2013 PJM RTEP - Market Efficiency Proposal Solutions

Solution 1: Loudoun TCSC

Solution 2: Morrisville TCSC

Solution 3: Mt. Storm TCSC

Dominion Virginia Power
701 E. Cary Street Richmond, VA 23219
September 26, 2013

Virginia Electric and Power Company (Dominion Virginia Power) is submitting this proposal with the intent to be considered as the Designated Entity to construct, own, operate, maintain, and finance the proposed solutions.

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Executive Summary

Virginia Electric and Power Company (Dominion Virginia Power, or Dominion), is proposing three separate solutions in response to PJM's Request For Proposal (RFP) dated August 12, 2013, in which PJM seeks technical solution alternatives (hereinafter referred to as "Solutions") to relieve constraints on PJM internal facilities identified on the list of Top 24 congestion events for the 2013 Market Efficiency Analysis from study years 2017, 2020, and 2023.

Specifically, Dominion is proposing the following three individual solutions:

1. **Loudoun TCSC**
   Install a Thyrister-controlled Series Capacitor (TCSC) on 500 kV Line #535 (Loudoun – Meadow Brook) at Loudoun Switching Station.

2. **Morrisville TCSC**
   Install a Thyrister-controlled Series Capacitor (TCSC) on 500 kV Line #541 (Morrisville – Front Royal) at Morrisvillle Switching Station.

3. **Mt. Storm TCSC**
   Install a Thyrister-controlled Series Capacitor (TCSC) on 500 kV Line #529 (Mount Storm – Meadow Brook) at Mount Storm Switching Station.

Each individual proposed solution is a unique, stand-alone solution which helps mitigate congestion costs on the PJM AP South Interface. PJM can also choose to combine two or more of these solutions at its discretion should it want to maximize potential congestion savings on the AP South Interface. Each proposed solution will be installed at an existing 500 kV Switching Station all within the boundaries of existing property already owned by Dominion.

Dominion is submitting these solutions as the Designated Entity to construct, own, operate and finance should PJM select and approve as a baseline upgrade. All three solutions are being proposed at existing substation facilities within Dominion existing PJM Southern Region and will be operated along with its existing 6300 miles of transmission and over 790 substations in Virginia, North Carolina and West Virginia.

As discussed in the Pre-Qualification package for Virginia Electric and Power Company (Dominion Virginia Power), Dominion has demonstrated its qualifications to construct, own, and operate electric facilities. All qualification information on record with PJM and posted on PJM's website reflects the company's current qualifications to be eligible for Designated Entity status as defined in the PJM Amended and Restated Operating Agreement ("PJM OA") in Section 1.5.8(a) (FERC acceptance pending.)

Solution 1:

Loudoun TCSC

Line #535 (Loudoun – Meadow Brook)

1.1 Summary of Solution 1

Dominion is proposing Solution 1 to install a Thyristor-controlled Series Capacitor (TCSC) on 500 kV Line #535 (Loudoun – Meadow Brook) in order to increase the transfer capability of AP South interface and other facilities in PJM to improve the market efficiency of the entire PJM system. Installing the proposed TCSC with steady state compensation of 30% (458.64 MVAR, 4,200 Amps, 0.005217 pu) will increase the transfer capability of AP South interface by 102 MW under the contingency condition of an outage of the Black Oak to Bedington 500 kV Line and by 152 MW under normal operating conditions without this contingency. Studies show that with this solution, whether under the contingency or during normal operations, no overloading of any other facilities in the PJM system would occur. The proposed Loudoun TCSC is estimated to cost $24.57 million dollars.

A comprehensive reliability analysis was conducted by Dominion using the 2018 RTEP Power Flow Case provided by PJM on August 13, 2013 in *.raw format with the title ”2018 RTEP SUMMER PEAK CASE 2013 LOAD FORECAST CEII DO NOT RELEASE”. This comprehensive reliability analysis evaluated not only the P-V capability of the AP South Interface but also the NERC Category B, Category C1(Bus), C2(Stuck Breaker) and C5(Tower Line) contingency conditions as provided by PJM in its August 13, 2013, RFP Solicitation. The P-V analysis was performed using the PSS/E Program; the P-V analysis is employed to examine system reactive power performance that allows evaluating the impacts of critical BES contingencies on system voltages as power transfers are increased on lines or interfaces. The critical system contingency as identified by PJM in its Market Efficiency Report for the AP South Interface is an outage of First Energy’s Black Oak – Bedington 500 kV Line. The results of the P-V Analysis determined that the installation of a 30% compensated TCSC at Loudoun switching station would increase the transfer capability of the AP South Interface by 102 MW under the Black Oak – Bedington 500 kV line outage contingency, and by 152 MW under normal condition without this contingency. PowerGEM’s TARA software was used to analyze the reliability impacts of the proposed Loudoun TCSC and no new reliability violations on the PJM System were identified. Comprehensive PROMOD studies have identified that the proposed Loudoun TCSC can provide about $75.01 million dollars economic benefit (15-Year Present Value) to PJM system. The proposed Loudoun TCSC has a calculated Benefit/Cost (B/C) ratio of 2.62 with a 0.0% annual inflation rate. The 2.62 B/C ratio of the proposed solution by Dominion has passed the 1.25 threshold required by PJM.

1.2 Details of Solution 1

1.2.1 Solution Description

In response to PJM's Request For Proposal (RFP) dated August 12, 2013, in which PJM seeks technical solution alternatives (hereinafter referred to as "Solutions") to relieve constraints on PJM internal facilities identified on the list of Top 24 congestion events from the 2013 Market Efficiency Analysis from study years 2017, 2020, and 2023 Dominion is proposing the following solution:

Loudoun TCSC
Install a Thyrister-controlled Series Capacitor (TCSC) on 500 kV Line #535 (Loudoun – Meadow Brook) at Loudoun Switching Station.

The proposed Loudoun TCSC will address congestion on the AP South Interface thus improving the Market Efficiency operation of the PJM Energy Market. The AP South interface, as identified by PJM comprises the following transmission facilities:

- 551 Mt Storm – Doubs 500kV line
- 540 Greenland Gap – Meadowbrook 500kV line
- 550 Mt Storm – Valley 500kV line
- Mt Storm – Meadowbrook (TrAIL) 500kV line

As identified by PJM in its 2013 Market Efficiency Analysis the AP South Interface is constrained for an outage of the Black Oak – Bedington 500 kV Line which is a First Energy Transmission Facility.

The proposed Loudoun TCSC has an estimated installation cost of $24.57 million dollars and a B/C Ratio of 2.62 with a 0.0% annual inflation rate thus fully satisfying the PJM Market Efficiency Requirements. The proposed Loudoun TCSC will be installed on land already owned by Dominion and has an estimated in service date 30 months after PJM authorizes Dominion to proceed with this "Solution".

A TCSC is considered a Flexible AC Transmission System (FACTS) device that adjusts the reactance of a transmission line under both normal and contingency conditions. Figure 1.1 shows a simplified one-line diagram of a TCSC that can be seen essentially as a static thyristor controlled reactor in parallel with conventional series capacitor for a fast adjustment of the line reactance.

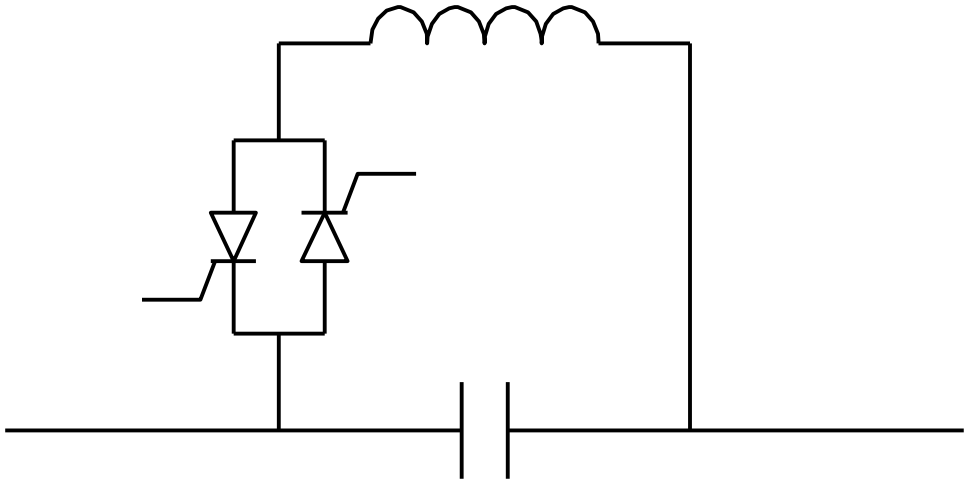


Figure 1.1 TCSC General Structure One Line Diagram

In addition to satisfying the market efficiency goals, the dynamic characteristics of the proposed TCSC will improve overall system performance by (1) eliminating risks of subsynchronous resonance, (2) damping of active power oscillations, (3) improving post-contingency stability, and (4) providing dynamic power flow control by increasing compensation level for a short duration immediately after a contingency. The additional system performance benefits of the TCSC technology should be considered when evaluating the merits of this solution. The proposed Loudoun TCSC has the following Equipment Parameters.

TCSC 10-30%
Xc(30%) = 0.005217 pu @100 MVA
458.64 MVAR
Continuous Current Rating 4200 amps @ 500 kV
Short Term Emergency Rating 4400 amps @ 500 kV (15 minutes)

Figure 1.2 shows the breaker one line diagram for new TCSC device at Loudoun.

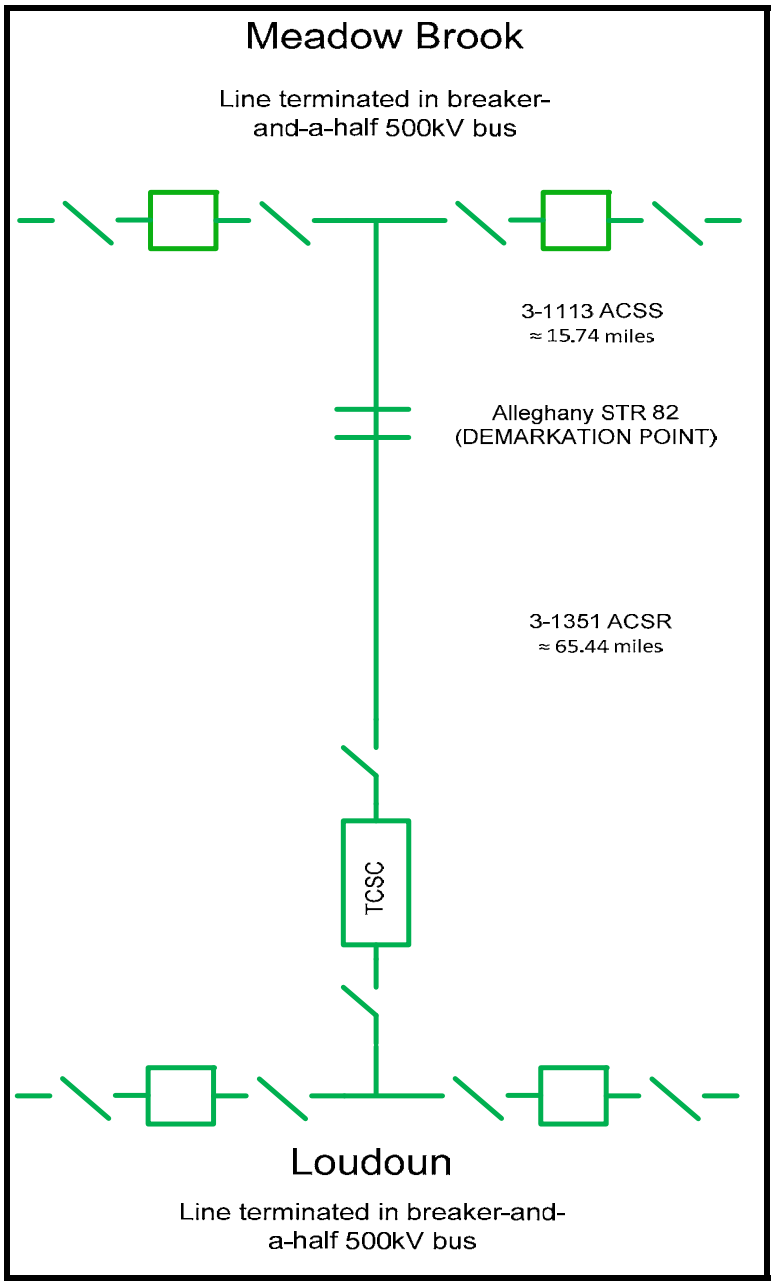


Figure 1.2 Station Breaker One Line Diagram with TCSC at Loudoun Station

1.2.2 Engineering Time Line and Cost Estimation

As addressed in the previous section of this report, Dominion Virginia Power intends to construct, own, operate, maintain, and finance the proposed solution. Details of the engineering time line and cost estimation are shown below. The lead time of the TCSC is 18months.

A. Solution Engineering Schedule Time Line

Upon approval, it is estimated that 30 months will be required to complete the installation of the Loudoun TCSC. Included in this estimate are engineering, permitting, site development, delivery of long lead equipment installation, and outage windows. This is based on the following activities run concurrently see below:

- Engineering includes Electrical, Civil, and site disciplines (18 – 20 months)
- No right of way or land acquisition required, all three proposed sites are presently fee owned with expansion capability within Dominion territory
- Long-lead time equipment procurement (18 months)
- No CPCN required, permitting will be required to comply with local and state regulations (12 - 15 months)
- Construction activities (10-12 months)
- Major outage windows (1 month)

B. Cost Estimates

The total cost of Solution 1 is estimated as $24,573,966, including

- Engineering
- Rights of way/land acquisition
- Long-lead time equipment procurement
- CPCN/Permitting
- Construction activities
- Work to be performed by incumbent Transmission Owners
- Risk and contingency costs

The protection strategies that are currently being used for fixed series compensated lines apply for the proposed TCSC compensated lines. Dominion has two 500 kV series capacitors on the Bath to Lexington and Bath to Valley lines that have been in operation since 2003.

1.3 Economic Study Results

PJM has provided the PROMOD models for the study year 2017, 2020 and 2023 and associated event file and outage library file, with two updated cases published on August 21, 2013 and August 30, 2013 respectively.

Dominion has conducted PROMOD simulation studies for 2017, 2020, and 2023 year, for the proposed solution, referred as Solution 1 herein, to improve PJM market efficiency. All the

PROMOD studies have used the exact models provided by PJM without any further stressing of system with the exception of proposed solution, for which fair results can be reached.

1.3.1 P-V Curve Analysis

A P-V Analysis is primarily used to analyze the transfer capability of a voltage limited condition in the interconnected transmission system. To evaluate the increased transfer capability of the AP South Interface, power transfer from west to east was gradually increased with Line #535 reactance decreased by 30% (steady-state value of the TCSC). The nose point of the compensation proposal was found and compared with the non-compensation scenario and it was determined that the Loudoun TCSC would increase the transfer limit of the AP South Interface by 102 MW under contingency and 152 MW under normal condition. The increased capabilities of the AP South Interface were added to the original transfer capabilities to come up with new ones in the PROMOD event file as the new transfer capabilities of AP South interface with the proposed solution in place. Figure 1.4 and Figure 1.5 have illustrated the P-V curves of AP South interface for the both normal and contingency conditions.

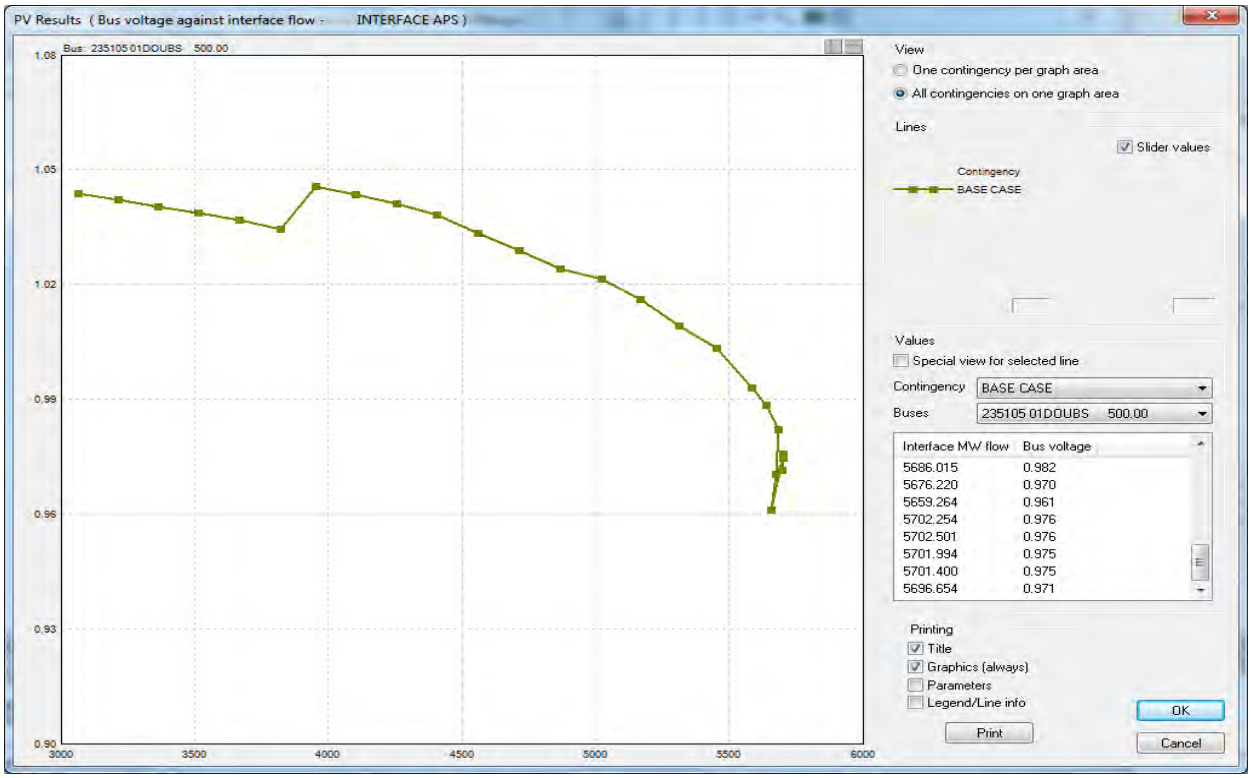


Figure 1.4 P-V Curve of AP South Interface under Normal Condition (Solution 1)

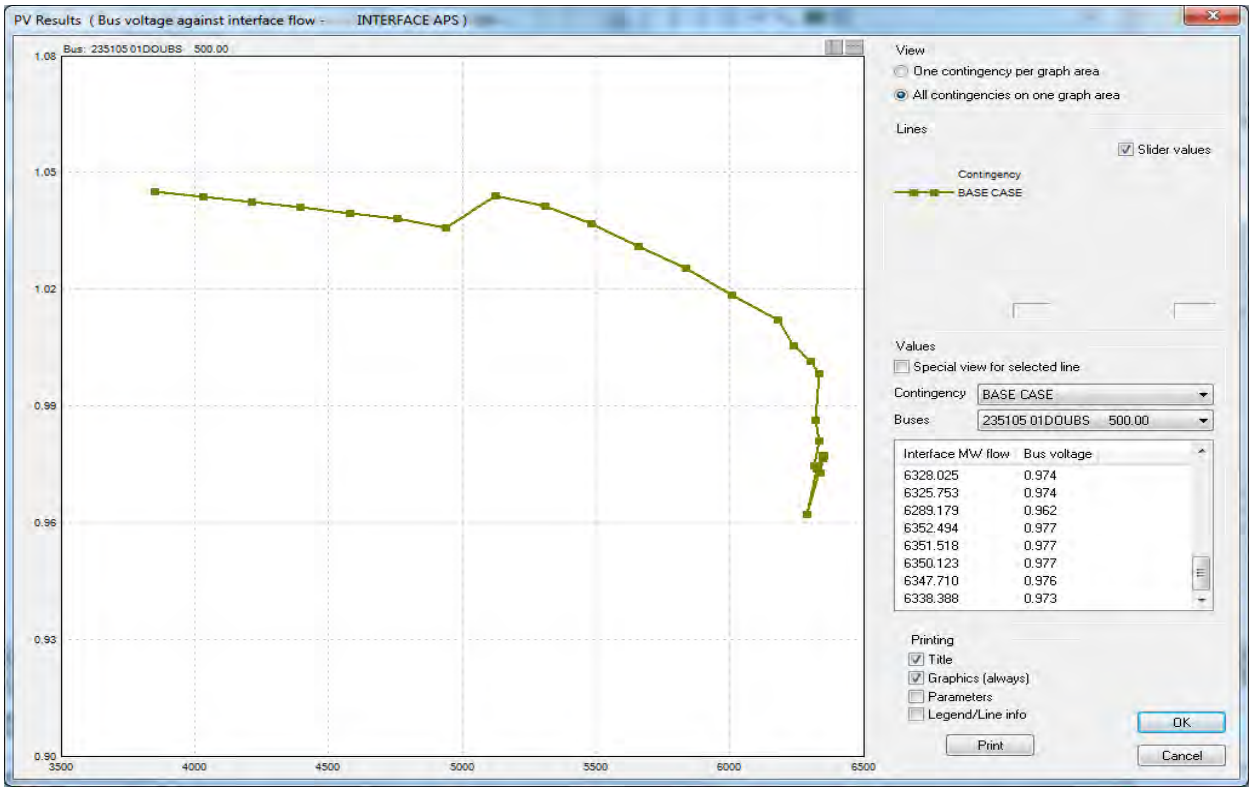


Figure 1.5 P-V Curve of AP South Interface under Black Oak – Bedington Contingency (Solution 1)

1.3.2 B/C Ratio and Congestion Reduction

Based on the P-V curve study results shown in Figures 1.4 and 1.5, Dominion adjusted the transfer capabilities of AP South interface for both base case and contingency events in the event file to reflect the transfer capability increases. PROMOD simulation studies for year 2017, 2020, and 2023 have identified about $75.01 million dollars economic benefit (15-Year Present Value) for the entire PJM system. The Benefit/Cost ratio has reached 2.62 based on the estimated cost of Dominion Solution 1, which is higher than the 1.25 B/C ratio required by PJM. Figure 1.6 has demonstrated the detail of the B/C ratio calculation.

The proposed Solution 1 not only dramatically reduces the congestion of AP South interface, but reduces the congestions on the majority of other 23 congestion facilities identified by PJM 2013 RTEP Market Efficiency study.

1.4 Power Flow Study Results

The Loudoun TCSC solution was modeled in PSS/E using PJM's summer 2018 RTEP case and the contingency analysis was performed using PowerGEM's TARA software. A single-line, stuck

breaker, tower-line, and bus contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).

1.4.3 N-1 Contingency Analysis

- A single-line N-1 contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category B event, the thermal limit was 94% of the Long Term Emergency Rating (Rate B). The voltage limit range was 93% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the single-line N-1 results:

N-1	Solution 1
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of N-1 contingency analysis show no new thermal or voltage violations for this solution.

1.4.4 Bus Contingency Analysis

- A bus contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the bus contingency results:

Bus	Solution 1
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of the bus contingency analysis show no new thermal or voltage violations for this solution.

1.4.5 Line FB Contingency Analysis

- A stuck breaker contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the stuck breaker contingency results:

Line FB	Solution 1
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of stuck breaker analysis show no new thermal or voltage violations for this solution.

1.4.6 Tower Contingency Analysis

- A tower-line contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the tower-line contingency results:

Tower	Solution 1
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of tower-line contingency analysis show no new thermal or voltage violations for this solution.

1.4.7 Contingency Analysis Summary

In summary the reliability analysis with the proposed Loudoun TCSC in-service did not identify any new NERC Reliability criteria violations.

Solution 2:

Morrisville TCSC

Line #541 (Morrisville to Front Royal)

2.1 Summary of Solution 2

Dominion is proposing Solution 2 to install a Thyristor-controlled Series Capacitor (TCSC) on 500 kV Line #541 (Morrisville – Front Royal) in order to increase the transfer capability of AP South interface and other facilities in PJM to improve the market efficiency of the entire PJM system. Installing the proposed TCSC with steady state compensation of 60% (257.2 MVAR, 4,000 Amps, 0.00627 pu) will increase the transfer capability of AP South interface by 165 MW under the contingency condition of an outage of the Black Oak to Bedington 500 kV Line and by 200 MW under normal operating conditions without this contingency. Studies show that with this solution, whether under the contingency or during normal operations, no overloading of any other facilities in the PJM system would occur. The proposed Morrisville TCSC is estimated to cost $20.07 million.

A comprehensive reliability analysis was conducted by Dominion using the 2018 RTEP Power Flow Case provided by PJM on August 13, 2013 in *.raw format with the title ”2018 RTEP SUMMER PEAK CASE 2013 LOAD FORECAST CEII DO NOT RELEASE”. This comprehensive reliability analysis evaluated not only the P-V capability of the AP South Interface but also the NERC Category B, Category C1(Bus), C2(Stuck Breaker) and C5(Tower Line) contingency conditions as provided by PJM in its August 13, 2013, RFP Solicitation. The P-V analysis was performed using the PSS/E Program; the P-V analysis is employed to examine system reactive power performance that allows evaluating the impacts of critical BES contingencies on system voltages as power transfers are increased on lines or interfaces. The critical system contingency as identified by PJM in its Market Efficiency Report for the AP South Interface is an outage of First Energy’s Black Oak – Bedington 500 kV Line. The results of the P-V Analysis determined that the installation of a 60% compensated TCSC at Morrisville switching station would increase the transfer capability of the AP South Interface by 165 MW under the Black Oak – Bedington 500 kV line outage contingency, and 200 MW under normal condition without this contingency. PowerGEM’s TARA software was used to analyze the reliability impacts of the proposed Morrisville TCSC and no new reliability violations on the PJM System were identifiedComprehensive PROMOD studies have identified that the proposed Morrisville TCSC can provide about $81.72 million dollars economic benefit (15-Year Present Value) to PJM system. The proposed Morrisville TCSC has a calculated Benefit/Cost (B/C) ratio of 3.49 with a 0.0% annual inflation rate. The 3.49 B/C ratio of the proposed solution by Dominion has passed the 1.25 threshold required by PJM.

2.2 Details of Solution 2

2.2.1 Solution Description

In response to PJM's Request For Proposal (RFP) dated August 12, 2013, in which PJM seeks technical solution alternatives (hereinafter referred to as "Solutions") to relieve constraints on PJM internal facilities identified on the list of Top 24 congestion events from the 2013 Market Efficiency Analysis from study years 2017, 2020, and 2023 Dominion is proposing the following solution:

Morrisville TCSC
Install a Thyrister-controlled Series Capacitor (TCSC) on 500 kV Line #541 (Morrisville – Front Royal) at Morrisville Switching Station.

The proposed Morrisville TCSC will address congestion on the AP South Interface thus improving the Market Efficiency operation of the PJM Energy Market. The AP South interface, as identified by PJM comprises the following transmission facilities:

- 551 Mt Storm – Doubs 500kV line
- 540 Greenland Gap – Meadowbrook 500kV line
- 550 Mt Storm – Valley 500kV line
- Mt Storm – Meadowbrook (TrAIL) 500kV line

As identified by PJM in its 2013 Market Efficiency Analysis the AP South Interface is constrained for an outage of the Black Oak – Bedington 500 kV Line which is a First Energy Transmission Facility.

The proposed Morrisville TCSC has an estimated installation cost of $20.07 million dollars and a B/C Ratio of 3.49 with a 0.0% annual inflation rate thus fully satisfying the PJM Market Efficiency Requirements. The proposed Morrisville TCSC will be installed on land already owned by Dominion and has an estimated in service date of 30 months after PJM authorizes Dominion to proceed with the proposed solution.

A TCSC is considered a Flexible AC Transmission System (FACTS) device and adjusts the reactance of a transmission line under both normal and contingency condition. Figure 2.1 shows a simplified one-line diagram of a TCSC general structure that can be seen essentially as a static thyristor controlled reactor in parallel with conventional series capacitor for a fast adjustment of the line reactance.

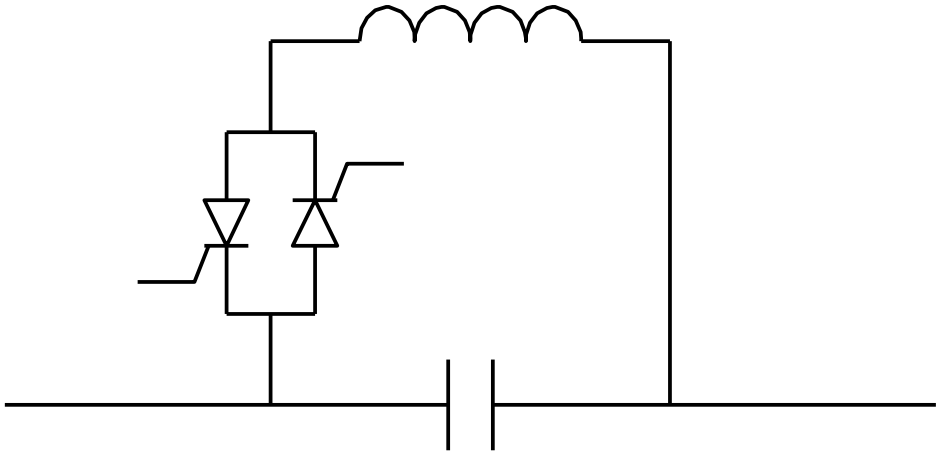


Figure 2.1 TCSC General Structure One Line Diagram

In addition to satisfying the market efficiency goals, the dynamic characteristics of the proposed TCSC will improve overall system performance by (1) eliminating risks of subsynchronous resonance, (2) damping of active power oscillations, (3) improving post-contingency stability, and (4) providing dynamic power flow control by increasing compensation level for a short duration immediately after a contingency. The additional system performance benefits of the TCSC technology should be considered when evaluating the merits of this solution. The proposed Morrisville TCSC has the following Equipment Parameters.

TCSC 10-60%
Xc(60%) = 0.00627pu @100 MVA
257.2 MVAR
Continuous Current Rating 4000 amps @ 500 kV
Short Term Emergency Rating 4200 amps @ 500 kV (15 minutes)

Figure 2.2 shows the breaker one line diagram for new TCSC device at Morrisville.

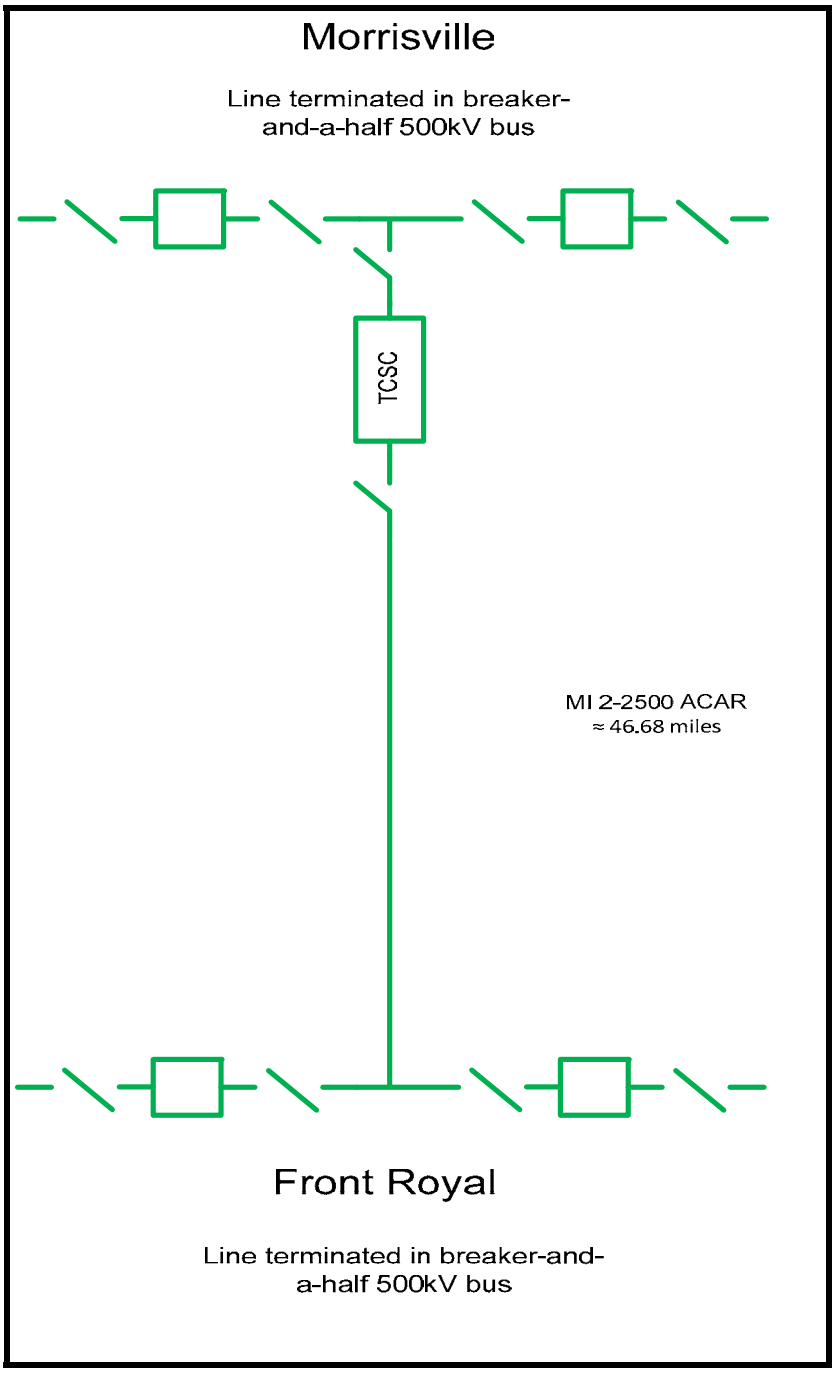


Figure 2.2 Station Breaker One Line Diagram with TCSC at Morrisville Station

2.2.2 Engineering Time Line and Cost Estimation

As addressed in the previous section of this report, Dominion Virginia Power intends to construct, own, operate, maintain, and finance the proposed solution. Details of the engineering time line and cost estimation are shown below. The lead time of the TCSC is 18 months.

A. Construction Time-Line

Upon approval, it is estimated that 30 months will be required to complete the installation of the Morrisville TCSC. Included in this estimate are engineering, permitting, site development, delivery of long lead equipment installation, and outage windows.

This is based on the following activities run concurrently see below:

- Engineering includes Electrical, Civil, and site disciplines (18 – 20 months)
- No right of way or land acquisition required, all three proposed sites are presently fee owned with expansion capability within Dominion territory
- Long-lead time equipment procurement (18 months)
- No CPCN required, permitting will be required to comply with local and state regulations (12 - 15 months)
- Construction activities (10-12 months)
- Major outage windows (1 month)

B. Cost Estimates

The total estimated cost for Solution 2 Proposal = $20,068,476

- Engineering
- Rights of way/land acquisition
- Long-lead time equipment procurement
- CPCN/Permitting
- Construction activities
- Work to be performed by incumbent Transmission Owners
- Risk and contingency costs

The protection strategies that are being currently used for fixed series compensated lines apply for the proposed TCSC compensated lines. Dominion has two 500 kV series capacitors on the Bath to Lexington and Bath to Valley lines that have been in operation since 2003.

2.3 Economic Study Results

PJM has provided the PROMOD models for the study year 2017, 2020 and 2023 and associated event file and outage library file, with two updated cases published on August 21, 2013 and August 30, 2013 respectively.

Dominion has conducted PROMOD simulation studies for 2017, 2020, and 2023 year, for the proposed solution, referred as Solution 2 herein, to improve PJM market efficiency. All the

PROMOD studies have used the exact models provided by PJM without any further stressing of system with the exception of proposed solution, for which fair results can be reached.

2.3.1 P-V Curve Analysis

A P-V Analysis is primarily used to analyze the transfer capability of a voltage limited condition in the interconnected transmission system. To evaluate the increased transfer capability of the AP South Interface, power transfer from west to east was gradually increased with Line #541 reactance decreased by 60% (steady-state value of the TCSC). The nose point of the compensation proposal was found and compared with the non-compensation scenario and it was determined that the Morrisville TCSC would increase the transfer limit of the AP South Interface by 165 MW under contingency and 200 MW under normal condition. The increased capabilities of the AP South Interface were added to the original transfer capabilities to come up with new ones in the PROMOD event file as the new transfer capabilities of AP South interface with the proposed solution in place. Figure 2.4 and Figure 2.5 have illustrated the P-V curves of AP South interface for the both normal and contingency conditions.

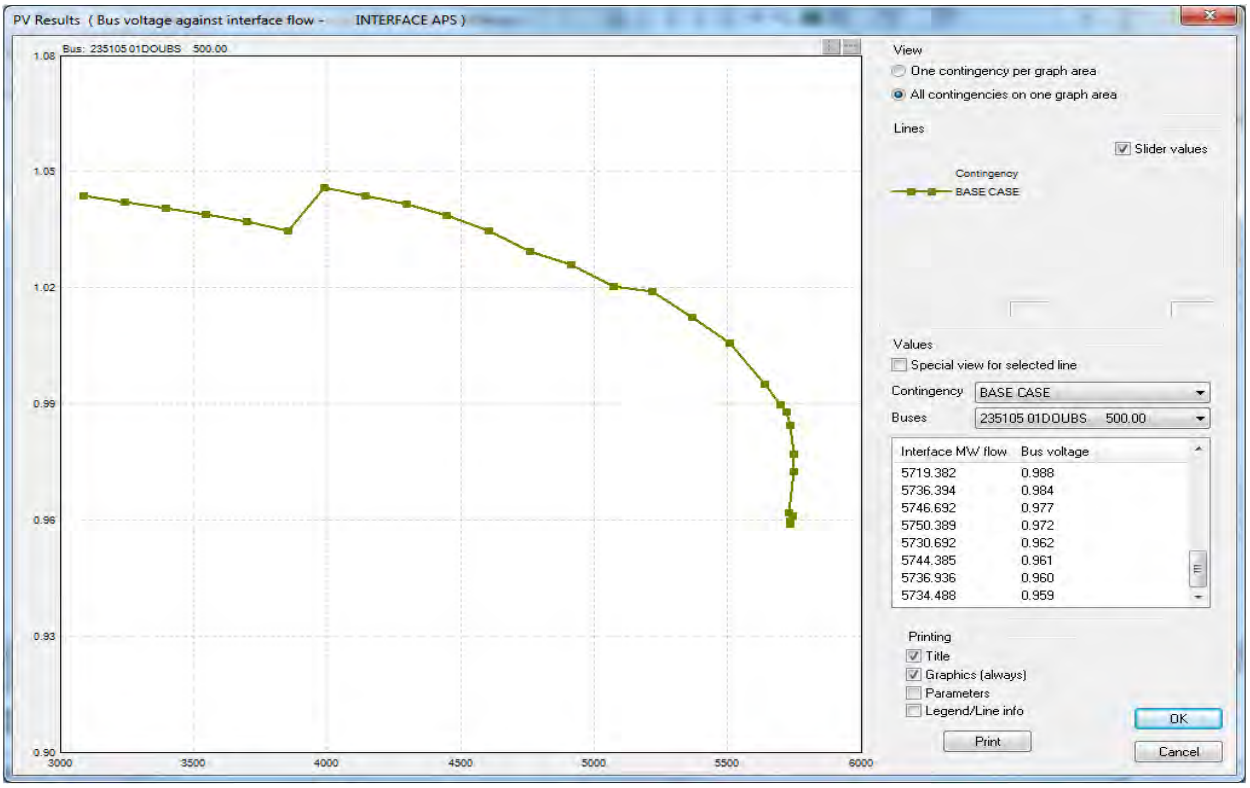


Figure 2.4 P-V Curve of AP South Interface under Normal Condition (Solution 2)

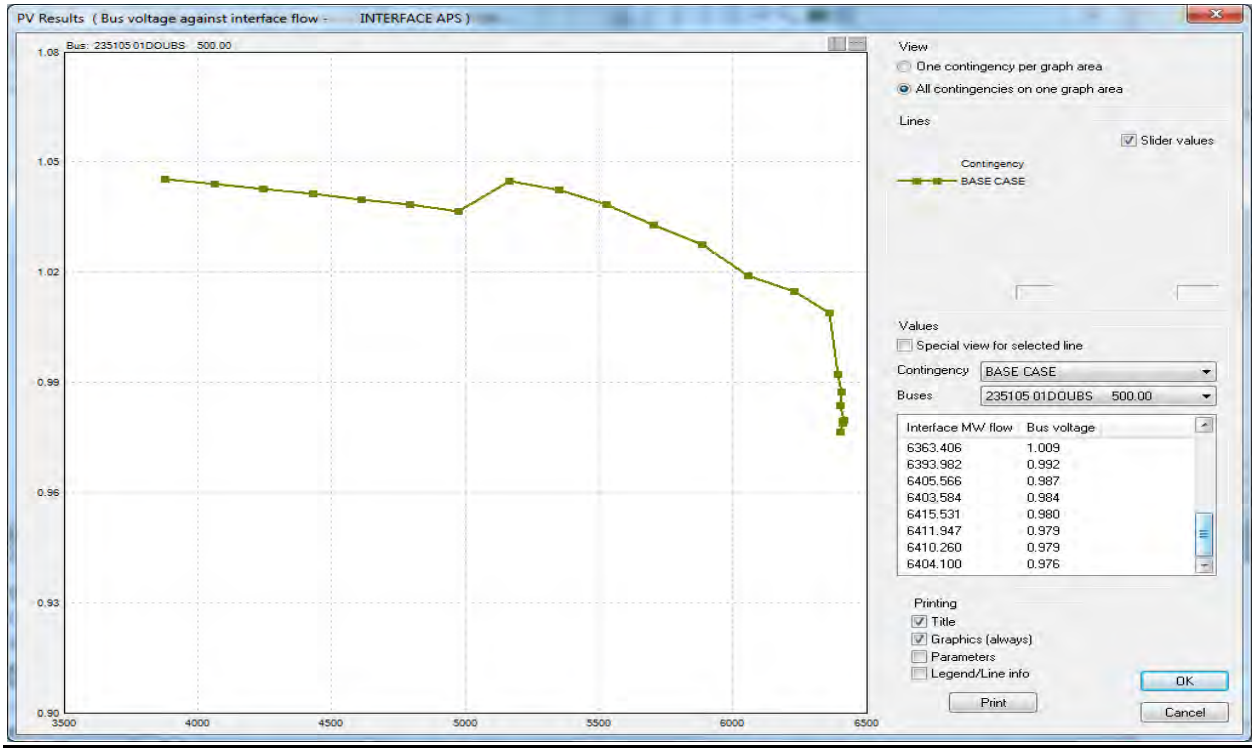


Figure 2.5 P-V Curve of AP South Interface under Black Oak – Bedington Contingency (Solution 2)

2.3.2 B/C Ratio and Congestion Reduction

Based on the P-V curve study results shown in Figures 2.4 and 2.5, Dominion adjusted the transfer capabilities of AP South interface for both base case and contingency events in the event file to reflect the transfer capability increases. PROMOD simulation studies for year 2017, 2020, and 2023 have identified about $81.72 million dollars economic benefit (15-Year Present Value) for the entire PJM system. The Benefit/Cost ratio has reached 3.49 based on the estimated cost of Dominion Solution 2, which is higher than the 1.25 B/C ratio required by PJM. Figure 2.6 has demonstrated the detail of the B/C ratio calculation.

The proposed Solution 2 not only dramatically reduces the congestion of AP South interface, but reduces the congestion on majority of other 23 congestion facilities identified by PJM 2013 RTEP Market Efficiency study.

2.4 Power Flow Study Results

The Morrisville TCSC solution was modeled in PSS/E using PJM's summer 2018 RTEP case and the contingency analysis was performed using PowerGEM's TARA software. A single-line, stuck breaker, tower-line, and bus contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).

2.4.3 N-1 Contingency Analysis

- A single-line N-1 contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category B event, the thermal limit was 94% of the Long Term Emergency Rating (Rate B). The voltage limit range was 93% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the single-line N-1 results:

N-1	Solution 2
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of N-1 contingency analysis show no new thermal or voltage violations for this solution.

2.4.4 Bus Contingency Analysis

- A bus contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the bus contingency results:

Bus	Solution 2
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of the bus contingency analysis show no new thermal or voltage violations for this solution.

2.4.5 Line FB Contingency Analysis

- A stuck breaker contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term

Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.

- The Table below summarizes the stuck breaker contingency results:

Line FB	Solution 2
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of stuck breaker analysis show no new thermal or voltage violations for this solution.

2.4.6 Tower Contingency Analysis

- A tower-line contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the tower-line contingency results:

Tower	Solution 2
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of tower-line contingency analysis show no new thermal or voltage violations for this solution.

2.4.7 Contingency Analysis Summary

In summary the reliability analysis with the proposed Morrisville TCSC in-service did not identify any new NERC Reliability criteria violations.

Solution 3:

Mt. Storm TCSC

Line #529 (Mt. Storm to Meadowbrook)

3.1 Summary of Solution 3

Dominion is proposing Solution 3 to install a Thyristor-controlled Series Capacitor (TCSC) on 500 kV Line #529 (Mt Storm – Meadow Brook) in order to increase the transfer capability of AP South interface and other facilities in PJM to improve the market efficiency of the entire PJM system. Installing the proposed TCSC with steady state compensation of 60% (458.64 MVAR, 4,200 Amps, 0.007944 pu) will increase the transfer capability of AP South interface by 199 MW under the contingency condition of an outage of the Black Oak to Bedington 500 kV Line and by 243 MW under normal operating conditions without this contingency. Studies show that with this solution, whether under the contingency or during normal operations, no overloading of any other facilities in the PJM system would occur. The proposed Mt. Storm TCSC is estimated to cost $24.73 million.

A comprehensive reliability analysis was conducted by Dominion using the 2018 RTEP Power Flow Case provided by PJM on August 13, 2013 in *.raw format with the title ”2018 RTEP SUMMER PEAK CASE 2013 LOAD FORECAST CEII DO NOT RELEASE”. This comprehensive reliability analysis evaluated not only the P-V capability of the AP South Interface but also the NERC Category B, Category C1(Bus), C2(Stuck Breaker) and C5(Tower Line) contingency conditions as provided by PJM in its August 13, 2013, RFP Solicitation. The P-V analysis was performed using the PSS/E Program; the P-V analysis is employed to examine system reactive power performance that allows evaluating the impacts of critical BES contingencies on system voltages as power transfers are increased on lines or interfaces. The critical system contingency as identified by PJM in its Market Efficiency Report for the AP South Interface is an outage of First Energy’s Black Oak – Bedington 500 kV Line. The results of the P-V Analysis determined that the installation of a 60% compensated TCSC at Mt. Storm switching station would increase the transfer capability of the AP South Interface by 199 MW under the Black Oak – Bedington 500 kV line outage contingency, and by 243 MW under normal condition without this contingency. PowerGEM’s TARA software was used to analyze the reliability impacts of the proposed Mt. Storm TCSC and no new reliability violations on the PJM System were identified.

Comprehensive PROMOD studies have identified that the proposed Mt. Storm TCSC can provide about $71.73 million dollars economic benefit (15-Year Present Value) to PJM system. The proposed Mt. Storm TCSC has a calculated Benefit/Cost (B/C) ratio of 2.49 with a 0.0% annual inflation rate. The 2.49 B/C ratio of the proposed solution by Dominion has passed the 1.25 threshold required by PJM.

3.2 Details of Solution 3

3.2.1 Solution Description

In response to PJM's Request For Proposal (RFP) dated August 12, 2013, in which PJM seeks technical solution alternatives (hereinafter referred to as "Solutions") to relieve constraints on PJM internal facilities identified on the list of Top 24 congestion events for the 2013 Market Efficiency Analysis from study years 2017, 2020, and 2023 Dominion is proposing the following solution:

Mt. Storm TCSC
Install a Thyrister-controlled Series Capacitor (TCSC) on 500 kV Line #529 (Mt. Storm – Meadow Brook) at Mt. Storm Switching Station.

The proposed Mt. Storm TCSC will address congestion on the AP South Interface thus improving the Market Efficiency operation of the PJM Energy Market. The AP South interface, as identified by PJM comprises the following transmission facilities:

551 Mt Storm – Doubs 500kV line
540 Greenland Gap – Meadowbrook 500kV line
550 Mt Storm – Valley 500kV line
Mt Storm – Meadowbrook (TrAIL) 500kV line

As identified by PJM in its 2013 Market Efficiency Analysis the AP South Interface is constrained for an outage of the Black Oak – Bedington 500 kV Line which is a First Energy Transmission Facility.

The proposed Mt. Storm TCSC has an estimated installation cost of $24.73 million dollars and a B/C Ratio of 2.49 with a 0.0% annual inflation rate thus fully satisfying the PJM Market Efficiency Requirements. The proposed Mt. Storm TCSC will be installed on land already owned by Dominion and has an estimated in service date 30 months after PJM authorizes Dominion to proceed with the proposed solution.

A TCSC is considered a Flexible AC Transmission System (FACTS) device and adjusts the reactance of a transmission line under both normal and contingency condition. Figure 3.1 shows a simplified one-line diagram of a TCSC that can be seen essentially as a static thyristor controlled reactor in parallel with conventional series capacitor for a fast adjustment of the line reactance.

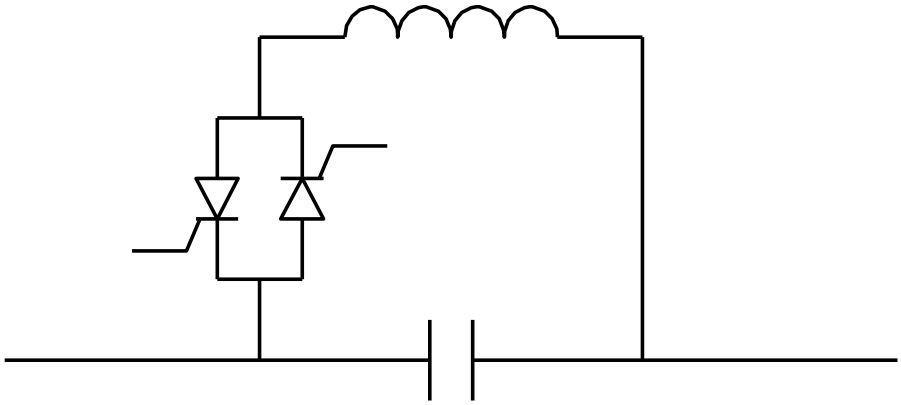


Figure 3.1 TCSC General Structure One Line Diagram

In addition to satisfying the market efficiency goals, the dynamic characteristics of the proposed TCSC will improve overall system performance by (1) eliminating risks of subsynchronous resonance, (2) damping of active power oscillations, (3) improving post-contingency stability, and (4) providing dynamic power flow control by increasing compensation level for a short duration immediately after a contingency. The additional system performance benefits of the TCSC technology should be considered when evaluating the merits of this solution. The proposed Mt. Storm TCSC has the following Equipment Parameters.

TCSC 10-60%
Xc(60%) = 0.007944pu @100 MVA
257.2 MVAR
Continuous Current Rating 4200 amps @ 500 kV
Short Term Emergency Rating 4400 amps @ 500 kV (15 minutes)

Figure 3.2 shows the breaker one line diagram for new TCSC device at Mt. Storm.

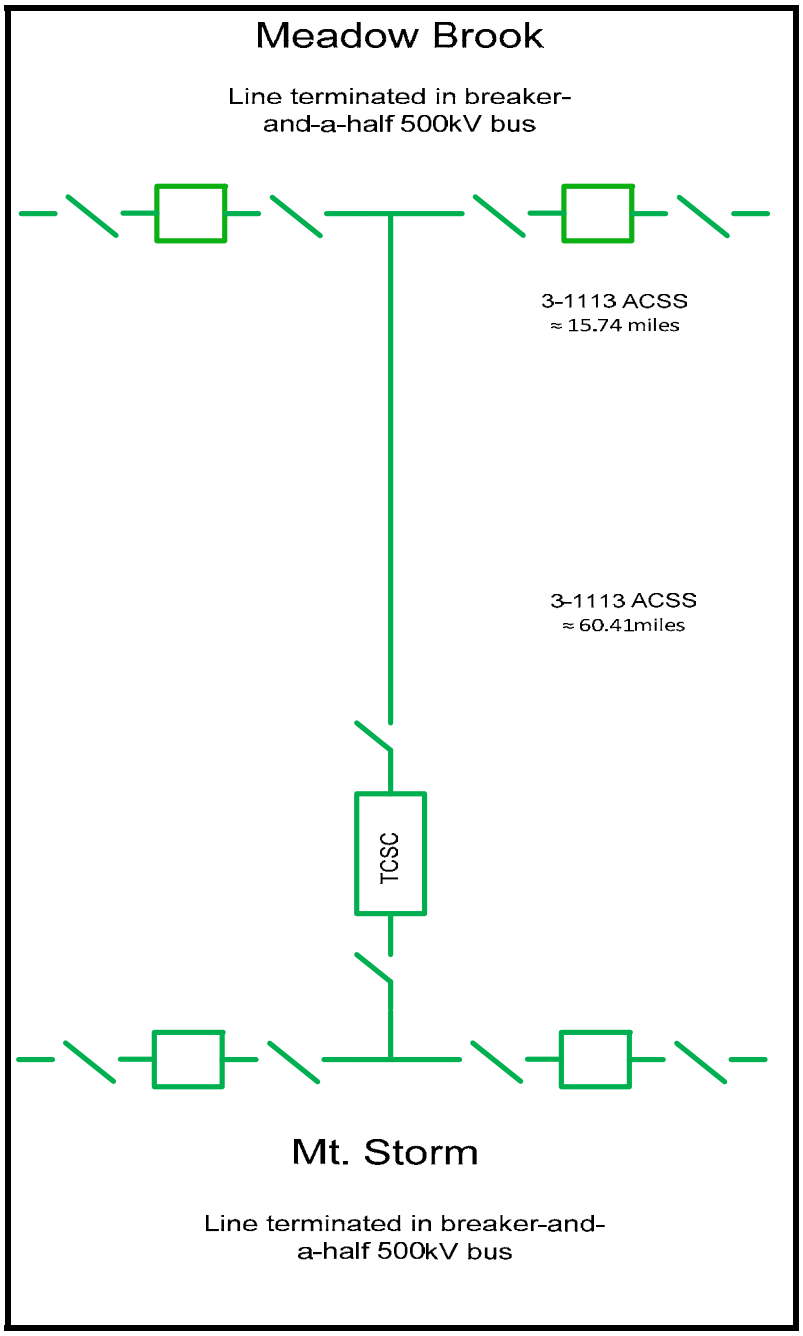


Figure 3.2 Station Breaker One Line Diagram with TCSC at Mt. Storm Station

3.2.2 Engineering Time Line and Cost Estimation

As addressed in the previous section of this report, Dominion Virginia Power intends to construct, own, operate, maintain, and finance the proposed solution. Details of the

engineering time line and cost estimation are shown below. The lead time of the TCSC is 18 months.

A. Solution Engineering Schedule Time-Line

Upon approval, it is estimated that 30 months will be required to complete the installation of the Mt Storm TCSC. Included in this estimate are engineering, permitting, site development, delivery of long lead equipment installation, and outage windows. This is based on the following activities run concurrently see below:

- Engineering includes Electrical, Civil, and site disciplines (18 – 20 months)
- No right of way or land acquisition required, all three proposed sites are presently fee owned with expansion capability within Dominion territory
- Long-lead time equipment procurement (18 months)
- No CPCN required, permitting will be required to comply with local and state regulations (12 - 15 months)
- Construction activities (10-12 months)
- Major outage windows (1 month)

B. Cost Estimates

The total cost of Solution 3 is estimated as $24,727,340, including

- Engineering
- Rights of way/land acquisition
- Long-lead time equipment procurement
- CPCN/Permitting
- Construction activities
- Work to be performed by incumbent Transmission Owners
- Risk and contingency costs

The protection strategies that are currently being used for fixed series compensated lines apply for the proposed TCSC compensated lines. Dominion has two 500 kV series capacitors on the Bath to Lexington and Bath to Valley lines that have been in operation since 2003.

3.3 Economic Study Results

PJM has provided the PROMOD models for the study year 2017, 2020 and 2023 and associated event file and outage library file, with two updated cases published on August 21, 2013 and August 30, 2013 respectively.

Dominion has conducted PROMOD simulation studies for 2017, 2020, and 2023 year, for the proposed solution, referred as Solution 3 herein, to improve PJM market efficiency. All the PROMOD studies have used the exact models provided by PJM without any further stressing of system with the exception of proposed solution, for which fair results can be reached.

3.3.1 P-V Curve Analysis

A P-V Analysis is primarily used to analyze the transfer capability of a voltage limited condition in the interconnected transmission system. To evaluate the increased transfer capability of the AP South Interface, power transfer from west to east was gradually increased with Line #529 reactance decreased by 60% (steady-state value of the TCSC). The nose point of the compensation proposal was found and compared with the non-compensation scenario and it was determined that the Mt Storm TCSC would increase the transfer limit of the AP South Interface by 199 MW under contingency and 243 MW under normal condition. The increased capabilities of the AP South Interface were added to the original transfer capabilities to come up with new ones in the PROMOD event file as the new transfer capabilities of AP South interface with the proposed solution in place. Figure 3.4 and Figure 3.5 have illustrated the P-V curves of AP South interface for the both normal and contingency conditions.

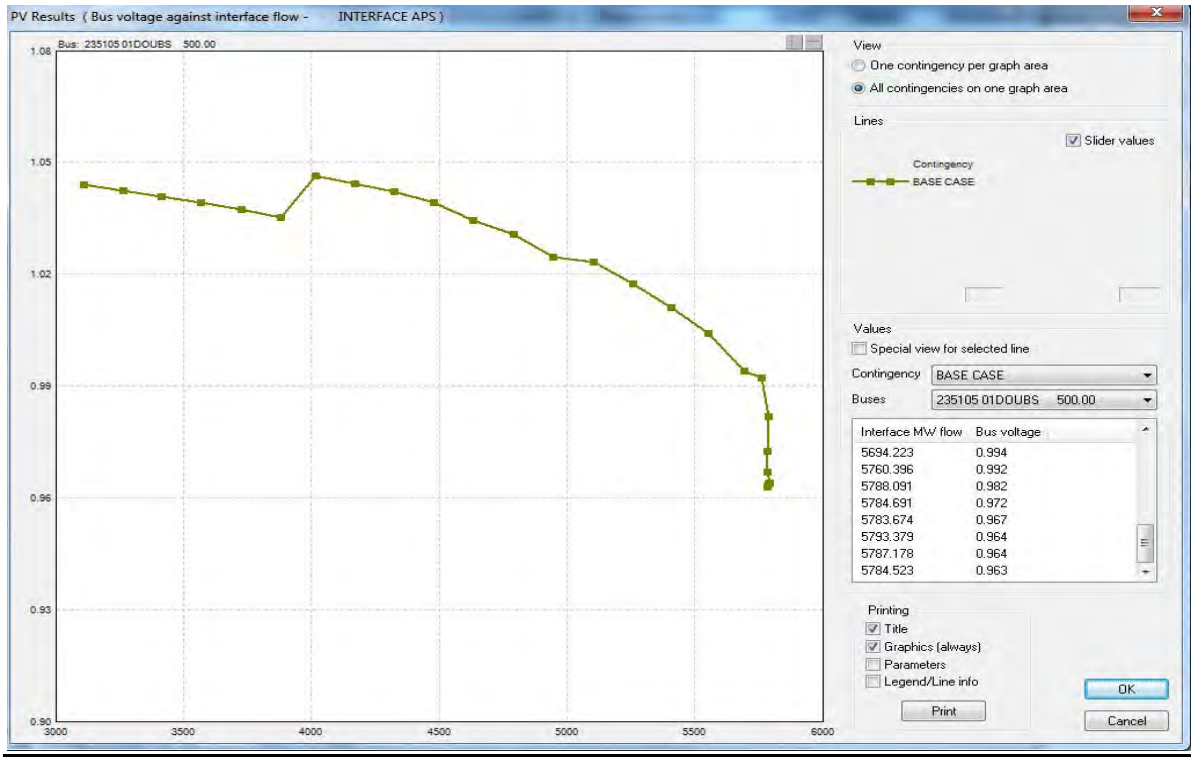


Figure 3.4 P-V Curve of AP South Interface under Normal Condition (Solution 3)

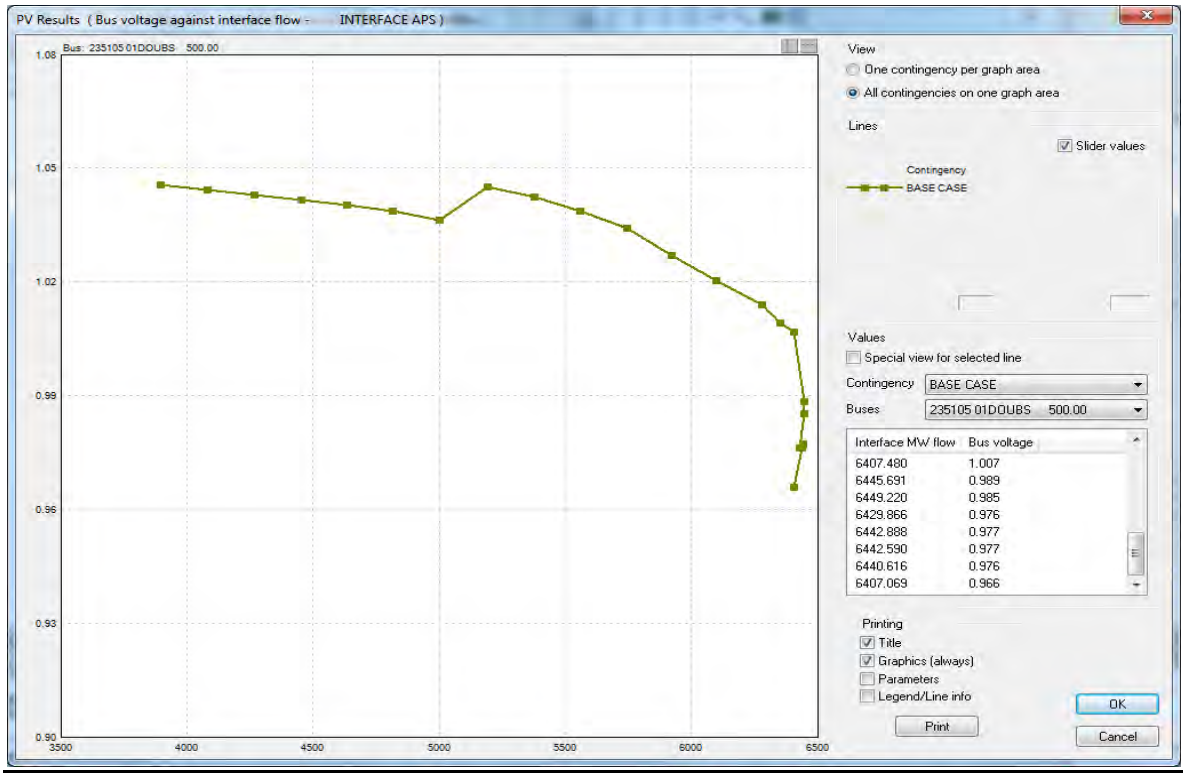


Figure 3.5 P-V Curve of AP South Interface under Black Oak – Bedington Contingency (Solution 3)

3.3.2 B/C Ratio and Congestion Reduction

Based on the P-V curve study results shown in Figures 3.4 and 3.5, Dominion adjusted the transfer capabilities of AP South interface for both base case and contingency events in the event file to reflect the transfer capability increases. PROMOD simulation studies for year 2017, 2020, and 2023 have identified about $71.73 million dollars economic benefit (15-Year Present Value) for the entire PJM system. The Benefit/Cost ratio has reached 2.49 based on the estimated cost of Dominion Solution 3, which is higher than the 1.25 B/C ratio required by PJM. Figure 3.6 has demonstrated the detail of the B/C ratio calculation.

The proposed Solution 3 not only dramatically reduces the congestion of AP South interface, but reduces the congestion on majority of other 23 congestion facilities identified by PJM 2013 RTEP Market Efficiency study.

3.4 Power Flow Simulation Results

The Mt. Storm TCSC solution was modeled in PSS/E using PJM's summer 2018 RTEP case and the contingency analysis was performed using PowerGEM's TARA software. A single-line, stuck breaker, tower-line, and bus contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).

3.4.3 N-1 Contingency Analysis

- A single-line N-1 contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category B event, the thermal limit was 94% of the Long Term Emergency Rating (Rate B). The voltage limit range was 93% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the single-line N-1 results:

N-1	Solution 3
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of N-1 contingency analysis show no new thermal or voltage violations for this solution.

3.4.4 Bus Contingency Analysis

- A bus contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the bus contingency results:

Bus	Solution 3
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of the bus contingency analysis show no new thermal or voltage violations for this solution.

3.4.5 Stuck Breaker (Line FB) Contingency Analysis

- A stuck breaker contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).
- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the stuck breaker contingency results:

Line FB	Solution 3
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of stuck breaker analysis show no new thermal or voltage violations for this solution.

3.4.6 Tower Contingency Analysis

- A tower-line contingency analysis was performed against the base case (2018 RTEP case) and the solution case (2018 RTEP case with the proposed solution).

- For this Category C event, the thermal limit was 100% of the Long Term Emergency Rating (Rate B). An additional thermal limit was monitored at 100% of the Short Term Emergency Rating (Rate C). The voltage limit range was 90% - 107% for 69kV through 230kV facilities and 101% - 108% for 500kV through 765kV facilities.
- The Table below summarizes the tower-line contingency results:

Tower	Solution 3
Branch Worst Case	no new violations
Voltage Worst Case	no new violations

- The results of tower-line contingency analysis show no new thermal or voltage violations for this solution.

3.4. 7 Contingency Analysis Summary

In summary the reliability analysis with the proposed Mt. Storm TCSC in-service did not identify any new NERC Reliability criteria violations.

Dominion Virginia Power

Qualifications

Technical and Engineering qualifications

Dominion has a fully staffed Substation Engineering and Transmission Line Engineering team. The Substation Engineers' capabilities include, but are not limited to, Physical Design, System Protection Design, Communications support, Civil Engineering support, and Site Plan Development. The Transmission Line Engineers' capabilities include, but not limited to, overhead and underground design, Civil Engineering support and Geotechnical support.

Dominion is fully staffed for engineering support activities inclusive of siting/routing transmission lines, site development for substations as well as all real estate related activities. Dominion is one of the nation's largest producers and transporters of energy, with a portfolio of approximately 27,500 megawatts of generation, 11,000 miles of natural gas transmission, gathering and storage pipeline and 6,300 miles of electric transmission lines. Dominion operates one of the nation's largest natural gas storage systems with 947 billion cubic feet of storage capacity and serves retail energy customers in 15 states.

The 6300 miles of electric transmission are all within the PJM footprint. Dominion has an Electric Transmission staff of over 800 engineers, technicians, operators, and other construction and support personnel dedicated to develop, construct, maintain, and operate these facilities.

Experience in developing, constructing, operating and maintaining the types of transmission facilities included in the solution proposal

The major component of these solutions is a series capacitor. Dominion currently owns, operates and maintains two 500 kV series capacitors on its transmission system at the following locations.

Lexington Substation
Series Capacitor: 500 kV 395 MVAR 60% Compensation

Year In-service: 2003

Location: Lexington Substation on the Bath to Lexington 500 kV line number 547

Valley Substation
Series Capacitor: 500 kV 395 MVAR 60% Compensation

Year In-service: 2003

Location: Valley Substation on the Bath to Valley 500 kV line number 548

Emergency response capability

The solutions submitted in the package would all be located within Dominions PJM Southern area where Dominion currently owns, maintains, and operates 6,300 miles of transmission lines and 245 transmission substations on a transmission network of 500 kV, 230 kV, and 115 kV. The System Operations Center (SOC) located in Glen Allen, VA just west of Richmond, VA will be responsible for operating and monitoring these new facilities around the clock and continually assessing the potential impacts on system reliability that could result from an unplanned loss or problem. The SOC would notify local support personal in Dominion's Substations and Field Operations originations located throughout the PJM Southern Region.

The Substations group is responsible for the operation, maintenance, and installation response of all substation electrical equipment throughout Dominion's Virginia, North Carolina, and West Virginia service territory.

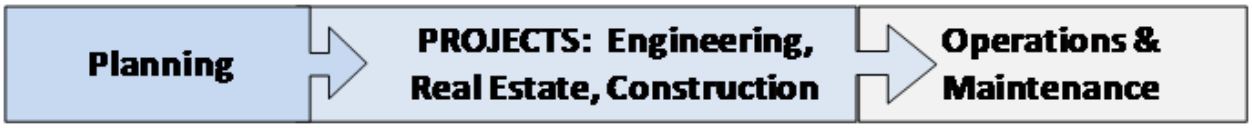
The Transmission Field Operations group is committed to safely and efficiently maintaining the Electric Transmission System, and insuring asset compliance, reliability, and performance. The department consists of the following groups: Electrical Equipment, System Protection, T&S Nuclear, and Operational Engineering Support.

Proposed Financing

These solutions would be financed by Dominion as part of its obligation as a signatory to the PJM Transmission Owners Agreement for baseline projects approved within its existing Transmission Owners zone. Also, please reference the financial statements included as part of Dominion's Designated Entity Pre-Qualification package approved by PJM. This package includes Dominion Resources Annual 10K reports for 2010-2012 (recent 3 years) and Virginia Electric and Power Company FERC Form 1 for 2010 -2012 (recent 3 years).

Description of managerial ability to contain costs and adhere to construction schedules

The Electric Transmission division of Dominion Virginia Power employs over 800 resources dedicated to safety, standardized construction, comprehensive maintenance, and reliable operating practices. To accomplish this, Electric Transmission is organized by cross-functional teams and groups with specific responsibilities.



Transmission Projects

The Projects Group is responsible for implementing transmission and substation projects to build new facilities or improve existing infrastructure. Our "customers" include transmission and distribution planning, transmission and distribution reliability, as well as generation facilities and electric cooperatives.

This group is directly responsible for acquiring all right of way, securing necessary permits, engineering design and overall project management with supply chain and construction support provided within the project teams. Safety is paramount and the assigned Project Manager is responsible for managing teams to deliver projects within specified schedules and budgets.

Project Managers are highly successful leading multi-disciplined teams representing various departments to develop and implement the appropriate solution that satisfies the customers' needs.

Since joining PJM on May 1, 2005, Dominion has completed approximately $3 billion of transmission construction projects, including the key projects listed below.

- **Meadowbrook to Loudoun 500 kV line (Part of TrAIL)** – Obtained ROW and CPCN in Virginia and constructed 65-mile line by the PJM target date of 6/01/2011.
- **Carson to Suffolk 500 kV line** - Obtained ROW and CPCN in Virginia and constructed 60-mile line by the PJM target date of 6/01/2011
- **Mt Storm to Doubs 500 kV Rebuild Project** – Project is to wreck and rebuild Dominion's 96.4 miles portion of this line. Project is currently underway and is on track to be completed well before the PJM required target date.