PJM RTEP – 2013 Market Efficiency Analysis

FirstEnergy's Proposed Solutions and Request for Construction Designation

- Redacted Version -

FirstEnergy Corp.
Energy Delivery, Transmission Planning and Protection
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Foreword

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Table of Contents

1.0 Executive Summary

This Proposal is submitted by FirstEnergy Corp. (FE) in response to the "PJM RTEP – 2013 Market Efficiency Proposal Window Problem Statement & Requirements Document" Request for Proposals (RFP) issued by PJM Interconnection, L.L.C. (PJM) on August 12, 2013. The Proposal presents proposed solutions for mitigating market congestion on transmission facilities in the FE Transmission Zones listed in the RFP documentation. If constructed, each of the proposed solutions would be located in one or more FE Transmission Zone. FE requests that Metropolitan Edison Company (Met-Ed), Monongahela Power Company (Mon Power), The Potomac Edison Company (Potomac Edison), American Transmission Systems Incorporated (ATSI) and/or Trans-Allegheny Interstate Line Company (TrAILCo), all FE affiliates, be designated to construct the proposed solutions presented in this Proposal.

In the RFP, PJM seeks technical solution alternatives to relieve constraints on PJM internal facilities identified on the list of top 25 congestion events for the 2013 Market Efficiency Analysis from study years 2017, 2020, and 2023.

In this Proposal, FE's offers cost effective solutions that will address the following PJM objectives:

1) Relieve internal PJM transmission constraints,

2) Meet the Benefit/Cost Ratio of 1.25, and

3) Ensure that proposed enhancements or expansions do not create any reliability issues.

Proposal Overview

This Proposal addresses PJM identified constraints within the FE Transmission Zones; hence, FE is only proposing solutions to address the following identified constraints or combinations of these constraints:

1). **Combined: AP South l/o BED BLA; Hunterstown 230 kV to Hunterstown 115 kV; and Pruntytown 500 kV to Mt. Storm 500 kV**

Solution: Expand Jacks Mountain Switching Station (existing PJM RTEP b0284) to include series compensation.

2). **Hunterstown 230 kV to Hunterstown 115 kV**

Solution: Add second transformer at Hunterstown Substation and reconductor Hunterstown to Oxford 115 kV line.

3). **Cleveland Interface**

Solution: Install +240/-150 MVar Static Var Compensator (SVC) designed with a 100 MVar capacitor bank at Lakeshore Substation.

4). **AES Ironwood 230 kV to South Lebanon Tap 2 30kV**

No solution proposed: Removed by PJM for consideration via e-mail notification on August 30, 2013.

5). **Pruntytown 500 kV to Mt Storm 500 kV**

Solution: FE's combined solution described in item 1 above.

Per the PJM Planning Committee meeting on June 6, 2013, it is FE's understanding that the solutions chosen by PJM could be selected from among the solutions proposed by one or more developers or multiple developers with additional segments as directed by PJM. FE has chosen to submit complete solutions to mitigate the congestion constraints listed in the RFP. Consequently, as indicated above, FE requests that PJM designate one or more of the FE affiliates identified above to construct the proposed solutions with FE making the final determination as to which of its affiliates will finance, construct, own, operate and maintain the new facilities.

2.0 PJM CONSTRAINTS: AP South l/o BED-BLA; Hunterstown 230 kV to Hunterstown 115 kV and Pruntytown 500 kV to Mt Storm 500 kV

2.A Proposed Solution

The AP South Interface, Hunterstown 230 kV to Hunterstown 115 kV transformer, and the Pruntytown-Mt. Storm 500 kV line were all identified as market constraints. The completion of the Jacks Mountain Switching Station RTEP project, with the addition of series capacitor banks (the Jacks Mountain Series Capacitor Project), lessens the loading on these constraints, thereby improving these identified market constraints.

2.A.1 Designated Entity Request

FE requests that Penelec or TrAILCo be the Designated Entity to design, construct, own, operate and maintain the Jacks Mountain Series Capacitor Project.

2.A.2 Description of the Solution

FE proposes the expansion of the existing RTEP project b0284, Jacks Mountain Switching Station, to include series capacitors to address the AP South Interface, the Hunterstown 230 kV to Hunterstown 115 kV transformer, and the Pruntytown-Mt. Storm 500 kV line.

- Complete RTEP project b0284, Jacks Mountain Switching Station, which includes:
    - Construction of a new 500 kV switching station consisting of a six breaker ring bus that connects the Keystone-Juniata 500 kV and Conemaugh-Juniata 500 kV lines,
    - Installation of four 250 Mvar capacitor banks with each protected by a 500 kV circuit breaker for a total of 1000 Mvars at the substation. And,
    - Associated work, including terminal upgrades at Keystone, Conemaugh, and Juniata 500 kV substations.
- Expand Jacks Mountain to include the Jacks Mountain Series Capacitor Project:
    - Installation of 600 Mvar series capacitors on the Keystone and Conemaugh 500 kV lines; and 400 Mvar series capacitors on each Juniata 500 kV line.

Figure 2.A.2-1 shows a detailed one-line diagram the Jacks Mountain Series Capacitor Project.

Figure 2.A.2-1: Jacks Mountain Switching Station with shunt reactive and series compensation

Breaker one-line diagram

Redacted Single Line

2.A.3 Detailed Analysis

Facilities Relieved

This Jacks Mountain Series Capacitor Project will relieve the AP South Interface, the Hunterstown 230 kV to Hunterstown 115 kV transformer, and the Pruntytown-Mt. Storm 500 kV line.

2.A.4 Project Details

Project Schedule

RTEP project b0284 - Jacks Mountain Switching Station

Jacks Mountain Switching Station – Construct 500 kV Switching Station

Engineering	03/1/2014	through	09/30/2016
Below grade construction	06/1/2015	through	09/30/2016
Above grade construction	10/1/2016	through	05/31/2017
In-Service Date	06/01/2017		

Jacks Mountain Switching Station – Construct two 500 kV loop lines

Engineering	01/1/2014	through	01/31/2014
Transmission line siting	09/1/2014	through	02/28/2015
Transmission line construction	03/1/2016	through	04/30/2016
In-Service Date	06/01/2017		

Jacks Mountain Switching Station – Install four 500 kV shunt capacitors

Engineering	08/1/2015	through	09/30/2016
Below grade construction	07/1/2016	through	10/31/2016
Above grade construction	10/1/2016	through	05/31/2017
In-Service Date	06/01/2017		

Market Efficiency – Jacks Mountain Series Capacitor Project

Jacks Mountain Series Capacitors – Install four 500 kV series capacitors

• Engineering	01/1/2014	through	09/30/2016
• Below grade construction	06/1/2015	through	09/30/2016
• Above grade construction	10/1/2016	through	05/31/2017
• In-Service Date	06/01/2017		

Project Costs

Market Efficiency Project – Jacks Mountain Series Capacitor

Description	$ Millions	
	Total Cost	Redacted Direct Costs and Overheads
Add four (4) 500 kV series capacitors @ Jacks Mountain	$54.275	

Construction Cost Caps or Commitments

None are identified for the Jacks Mountain Series Capacitor Project.

ROW / Land Acquisition

Subject to the full evaluation of detailed engineering for the Jacks Mountain Series Capacitor Project, no acquisition of additional rights-of-way (ROW) or interests in land is anticipated for this proposed solution.

2.A.5 Equipment Parameters and Assumptions

Table 2.A.5-1 lists the line parameters with the series compensation included. Table 2.A.5-2 lists the substation bus parameters and Table 2.A.5-3 lists the switched shunt parameters used to model the Jacks Mountain Switching Station.

Table 2.A.5-1: 500 kV Line Parameters

Parameter	*Values*
From Bus	Redacted Values
To Bus	[redacted]
Circuit ID	[redacted]
R (p.u.)	[redacted]
X (p.u.)	[redacted]
B (p.u.)	[redacted]
Rate A (SN)	[redacted]
Rate B (SE)	[redacted]

Table 2.A.5-2: 500 kV Substation Bus Parameters

Parameter	*Values*
From Bus	Redacted Values
To Bus	[redacted]
Circuit ID	[redacted]
R (p.u.)	[redacted]
X (p.u.)	[redacted]
B (p.u.)	[redacted]
Rate A (SN)	[redacted]
Rate B (SE)	[redacted]

Table 2.A.5-3: 500 kV Switched Shunt Parameters

Parameter	*Values*
Bus	Redacted Values
# of Steps	[redacted]
Ctrl Mode	[redacted]
Remote Bus	[redacted]
Admittance	[redacted]
Upper Voltage	[redacted]
Lower Voltage	[redacted]

2.A.6 Modeling for Economic Simulation

Market studies were performed to calculate the Energy Market Benefit in accordance with PJM's instructions. These were run using Ventyx's PROMOD v10.1, subscribing base case data from PJM's postings. Since PJM did not provide the 2013 PROMOD study scenario with 2017 transmission, FE created that scenario in consultation with PJM by replacing transmission data in the 2013 scenario with transmission data used in the 2017 scenario.

The 2017 Outage Library (LIB) and 2017 Event (EVE) files provided by PJM were used in all cases, with one necessary correction to the Event file (changing the Stout-Thompson 345 kV circuit from '4' to '04'). See Appendix B for reference file. To ensure consistency between scenarios, FE also created load (DAT) and maintenance (OUT) files from base case runs to apply as load and maintenance schedules in all corresponding change cases. PROMOD scenarios for each proposal were created by adding Change Case files (see below) for each proposal to the elements of the base case scenarios, as well as necessary modifications to the Event file (e.g., where the proposal calls for reconfiguration of lines represented in the Event file).

For each proposal deemed to improve reactive interface constraints, AC transfer limit analysis was performed on each interface with and without the proposed transmission improvements, and the resulting increments in interface flows were added to limits PJM provided in Event files for the corresponding proposal. The Event file for this proposal was also modified to change the western terminal of former Conemaugh-Juniata & Keystone-Juniata lines in interface definitions.

The following files are provided with the Jacks Mountain Series Capacitor Project:

- CC3-4- Jacks Mtn with Series Comp.xml, and
- CC3-4_PJM2017Topology_MonCon_0603_1rev3.eve.

2.A.7 Modeling for Power Flow Simulation

IDEV File

The *.IDV file to model the Jacks Mountain Switching Station in the 2018 RTEP power flow model is also included with the Jacks Mountain Series Capacitor Project and titled "JacksMountain(4).IDV"

Contingency File Update

The additions to the *.CON files used for contingency analysis in the 2018 RTEP power flow model are also included with the Jacks Mountain Series Capacitor Project and titled "JacksMountain_B.CON" and "JacksMountain_C2.CON".

Monitored Element File

The additions to the *.MON file used for analysis in the 2018 RTEP power flow model is also included with this Jacks Mountain Series Capacitor Project and titled "JacksMountain.MON".

2.A.8 High Level Contingency Analysis Results

Case Descriptions

FE modified the 2018 RTEP base case provided by PJM. The modifications to the original case consisted of turning off the Hatfield and Mitchell generating facilities and re-dispatching the case. This case was used as the base case. In addition, FE developed an additional power flow case to analyze the system impact of the Jacks Mountain Series Capacitor Project. Table 2.A.8-1 details the analysis performed on each of the cases. A description of each case follows the table.

Table 2.A.8-1: Power Flow Cases

Case	*Cat A*	*Cat B*	*Cat C*
PJM 2018 RTEP Base Case (modified)	●	●	●
Modified PJM 2018 RTEP with Jacks Mountain Series Compensation Switching Station	●	●	●

PJM 2018 RTEP Base Case (modified) – Used as the base case

The 50/50 summer peak case represents a forecasted load level for which there is a 50% chance that the actual summer peak load will be higher than the forecasted load, and a 50% chance that the actual peak will be lower. This case was provided by PJM. FE modified this case by turning off the Hatfield and Mitchell generating stations and making up the generation by scaling the remaining on-line generation in the PJM footprint.

Modified PJM 2018 RTEP with Jacks Mountain Series Compensation Switching Station

This case is the PJM 2018 RTEP Base Case (modified) with the Jacks Mountain Switching Station with four 250 Mvar shunt capacitors connected to the Keystone-Juniata 500 kV line and the Conemaugh-Juniata 500 kV line with four series capacitors -- one on each 500 kV line at Jacks Mountain, one 600 Mvar series capacitor on the Keystone-Jacks Mountain 500 kV line, one 600 Mvar series capacitor on the Conemaugh-Jacks Mountain 500 kV line, and one 400 Mvar series capacitor on each Jacks Mountain-Juniata 500 kV line.

Steady State Power Flow Results

(See Appendix A for the contingency analysis details and screening criteria used for in the power flow analysis.)

FE did not identify any planning criteria violations from NERC Category B, C1, C2, or C5 contingencies in the base case or with the Jacks Mountain Series Compensation Switching Station installed.

3.0 PJM CONSTRAINT: Hunterstown 230 kV to Hunterstown 115 kV

3.A Proposed Solution:

The Hunterstown 230 kV to Hunterstown 115 kV transformer was identified as a PJM market efficiency constraint. FE's proposed solution to mitigate congestion associated with this constraint is to (1) install a second Hunterstown 230/115 kV transformer at Hunterstown including substation facilities necessary to complete the connection of the new transformer and (2) reconductor approximately 2.8 miles of the Hunterstown-Oxford 115 kV line (the Hunterstown Project).

3.A.1 Designated Entity Request

FE requests that Met-Ed or TrAILCo be the Designated Entity to design, construct, own, operate and maintain the Hunterstown Project.

3.A.2 Description of the Solution

FE proposes the following solution as the Hunterstown Project to address the Hunterstown 230 kV to Hunterstown 115 kV market congestion.

- Install a second 300 MVA 230/115 kV transformer at Hunterstown Substation.
    - The second transformer will be connected in parallel with the existing 230/115 kV transformer with each transformer having a SCADA controlled 230 kV motor operated switch.

      ***Note:** Transformer will be installed such that it can be connected separately to the 230 kV bus in the future.*
- Relocate the existing 115 kV transformer lead line to serve as the lead line for the second Hunterstown 230/115 kV transformer.
- Construct a new 115 kV transformer lead line to connect the existing transformer to the 115 kV yard.
- Install a new 115 kV transformer breaker and a new 115 kV bus tie breaker in the Hunterstown 115 kV yard.

Due to a contingency overload identified in FE's contingency analysis study of the second transformer, FE also proposes to reconductor approximately 2.8 miles of 556 ACSR, 115 kV line conductor between FE's Hunterstown and Oxford Substations with 556 ACSS high temperature conductor, or a thermal equivalent conductor.

Figure 3.A.3 shows a detailed one-line diagram of the Hunterstown Project.

Figure 3.A.3: Hunterstown Project One-Line

Breaker one-line diagram

Redacted Single Line

3.A.3 Detailed Analysis

Facilities Relieved

The Hunterstown Project will relieve the Hunterstown 230 kV to Hunterstown 115 kV congestion in the Met-Ed area.

3.A.4 Project Details

Project Scope

Hunterstown Substation

- Install a second 230/115 kV transformer.
- Install a 230 kV motor operated switch with SCADA control.
- Install two 115 kV breakers.
- Relocate the existing 115 kV transformer lead to connect new transformer to the #8 115 kV bus.
- Construct a new 115 kV transformer lead to connect the existing transformer to the #4 115 kV bus.

Hunterstown – Oxford 115 kV line Reconductor

- Reconductor approximately 2.8 miles of 115 kV line with 556 kcmil ACSS conductor, replacing the existing 556 kcmil ACSR conductor.

Project Schedule

The construction schedule below is based on a PJM requested in-service date of June, 1, 2017. The anticipated Hunterstown Project duration is approximately 14 months from beginning of engineering to completion of construction. The project can be completed by June 1, 2015 if requested by PJM.

Hunterstown Substation

• Engineering	03/01/2016 through 09/14/2016
• Below Grade Construction	09/15/2016 through 12/31/2016
• Above Grade Construction	01/01/2017 through 05/31/2017
• Major Equipment Delivery	01/01/2017
• In-Service Date	06/01/2017

Hunterstown – Oxford 115 kV line Reconductor

- Transmission Engineering	01/01/2016 through 05/31/2016
- Right-of-Way and Permitting	05/01/2016 through 08/31/2016
- Transmission Line Construction	10/01/2016 through 12/31/2016
- Transmission Line Siting	02/01/2016 through 05/31/2016
- In Service Date	1/01/2017

Project Costs

Description	$ Millions	
	Total Cost	Redacted Direct Costs and Overheads
Install 2nd Hunterstown 230/115 kV Transformer	$ 5.180	
Relocate existing 115 kV transformer leads and construct new 115 kV transformer leads	$ 0.240	
Reconductor 2.8 miles of the Hunterstown – Oxford 115 kV line with 556 ACSS Conductor	$ 2.598	
Total Cost	**$ 8.018**	

Construction Cost Caps or Commitments

None are proposed for the Hunterstown Project.

ROW / Land Acquisition

No acquisition of additional ROW or interests in land is anticipated for the Hunterstown Project.

3.A.5 Equipment Parameters and Assumptions

Table 3.A.4-1 lists the transformer parameters used to model a second 230/115 kV transformer at Hunterstown Substation. Table 3.A.4-2 lists the revised transmission line parameters that represent the Hunterstown – Oxford 115 kV line section after the reconductoring is complete.

Table 3.A.4-1: 230/115 kV Transformer Parameters

Parameter	*Value*
From Bus	Redacted Values
To Bus	
Circuit ID	[redacted]
R (p.u.)	[redacted]
X (p.u.)	[redacted]
Rate A (SN)	[redacted]
Rate B (SE)	[redacted]
Vmax	[redacted]
Vmin	[redacted]

Note: A second transformer was included in the PJM supplied 2018 RTEP load flow case but was out of service. The parameters of this offline transformer should be updated with the above data when the transformer is placed in-service in the model.

Table 3.A.4-2: 115 kV Line Parameters

Parameter	*Value*
From Bus	Redacted Values
To Bus	
Circuit ID	[redacted]
R (p.u.)	[redacted]
X (p.u.)	[redacted]
B (p.u.)	[redacted]
Rate A (SN)	[redacted]
Rate B (SE)	[redacted]

3.A.6 Modeling for Economic Simulation

Market studies were performed to calculate the Energy Market Benefit in accordance with PJM's instructions. These were run using Ventyx's PROMOD v10.1, subscribing base case data from PJM's postings. Since PJM did not provide the 2013 PROMOD study scenario with 2017 transmission, FE created that scenario in consultation with PJM by replacing transmission data in the 2013 scenario with transmission data used in the 2017 scenario.

The 2017 Outage Library (LIB) and 2017 Event (EVE) files provided by PJM were used in all cases, with one necessary correction to the Event file (changing the Stout-Thompson 345 kV circuit from '4' to '04'). See Appendix B for reference file. To ensure consistency between scenarios, FE also created load (DAT) and maintenance (OUT) files from base case runs to apply as load and maintenance schedules in all corresponding change cases. PROMOD scenarios for each proposal were created by adding Change Case files (see below) for each proposal to the elements of the base case scenarios, as well as necessary modifications to the Event file (e.g., where the proposal calls for reconfiguration of lines represented in the Event file).

The following files are provided with the Hunterstown Project:

- CC1A - add Hunterstown 2nd TR.xml
- CC1A_PJM2017Topology_MonCon_0603_1rev2.eve

3.A.7 Modeling for Power Flow Simulation

IDEV File

Attached is the IDEV file (*.IDV) used to model the Hunterstown Project in the 2018 RTEP Base Case. The *.IDV file is also included as part of the proposal submitted and is titled "Hunterstown_2ndTrf.IDV".

Contingency File Update

Attached are the updated contingency files (*.CON) used to model the second Hunterstown 230/115 kV transformer in the 2018 RTEP model. The *.CON files are also included as part of the proposal submitted and are titled "Hunterstown_2ndTrf_B.CON", and "Hunterstown_2ndTrf_C1.CON".

Monitored Element File

No changes to the PJM monitor file are required for the Hunterstown Project.

3.A.8 High Level Contingency Analysis Results

Base Case Description

FE used the 2018 RTEP base case provided by PJM. In addition, FE developed three additional cases to analyze the system impact of the Hunterstown Project. Table 3.A.9-1 details the analysis performed on each of the cases. A description of each case follows the table.

Table 3.A.9-1: Power Flow Cases

Case	*Cat A*	*Cat B*	*Cat C*
PJM 2018 RTEP Base Case	●	●	●
PJM 2018 RTEP Base Case with Second Transformer	●	●	●
PJM 2018 RTEP Base Case with Hunterstown – Conastone 500 kV Open	●	●	-
PJM 2018 RTEP Base Case with Second Transformer and with Hunterstown – Conastone 500 kV Open	●	●	-

Base Case

The 50/50 summer peak case represents a forecasted load level for which there is a 50% chance that the actual summer peak load will be higher than the forecasted load, and a 50% chance that the actual peak will be lower. This case was provided by PJM.

Base Case with Second Transformer

This case models a second 230/115 kV transformer at Hunterstown in order to compare the impact to the transmission system.

Base Case with Hunterstown – Conastone 500 kV Open

Through a PROMOD analysis, the loss of the Hunterstown – Conastone 500 kV line was identified as the contingency that had the greatest impact on the loading of the existing transformer. Therefore, to determine the impact of a second contingency, this line was modeled as out of service as a pre-existing condition prior to performing a category B contingency analysis. The contingency analysis was reviewed for compliance with NERC Category C3 contingency testing.

Base Case with Second Transformer and Hunterstown – Conastone 500 kV Open

As with the base case above, this case models a second 230/115 kV transformer at Hunterstown with the Hunterstown – Conastone 500 kV line open in order to compare the impact to the transmission system.

Steady State Power Flow Results

(See Appendix A for the contingency analysis details and screening criteria used in the power flow analysis.)

FE did not identify any planning criteria violations resulting from NERC Category B, C1, C2, or C5 contingencies in the base case or with the second Hunterstown transformer installed. FE did identify Planning Criteria violations when performing the analysis with Hunterstown – Conastone 500 kV open. Table 3.A.9-2 compares the contingency thermal violations in the Met-Ed transmission zone with and without the second Hunterstown transformer during an outage of the Hunterstown – Conastone 500 kV line for loss of the Hunterstown – Jackson 230 kV line.

Table 2.A.9-2: Hunterstown – Conastone 500 kV Line Outage Thermal Violations

Overloaded Element	*Contingency Description*	*Rating (LTE)*	*Without 2nd Transformer*	*With 2nd Transformer*
Hunterstown 230/115 kV Transformer	Hunterstown – Jackson 230 kV Line	Redacted Values		
Hunterstown – Oxford 115 kV Line	Hunterstown – Jackson 230 kV Line			

As shown above, the addition of the second 230/115 kV Hunterstown transformer reduces loading on the existing 230/115 kV transformer. However, the installation of the second 230/115 kV Hunterstown transformer results in an overload of the Hunterstown – Oxford 115 kV line. As such, the Hunterstown Project includes reconductoring approximately 2.8 miles of the Hunterstown – Oxford 115 kV line with 556 ACSS to mitigate the overloaded condition.

The Hunterstown project connects the two Hunterstown transformers in parallel with SCADA controlled 230 kV switches. This arrangement is intended to address the N-1-1 loss of the Hunterstown – Conastone 500 kV line and either of the Hunterstown 230/115 kV transformers. Depending on system conditions, the loss of the Hunterstown – Conastone 500 kV line and one of the Hunterstown 230/115 kV transformers can overload the remaining transformer. With the Hunterstown 230/115 kV transformers connected in parallel, the initial contingency trips both transformers eliminating the possibility of overloading the remaining transformer. Depending on system conditions, the operator can open the SCADA controlled switch isolating the faulted transformer and re-energize the remaining transformer. The second transformer will be designed to connect to its own position in the 230 kV ring such that the transformers will no longer be paralleled or share a common breaker in the future.

4.0 PJM CONSTRAINT: Cleveland Interface

4.A Proposed Solution

While performing the 2013 Market Efficiency Analysis, PJM identified the Cleveland Interface as a baseline constraint. The facilities that comprise the Cleveland Interface are shown in the table below (per the PJM Manual 03: Transmission Operations document).

Redacted Cleveland Interface Table

Installation of a Static Var Compensator (SVC) with a capacitor bank at Lakeshore Substation lessens the voltage constraints, thereby improving the overall system conditions. (the Lakeshore SVC Project)

4.A.1 Designated Entity Request

FE requests that ATSI be the Designated Entity to design, construct, own, operate and maintain the Lakeshore SVC Project.

4.A.2 Description of the Solution

FE proposes the installation of a Lakeshore +240/-150 MVar 138 kV SVC designed with a static 100 MVar Capacitor Bank to address the market constraints on the Cleveland Interface.

- This installation will utilize a 138 kV high-side circuit breaker on the SVC step-up transformer and connect directly to the Lakeshore 138 kV bus.
- The 100 MVar Capacitor Bank will be installed as a branch on the SVC low-side terminal bus.
- Approximately 0.3 miles of transmission line will need to be built from the existing Lakeshore Substation to the site location.

Figure 4.B.3 shows a detailed one-line diagram the Lakeshore SVC Project.

Figure 4.B.3: Lakeshore SVC Installation with Capacitor Bank

Breaker one-line diagram

Redacted Single Line

4.A.3 Detailed Analysis

Facilities Relieved

The Lakeshore SVC Project will relieve the Cleveland Interface congestion in the ATSI area.

4.A.4 Project Details

Project Schedule

The construction schedule below is based on a PJM requested in-service date of June, 1, 2017. The anticipated Lakeshore SVC Project duration is approximately 24 months from beginning of engineering to completion of construction.

Lakeshore +240/-150 MVar 138 kV SVC with a static 100 MVar Capacitor Bank

• Engineering	06/01/2015 through 05/30/2016
• Below Grade Construction	09/01/2016 through 11/30/2016
• Above Grade Construction	12/01/2016 through 05/31/2017
• Major Equipment Delivery	12/01/2016
• In-Service Date	06/01/2017

Project Costs

	$ Millions	
Description	Total Cost	Redacted Direct Costs and Overheads
Install +240/-150 MVar SVC designed with a static 100 MVar static capacitor bank at Lakeshore substation	61.70	

Construction Cost Caps or Commitments

None are identified for the Lakeshore SVC Project.

ROW / Land Acquisition

Subject to the full evaluation of detailed engineering for this proposed solution, acquisition of additional rights-of-way (ROW) or interests in land is anticipated for the Lakeshore SVC Project to build the 0.3 mile of 138 kV line.

4.A.5 Equipment Parameters and Assumptions

Table 4.B.9-5 lists the Lakeshore parameters used to model a Lakeshore +240/-150 MVar 138 kV SVC with a static 100 MVar Capacitor Bank.

Table 4.B.9-5: Lakeshore SVC Parameters with Static Capacitor Bank

Lakeshore SVC

Parameter	*Value*
Bus No.	Redacted Values
Reg Bus	
Circuit ID	
Qmax	
Qmin	
Vsched (p.u.)	

Lakeshore Capacitor Bank

Parameter	*Value*
Bus No.	Redacted Values
Reg Bus	
Circuit ID	
Control Type	
Admittance (p.u.)	

4.A.6 Modeling for Economic Simulation

Market studies were performed to calculate the Energy Market Benefit in accordance with PJM's instructions. These were run using Ventyx's PROMOD v10.1, subscribing base case data from PJM's postings. Since PJM did not provide the 2013 PROMOD study scenario with 2017 transmission, FE created that scenario in consultation with PJM by replacing transmission data in the 2013 scenario with transmission data used in the 2017 scenario.

The 2017 Outage Library (LIB) and 2017 Event (EVE) files provided by PJM were used in all cases, with one necessary correction to the Event file (changing the Stout-Thompson 345 kV circuit from '4' to '04'). See Appendix B for reference file. To ensure consistency between scenarios, FE also created load (DAT) and maintenance (OUT) files from base case runs to apply as load and maintenance schedules in all corresponding change cases. PROMOD scenarios for each proposal were created by adding Change Case files (see below) for each proposal to the elements of the base case scenarios, as well as necessary modifications to the Event file (e.g., where the proposal calls for reconfiguration of lines represented in the Event file).

For each proposal deemed to improve reactive interface constraints, AC transfer limit analysis was performed on each interface with and without the proposed transmission improvements, and the resulting increments in interface flows were added to limits PJM provided in Event files for the corresponding proposal.

The following files are provided with the Lakeshore SVC Project:

- CC2d_PJM2017Topology_MonCon_0603_1rev2.eve

4.A.7 Modeling for Power Flow Simulation

IDEV File

Attached is the IDEV file used to model the Lakeshore +240/-150 MVar 138 kV SVC designed with a static 100 MVar Capacitor Bank in the 2018 RTEP case. The *.IDV file is also included as part of the Lakeshore SVC Project, submitted and is titled "Lakeshore_240MX_SVC.IDV"

Contingency File Update

Attached is the CON files used to model the contingency of the Lakeshore +240/-150 MVar 138 kV SVC designed with a static 100 MVar Capacitor Bank in the 2018 RTEP case. The *.CON files are also included as part of the Lakeshore SVC Project, submitted and are titled "Lakeshore_SVC_Cap_B.CON", "Lakeshore_SVC_Cap_C1.CON", "Lakeshore_SVC_Cap_C2.CON".

Monitored Element File

Attached is the MON file used to monitor facilities within PJM with the Lakeshore +240/-150 MVar 138 kV SVC designed with a static 100 MVar Capacitor Bank in the 2018 RTEP case. The *.MON file is also included as part of the Lakeshore SVC Project, submitted and is titled "Lakeshore_SVC.MON".

4.A.8 High Level Contingency Analysis Results

Base Case Description

The original 2013 Market Efficiency Analysis utilized the 2017 RTEP model the study years of 2017, 2018, 2020, 2023, and 2027. After review of the 2017 RTEP model, FirstEnergy identified the following system topology changes that should not have been included within this model for various unforeseen reasons (i.e. subsequent project deferrals, subsequent reinstatement of generator Capacity Inject Rights in the PJM Capacity Market, updates to the system topology due to recent Supplemental RTEP project submittals, updated modeling information, etc.): Redacted Text [redacted]

[redacted] Please note that the FirstEnergy review of the 2018 PJM RTEP model did not identify any inconsistencies with the present RTEP Transmission Construction Status or Generation Interconnection/Deactivation reports. Analysis performed using the 2018 RTEP model should provide an accurate assessment of the PJM market conditions within ATSI for 2018 and beyond.

In the 2013 Market Efficiency Analysis performed by PJM, the baseline constraint identified for the Cleveland Interface was a voltage constraint. Due to this fact, FirstEnergy performed P-V analysis to determine the appropriate alternatives to alleviate the constraint. After the performance of P-V analysis, subsequent thermal analysis was performed to ensure that the proposed alternatives did not cause additional reliability issues on the 100 kV and above transmission system.

FE used the 2018 RTEP base case provided by PJM to perform both P-V and steady-state load flow analysis. In addition, FE developed an additional case to analyze the system impact of the Lakeshore SVC Project. Table 4.B.9-6 details the analysis performed on each of the cases. Please note that FE's analysis included simulation of all NERC Category B (N-1); NERC Category C1, C2, and C5 (N-2); and several NERC C3 (N-1-1) contingencies within ATSI, AEP, Former Allegheny Power, Penelec, and the PJM 500 kV when evaluating this alternative. A description of each case follows the table.

Table 4.B.9-6: Power Flow Cases

Case	*Cat A*	*Cat B*	*Cat C*
PJM 2018 RTEP Base Case	•	•	•
Base Case with Lakeshore +240/-150 MVar 138 kV SVC w/ 100 MVar Cap	•	•	•

Base Case

The 50/50 summer peak case represents a forecasted load level for which there is a 50% chance that the actual summer peak load will be higher than the forecasted load, and a 50% chance that the actual peak will be lower. This case was provided by PJM.

Base Case with Lakeshore +240/-150 MVar 138 kV SVC designed with a 100 MVar Static Capacitor Bank

This case models a +240/-150 MVar SVC and 100 MVar Static Capacitor Bank connected to the Lakeshore 138 kV bus in order to compare the impact to the transmission system.

Steady State Power Flow Results

(See Appendix A for the contingency analysis details and screening criteria used for in the power flow analysis.)

Please note that while performing baseline load flow analysis on the 2018 PJM RTEP model provided, it was found that a total of six NERC Category B (N-1) contingencies caused the Warren – Falconer 115 kV line to exceed both its Summer Normal (SN) and Summer Emergency (SE) rating (116 MVA SN/SE 116 MVA). The worst case N-1 contingency was for a fault on the Forest #1 230/115kV transformer, which caused the Warren – Falconer 115 kV line to load to **(Redacted Number)** [redacted]% of both its Summer Normal/Summer Emergency rating. Per PJM Manual 03: Transmission Operations, for line overloads on the Warren – Falconer 115kV line, the Falconer 115 kV circuit breaker at Warren substation is normally opened during real-time operations. Due to this operational guideline, the remaining thermal analysis for the Cleveland Interface alternatives was performed with the Warren – Falconer 115 kV line normally opened.

FE did not identify any planning criteria violations from the screened NERC Category B, C1, C2, C3, or C5 contingencies as a result of the Lakeshore +240/-150 MVar 138 kV SVC designed with a static 100 MVar Capacitor Bank being connected to the system.

5.0 Statement of Intent to be the Designated Entity

FE requests that its affiliates identified above are named as the Designated Entity to design, construct, own, operate, and maintain each of the proposed solutions.

FE's affiliates identified above have been pre-qualified for Designated Entity status by PJM prior to the opening of this Market Efficiency project proposal window. PJM notified FE by letter dated July 25, 2013 to Richard O'Callaghan that the FirstEnergy Transmission Affiliates Pre-Qualification Submittal assigned PJM ID 13-10 satisfied the pre-qualification requirements for Designated Entity status as defined in the PJM Amended and Restated Operating Agreement in Section 1.5.8(a) (FERC acceptance pending).

FE confirms that the above-reference pre-qualification information on record with PJM and as posted on PJM's website reflects the current qualifications for its affiliates to be eligible for Designated Entity status as defined by the PJM Amended and Restated Operating Agreement in Section 1.5.8(a) (FERC acceptance pending).

6.0 Pre-Qualification Statement

See Appendix C for the FirstEnergy Transmission Affiliates Pre-Qualification Submittal for Designated Transmission Entity Status.

Included within the attached documentation "FirstEnergy Transmission Affiliates Pre-Qualification Submittal for Designated Transmission Entity Status" is the following detail that FE believes satisfies the additional required submittal documentation as outlined in the PJM RTEP – 2013 Market Efficiency Proposal Window Problem Statement & Requirements Document on page 4 item 10.

(A) Name and Address of the Entity with Point of Contact (include parent company, affiliates or partners)

(B) Technical and Engineering Qualifications.

(C) Demonstrated experience of the entity or its affiliate to develop, construct, maintain and operate transmission facilities.

(D) Prior record of the entity or its affiliate to adhere to standardized construction, maintenance and operating practices.

(E) Capability of the entity or its affiliate to adhere to standardized construction, maintenance and operating practices.

(F) Financial statements of the entity or its affiliate; to include most recent fiscal quarter, most recent three fiscal years or period of existence of the entity.

(G) Commitment by the entity to execute the Consolidated Transmission Owners Agreement.

(H) Evidence demonstrating the ability of the entity to address and timely remedy failure of the facilities.

(I) Evidence of the entity's ability to acquire rights of way.

7.0 Appendix A – System Planning

Redacted Appendix A Text

Redacted Appendix A Text

8.0 Appendix B – PROMOD Base Case Correction

Base Case Correction

Base_PJM2017Topology_MonCon_0603_1rev2.eve

9.0 Appendix C – Pre-Qualification

Redacted Appendix C Text