadwick 138 kV bus	$1.10	AEP	AEP	6/1/2022
b3118.6	Chadwick – Tri-State #2 138 kV circuit will be reconfigured within the station to terminate into the newly established 138 kV bus #2 at Chadwick due to construability aspects.	$0.10	AEP	AEP	6/1/2022
b3118.7	Reconductor Chadwick-Leach and Chadwick-England Hill 69 kV lines with 795 ACSS conductor. Perform a LiDAR survey and a sag study to confirm that the reconductored circuits would maintain acceptable clearances.	$3.30	AEP	AEP	6/1/2022
b3118.8	Replace 20 kA 69 kV circuit breaker 'F' at South Neal station with a new 3000A 40 kA 69 kV circuit breaker. Replace line risers towards Leach station.	$0.00	AEP	AEP	6/1/2022
b3118.9	Rebuild 336 ACSR portion of Leach - Miller S.S 69 kV line section (~0.3 miles) with 795 ACSS conductor.	$1.50	AEP	AEP	6/1/2022

b3208	Retire approximately 38 miles of the 44 mile Clifford-Scottsville 46 kV circuit. Build new 138 kV "in and out" to two new Distribution stations to serve the load formerly served by Phoenix, Shipman, Schuyler (AEP), and Rockfish stations. Construct new 138 kV lines from Joshua Falls-Riverville (~10 mi.) and Riverville-Gladstone (~5 mi.). Install required station upgrades at Joshua Falls, Riverville and Gladstone stations to accommodate the new 138 kV circuits. Rebuild Reusen – Monroe (~4 mi.)	$85.00	AEP	AEP	12/1/2022
b3209	Rebuild the 10.5 mile Berne – South Decatur 69 kV line using 556 ACSR in order to alleviate the overload and address a deteriorating asset.	$16.60	AEP	AEP	6/1/2022

Attachment B - Reliability Project Multi-Zone Allocations

Upgrade ID	Description	Cost Estimate ($M)	Trans Owner	Cost Responsibility	Required IS Date
b3012.1	Construct two new 138 kV ties with the single structure from APS's new substation to DUQ's new substation. The estimated line length is approximately 4.7 miles. The line is planned to use multiple ACSS conductors per phase.	$23.10	APS	ATSI (38.21%)/DL (61.79%)	6/1/2021
b3012.2	Construct two new ties from a new First Energy substation to a new Duquesne substation by using two separate structures - Duquesne portion.	$4.60	DL	ATSI (38.21%)/DL (61.79%)	6/1/2021