

***Generation Interconnection  
Feasibility Study Report-Web Version***

***For***

***PJM Generation Interconnection Request  
Queue Position Z1-110***

***Grover 34.5kV Project***

***April 2014***

# **Feasibility Study Report**

## **Grover 34.5kV Project**

### **Introduction**

This Feasibility Study report provides the documentation of an assessment that has been performed by PJM Interconnection and FirstEnergy (FE) in response to a request made by the interconnection customer (IC) for the connection of a 19.9 MW (19.9 MW Capacity) Grover (Z1-110) Generation Project to the Penelec Distribution System.

The intent of the Feasibility study is to determine a plan, with estimated costs and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

### **Connection Facilities**

In compliance with the PJM Generation Interconnection Procedures, Interconnection Customer has submitted a "Generation Interconnection Feasibility Study agreement" to PJM that identifies its plan to install 5 – 4 MW reciprocating engines to a common bus with a total capability of 19.9 MW (19.9 MW capacity) on a property that is approximately 2.5 miles South of Canton, PA., on Brague Road. (see Attachment 1).

Interconnection Customer has requested a 34.5kV interconnection. It was proposed that the project be studied as an interconnection into the First Energy distribution system at Grover Substation 34.5kV bus via a new breaker position. Interconnection Customer is responsible for constructing all of the facilities on its side of the point of interconnection, on the line to the generating plant. Interconnection Customer will also be responsible for the modifications at Grover substation that are required due to connecting the facility.

The 34.5kV interconnection point will require the installation of a Penelec installed/owned main line breaker in the Grover 34.5kV bus (which will act as the disconnect point between First Energy and the generator interconnection) and a new disconnect switch situated just outside of the Grover substation fence line (POI).

A summary of the Grover 34.5 kV Project direct connection facilities that will be required and their estimated cost are shown on Attachment 3.

## PJM Interconnection Study Results

The following are the results of the analysis performed by PJM engineers with respect to the transmission system impacts. This section also includes the reinforcements, their costs and schedules for upgrades on the Interconnected Transmission Owner (Penelec) and the affected Transmission Owner(s).

### Network Impacts

The Queue Project #Z1-110 was studied as a 19.9 MW (Capacity 19.9 MW) injection at the Grover 34.5 kV substation in the Penelec area. Project #Z1-110 was evaluated for compliance with reliability criteria for summer peak conditions in 2017. Potential network impacts were as follow:

#### Generator Deliverability

*(Single or N-1 contingencies for the Capacity portion only of the interconnection)*

1. (PENELEC - PENELEC) The TOWANDA-NO MESHOPPEN 115 kV line (from bus 200674 to bus 200677 ckt 1) loads from 98.89% to 100.19% (**DC power flow**) of its emergency rating (172 MVA) for the single line contingency outage of 'B\_PN230-SX-#11'. This project contributes approximately 2.24 MW to the thermal violation.

```
CONTINGENCY 'B_PN230-SX-#11'                               /* EAST TOWANDA - N
MESHOPPEN (ETP) 230 KV & N MESHOPPEN BK 4
DISCONNECT BRANCH FROM BUS 200675 TO BUS 200924 CKT 1F
DISCONNECT BRANCH FROM BUS 200924 TO BUS 200706 CKT 1F
DISCONNECT BRANCH FROM BUS 200706 TO BUS 200677 CKT 4
END
```

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

### Light Load Analysis

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects)

#### Multiple Facility Contingency

*(Double Circuit Tower Line, Failed Breaker and Bus Fault contingencies for the full energy output)*

None

## Short Circuit

No problems were identified. A circuit breaker analysis was completed for the Z1-110 study. No overdutied breakers were found to be directly attributable to the Z1-110 project.

### Contribution to Previously Identified Overloads

*(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)*

1. (PENELEC - PENELEC) The N.MESHHPN 230/115 kV transformer (from bus 200825 to bus 200706 ckt 3) loads from 101.07% to 102.08% (**DC power flow**) of its emergency rating (188 MVA) for the single line contingency outage of 'B\_PN230-SX-#11'. This project contributes approximately 2.07 MW to the thermal violation.

```
CONTINGENCY 'B_PN230-SX-#11'                                /* EAST TOWANDA - N
MESHOPPEN (ETP) 230 KV & N MESHOPPEN BK 4
DISCONNECT BRANCH FROM BUS 200675 TO BUS 200924 CKT 1F
DISCONNECT BRANCH FROM BUS 200924 TO BUS 200706 CKT 1F
DISCONNECT BRANCH FROM BUS 200706 TO BUS 200677 CKT 4
END
```

Please refer to Appendix 2 for a table containing the generators having contribution to this flowgate.

2. (PENELEC - NYISO) The E.SAYRE-N.WAV115 115 kV line (from bus 200676 to bus 130836 ckt 1) loads from 112.79% to 114.22% (**DC power flow**) of its emergency rating (128 MVA) for the single line contingency outage of 'B\_PN230-SX-#8'. This project contributes approximately 1.95 MW to the thermal violation.

```
CONTINGENCY 'B_PN230-SX-#8'                                /* EAST TOWANDA -
HILLSIDE (ETH) 230 KV
DISCONNECT BRANCH FROM BUS 200675 TO BUS 130763 CKT 1
END
```

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

3. (PENELEC - PENELEC) The N.MESHHPN-OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 114.32% to 115.0% (AC power flow) of its emergency rating (617

MVA) for the single line contingency outage of 'SUSQ 1'. This project contributes approximately 6.24 MW to the thermal violation.

```
CONTINGENCY 'SUSQ 1'  
REMOVE MACHINE 1 FROM BUS 208918  
END
```

Please refer to Appendix 4 for a table containing the generators having contribution to this flowgate.

4. (PENELEC - PL) The OXBOW-LACK 230 kV line (from bus 200708 to bus 208009 ckt 1) loads from 115.28% to 115.97% (AC power flow) of its emergency rating (624 MVA) for the single line contingency outage of 'PL100903'. This project contributes approximately 6.31 MW to the thermal violation.

```
CONTINGENCY 'PL100903'                               /* SUSQUEHANNA-SUSQ GEN 1  
230KV  
DISCONNECT BUS 208114  
END
```

Please refer to Appendix 5 for a table containing the generators having contribution to this flowgate.

5. (PENELEC - PENELEC) The N.MESHPPN-OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 120.78% to 121.84% (**DC power flow**) of its emergency rating (617 MVA) for the bus fault outage of 'C1\_PN230-BS-22B\_A'. This project contributes approximately 6.55 MW to the thermal violation.

```
CONTINGENCY 'C1_PN230-BS-22B_A'                       /* LEWISTOWN 2 230 KV  
BUS FAULT  
DISCONNECT BRANCH FROM BUS 200513 TO BUS 200512 TO BUS 200548 CKT 2  
DISCONNECT BRANCH FROM BUS 200513 TO BUS 200512 CKT 3  
DISCONNECT BRANCH FROM BUS 200513 TO BUS 914320 CKT 1  
DISCONNECT BRANCH FROM BUS 200513 TO BUS 235248 CKT 1  
DISCONNECT BRANCH FROM BUS 200513 TO BUS 200531 CKT 2  
END
```

Please refer to Appendix 6 for a table containing the generators having contribution to this flowgate.

6. (PENELEC - PENELEC) The TOWANDA-E.SAYRE 115 kV line (from bus 200674 to bus 200676 ckt 1) loads from 128.83% to 130.0% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B\_PN230-SX-#8'. This project contributes approximately 1.95 MW to the thermal violation.

```
CONTINGENCY 'B_PN230-SX-#8'                                /* EAST TOWANDA -  
HILLSIDE (ETH) 230 KV  
DISCONNECT BRANCH FROM BUS 200675 TO BUS 130763 CKT 1  
END
```

Please refer to Appendix 7 for a table containing the generators having contribution to this flowgate.

7. (PENELEC - PENELEC) The E.TWANDA-CNYO&G 230 kV line (from bus 200675 to bus 200924 ckt 1F) loads from 107.4% to 108.46% (AC power flow) of its emergency rating (549 MVA) for the line fault with failed breaker contingency outage of 'C2\_PN115-SB-#19F'. This project contributes approximately 5.83 MW to the thermal violation.

```
CONTINGENCY 'C2_PN115-SB-#19F'                            /* EAST TOWANDA 115 KV  
STUCK CB - CBE (EAST TOWANDA BUS TIE CB)  
DISCONNECT BRANCH FROM BUS 200674 TO BUS 200677 CKT 1  
REDUCE BUS 200674 SHUNT BY 100 PERCENT  
DISCONNECT BRANCH FROM BUS 200674 TO BUS 200689 CKT 1  
DISCONNECT BRANCH FROM BUS 200674 TO BUS 200689 CKT 2  
DISCONNECT BRANCH FROM BUS 200676 TO BUS 200674 CKT 1  
DISCONNECT BRANCH FROM BUS 200674 TO BUS 200866 CKT 1  
DISCONNECT BRANCH FROM BUS 200674 TO BUS 200675 CKT 3  
DISCONNECT BRANCH FROM BUS 200674 TO BUS 200675 CKT 4  
END
```

Please refer to Appendix 8 for a table containing the generators having contribution to this flowgate.

8. (PENELEC - PL) The OXBOW-LACK 230 kV line (from bus 200708 to bus 208009 ckt 1) loads from 135.32% to 136.13% (AC power flow) of its normal rating (494 MVA) for non-contingency condition. This project contributes approximately 6.32 MW to the thermal violation.

Please refer to Appendix 9 for a table containing the generators having contribution to this flowgate.

9. (PENELEC - PENELEC) The N.MESHPPN-OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 138.0% to 138.81% (AC power flow) of its normal rating (478 MVA) for non-contingency condition. This project contributes approximately 6.24 MW to the thermal violation.

Please refer to Appendix 10 for a table containing the generators having contribution to this flowgate.

### **Steady-State Voltage Requirements**

*(Results of the steady-state voltage studies should be inserted here)*

Not required

### **Stability and Reactive Power Requirement**

*(Results of the dynamic studies should be inserted here)*

Note that stability studies will be conducted by the PJM staff during the System Impact Study phase.

### **New System Reinforcements**

*(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)*

1. (PENELEC - PENELEC) The TOWANDA-NO MESHO 115 kV line:  
Replace 115 kV switch at East Towanda on North Meshoppen terminal. Estimated Cost: \$113,300 including \$26,300 in tax; Estimated Time: 8 months (PN-S-743)

### **Contribution to Previously Identified System Reinforcements**

*(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)*

*(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)*

1. (PENELEC - PENELEC) The N.MESHPPN 230/115 kV transformer:  
Replace North Meshoppen #3 Transformer. Estimated Cost: \$4,250,900 including \$984,500 in tax; Estimated Time: 14 months (PN-S-742)

2. (PENELEC - NYISO) The E.SAYRE-N.WAV115 115 kV line:  
There is an operating procedure between PJM and NYISO that governs this line; the operating procedure alleviates the overload.

3, 5, 9. (PENELEC - PENELEC) The N.MESHPPN-OXBOW 230 kV line:  
Rebuild line using 1622 ACSS conductor. Upgrade terminals at North Meshoppen and Oxbow.  
Estimated Cost: \$27,312,900 including \$6,325,700 in tax; Estimated Time: 37 months (PN-S-746,747, PN-T-202)

4, 8. (PENELEC - PL) The OXBOW-LACK 230 kV line:

**PPL:**

This overload can be mitigated by upgrading the bay equipment at Lackawanna to 3000 A at a cost of approximately \$2M to achieve the required ratings (938 MVA Summer Emergency). This assumes that the FirstEnergy/Penelec upgrades the line to meet this rating as well. This upgrade may take approximately 18-24 months to complete.

**Penelec:**

Rebuild line using 1622 ACSS conductor. Upgrade terminals at Oxbow. Estimated Cost: \$42,134,300 including \$9,758,300 in tax; Estimated Time: 27 months (PN-S-748, PN-T-203)

6. (PENELEC - PENELEC) The TOWANDA-E.SAYRE 115 kV line:

There is an operating procedure that governs this line; the operating procedure alleviates the overload.

7. (PENELEC - PENELEC) The E.TWANDA-CNYO&G 230 kV line:

Reconductor 230 kV line with 1033 ACSS conductor. Upgrade terminal equipment at East Towanda. Replace switch at Canyon. Estimated Cost: \$14,269,200 including \$3,304,800 in tax; Estimated Time: 33 months (PN-S-744, PN-S-745, PN-T-201)

**Delivery of Energy Portion of Interconnection Request**

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

None

## **Interconnected Transmission Owner’s Analysis Results**

The following was generated by FirstEnergy, the Interconnected Transmission Owner, based upon its analysis, as well as that of PJM, for mitigation of the project’s impacts on the transmission and lower voltage system as applicable. It includes the costs and schedules for any FirstEnergy system upgrades only.

Costs for affected Transmission owners other than FirstEnergy, if applicable, are included and reported in the “New System Reinforcements” and “Contribution to Previously Identified System Reinforcements” sections of the “PJM Interconnection Study Results” above.

## **Power Flow Analysis (New Project Upgrades and Contributions)**

A Power Flow study was conducted to determine the reliability impact of the proposed Grover 34.5 kV (Z1-110) Project on the FE Bulk Transmission System (greater than 100 kV). This included the performance of a contingency analysis to identify any facility overload or voltage condition that violates the FE Planning Criteria. Any such violation that is either directly attributable to this project or for which it will have a shared responsibility is included in this report with a least cost plan identified to mitigate them. The Grover 34.5 kV (Z1-110) Project Power Flow Analysis was completed using a 2017 summer peak load base case power flow provided by the PJM staff. This base case included an equivalent representation of the Penelec 34.5kV distribution system modeled as lumped equivalent load at the Grover 230 kV substation. The Grover 34.5 kV (Z1-110) Project was modeled as an injection into the Grover 34.5 kV substation via a New Breaker position. A simulation of all possible contingencies within the NERC and FE Planning Standards that are impacted by the Grover 34.5 kV (Z1-110) Project was conducted to test for criteria compliance. The conclusion from this analysis is that there are new bulk electric system network upgrades required for the Grover 34.5kV (Z1-110) Project. Furthermore, there are findings of previously identified criteria violations from other generation or transmission interconnection projects in which the Grover 34.5kV (Z1-110) Project contributes.

## **Power Flow Analysis (Detailed 34.5kV)**

In order to identify any overloads or voltage conditions on the 34.5kV system near the Grover 34.5kV (Z1-110) Project, FirstEnergy studied its own detailed model for the 2017 Penelec Summer Peak case. The Grover 34.5kV (Z1-110) Project was modeled at both 19.9 MW output, and with the generator at unity power factor (see Attachment 4).

19.9 MW Energy Output

No overload/voltage issues identified

## **Short Circuit and Dynamics Analysis**

No problems were identified. A circuit breaker analysis was completed for the Z1-110 study. No overdutied breakers were found to be directly attributable to the Z1-110 project.

Note that stability studies will be conducted by the PJM staff during the System Impact Study phase.

### **System Protection Analysis**

An analysis was conducted to assess the impact of the Grover 34.5 kV (Z1-110) Project on the system protection requirements in the area. The results of this review show that the following relay additions will be required:

Proposed single lines show Interconnection Customer constructing a dedicated 34.5kV line to connect their Beaver Dam Energy generation to Penelec's Grover substation 34.5kV bus.

In association with the new 34.5kV line exit equipment (circuit breaker (CB), disconnect switches, arresters etc.) at Grover substation, will be a First Energy corporate group designed distribution line relay panel, for installation inside the Grover substation control house.

This panel will provide control of the new 34.5kV line exit CB at Grover substation (and this CB will provide isolation of the Beaver Dam Energy generation facility for abnormal utility system conditions).

This panel will provide sensing of line faults occurring on the 34.5kV line between Grover substation and Beaver Dam Energy Generation's facility, and will provide trip initiation to the CB at Grover substation, as well as appropriate closing/reclosing of the CB into the new line.

Existing Grover substation protection (i.e. bus differential schemes, operational conditions requiring tripping of the CB) will interface with this relay panel and not directly with Beaver Dam Energy Generation's facility equipment.

Additionally:

This panel will follow current FE corporate specifications/design methods for a distribution line installation and to include the following **extra protection:**

- 34.5kV line potential sensing (requiring a line potential transformer installation to the new line at Grover substation)
- Protection against CB closing out of phase into Beaver Dam Energy generation using a synch check/dead line closing relay.
- Trip & LO initiation to the CB at Grover substation for the condition of 'open' 34.5kV No.1 transformer CB at Grover substation.

Modified protective relay settings may be required for No.1 transformer reverse power and 34.5kV Canton line protection at Grover substation, based on power flows, fault levels, and generation capabilities.

## Notes

The proposed interconnection Owners/developer's facilities must be designed in accordance with the *Generator Interconnection Technical Requirement for Distribution Connection Facilities* document located at either of the following links:

[www.firstenergycorp.com/feconnect](http://www.firstenergycorp.com/feconnect)

[www.pjm.com/planning/design-engineering/to-tech-standards.aspx](http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx)

Additional Note: F.E.'s policy, (as noted in F.E. (**Engineering Practices**)) EP(# 02-280 C 3.11)

Generator owner is responsible to provide adequate protection (for their equipment) under any distribution system operating condition' - which includes 'Separation from supply' (i.e. tripping of F.E. circuit breakers) and 'Re-synchronizing the generation after electric restoration of the supply' (i.e. reclosing of F.E. circuit breakers).

Generator owner protection must be designed to coordinate with the reclosing practices of FirstEnergy line protective devices. The generator must cease to energize the FirstEnergy circuit to which it is connected prior to reclosing of any (FE) automatic reclosing devices.

## **Metering**

Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. These FE requirements are detailed on Attachment 6 of this report.

The 34.5 kV revenue quality metering equipment shall be designed, furnished and installed by FirstEnergy. The Interconnection Customer will be responsible for designing, furnishing and installing a SCADA RTU in their generation substation and obtaining the telecommunication circuits from the RTU to the Penelec Data Center. The connection to the Penelec Data Center will be to provide MW, MVAR and 34.5kV voltage at Interconnection Customer generation substation. Please reference the FirstEnergy Metering Requirements for Interconnection Customers, for more details on the metering requirements for FirstEnergy. This document can be found on the FE website at:

<https://www.firstenergycorp.com/feconnect/penelec/wholesale.html>

## **Compliance Issues**

Interconnection Customer will be responsible for meeting a power factor between 0.95 leading (absorbing MVARs) and 0.95 lagging (producing MVARs) to assure that voltage deviation will be less than 1.0 volt as measured at the POI under all Gen operating conditions.

Interconnection Customer must also meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures required for standards compliance. For example, the Developer will need to properly locate and report the over and under-voltage and over and under-frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

### **FE Facility Upgrades and Costs**

The results from the FE power flow analysis (Attachment 4) show that there are FE criteria violations that are directly attributable to the capacity of the Grover 34.5 kV (Z1-110) Project. Furthermore, there are violations affecting thermal overload on network branches in which the capacity of the Grover 34.5 kV (Z1-110) Project is a contributor. In accordance with the Generation Interconnection procedures defined in the PJM Open Access Transmission Tariff and PJM Manuals, Interconnection Customer is responsible for network upgrades, and Attachment 5 has the details of those upgrades. The direct connection costs are detailed in Attachment 3.

Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to error. More accurate estimates will be determined as a part of the Facilities Study. The Interconnection Customer will be responsible for the actual cost of the direct connection that is implemented. In addition, Interconnection Customer is responsible to provide the distribution line between the tap at pole # STS-389 and the Z1-110 generating substation, as Interconnection Customer will own this distribution line. FE herein reserves the right to return to any previously identified issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the distribution system.

### **Generation Connection Requirements**

The proposed interconnection facilities must be designed in accordance with Attachment 7, FirstEnergy's "Technical Requirements for the Interconnection of Parallel-Operated Generation to the FirstEnergy Distribution System" and must also meet IEEE 1547.

The Interconnection Customer will also be responsible for following the requirements of the "FE Approved Vendors and Contractors" documents which is located at the above link.

### **Interconnection Customer Requirements**

In addition to the FE facilities, Interconnection Customer will also be responsible for meeting all criteria as specified in the applicable sections of the "FE Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
2. The installation of a Penelec provided 34.5 kV interconnection metering instrument transformer. FE will provide the ratio and accuracy specifications based on the customer load and generation levels.
3. The installation of a Penelec provided revenue class meter for each unit to measure the power delivered in compliance with the FE standards.
4. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center.
5. The establishment of dedicated communication circuits for SCADA report to the FE Transmission System Control Center.
6. A compliance with the FE and PJM generator power factor and voltage control requirements.
7. The execution of a back-up service agreement to serve the customer load when the units are out-of-service. This assumes the intent of Interconnection Customer is to net the generation with the load.
8. The rough grade of the property for the Z1-110 Interconnection and an access road for the delivery of equipment to this site.

The above requirements are in addition to any metering and telecommunications required by PJM as specified in PJM Manuals M-01 and M-14D

## Summary

The Grover 34.5 kV (Z1-110) will require the First Energy Attachment/Direct Connection facilities as defined in Attachment 3. As shown, the total estimated cost for those facilities is \$720,200. Based on the scope of the FE direct connection, it is expected to take approximately one 1 year from the signing of a Connection Service Agreement to complete the installation of these facilities.

The Grover 34.5 kV (Z1-110) Project also requires network upgrades on the FE system, as defined in Attachment 5. As shown, the total estimated cost of the FirstEnergy upgrades is \$74,979,400 plus any applicable taxes. These required network upgrades are estimated to take approximately 37 months to complete.

This project also creates an overload in the PPL transmission territory as reported in the PJM Interconnection Study Results section of this report. This overload can be mitigated by upgrading the bay equipment at Lackawanna to 3000 Amps at a cost of approximately \$2,000,000 plus any applicable taxes. to achieve the required ratings (938 MVA Summer Emergency). This assumes that the FirstEnergy/Penelec upgrades the line to meet this rating as well. This upgrade will take up to 24 months to complete.

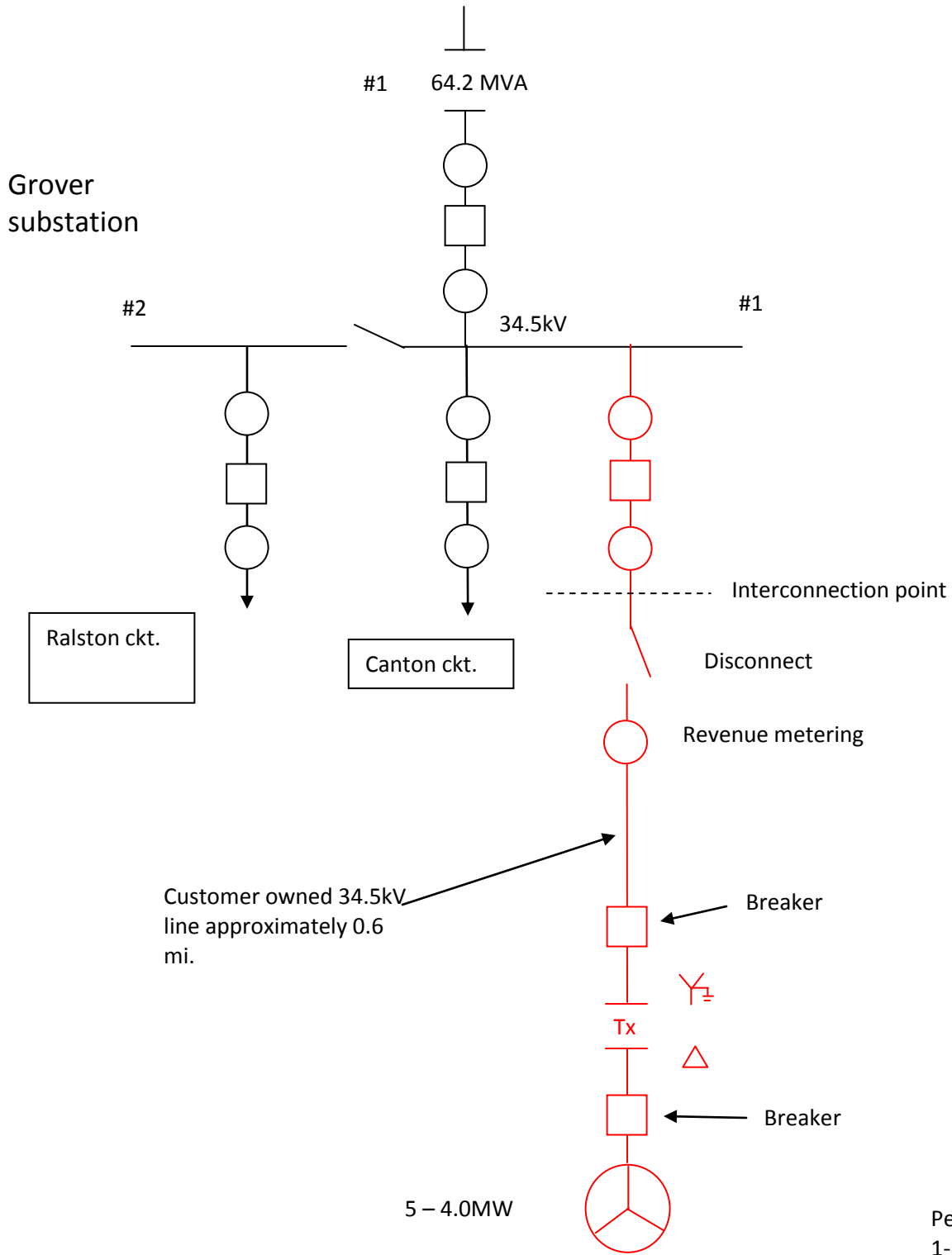
Based on the foregoing, the total estimated cost for this project is \$77,699,600 plus any applicable taxes. This is an unallocated cost estimate. The cost allocations will be determined and presented in the System Impact Study report.

It is assumed that Interconnection Customer will provide the property for the attachment tap pole and all right-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and network upgrades, and that FE will allow all distribution system outages when requested.

**Project Location**



# Attachment 2 Grover 34.5kV (Z1-110) Project Conceptual 34.5 kV Interconnection



Penelec Engr.  
1-14-14

**Attachment 3**  
**Grover 34.5kV (Z1-110) Project**  
**Conceptual 34.5 kV Interconnection Attachment 4**

Item	Description	Conceptual Cost Estimate
PN-S-737	<b>Grover SS</b> Install new 34.5kV line exit for the Z1-110 generation interconnection	\$469,700
EOC	Engineering, Oversight, & Commissioning	\$62,000
1	RTU programming for connection to the First Energy SCADA and relay support for the generation installation.	\$7,500
2	Revenue metering	\$13,100
3	Express 0.1 mile 34.5kV line from Grover Substation interconnection disconnect switch to Z1-110, plus Z1-110 line breaker located at PV generator site	Customer Owned
4	CIAC and Federal Income Tax Gross Up	\$167,900

Note:

Conceptual Estimate:

\$720,200

Estimated Lead Time:

1 year from signed CA

Notes:

- Detailed Engineering & Construction Estimates TBD via Facility Study
- The above estimates do not include 1) property costs and site development up to rough grade which is to be provided by the developer, 2) generation SCADA to be provided by the developer, and 3) engineering and field activities for design review and commissioning of the developer's facilities.

## **Grover 34.5kV (Z1-110) Project** **FE Contingency Analysis Results**

The Detailed 34.5kV analysis resulted in no overloaded elements.

Refer to PJM analysis for Transmission System Analysis and resultant upgrades

**Attachment 5**  
**Grover 34.5kV (Z1-110) Project**  
**FE Network Facility Reinforcement Conceptual Cost Estimates**

**North Meshoppen: Replace #3 230/115kV Transformer**

Estimate No.	Description	Total with Tax	Tax	Total Cost
PN-S-742	Replace No. 3 Transformer and remove 115kV reactor. @ North Meshoppen	\$4,250,900	\$984,500	\$3,266,400
<b>Total</b>		\$4,250,900	\$984,500	\$3,266,400

**East Towanda – North Meshoppen 115kV: Upgrade terminal at East Towanda**

Estimate No.	Description	Total with Tax	Tax	Total Cost
PN-S-743	<b>East Towanda SS.</b> Upgrade terminal equipment	\$113,300	\$26,300	\$87,000
<b>Total</b>		\$113,300	\$26,300	\$87,000

**North Meshoppen – Oxbow 230kV: Rebuild line and upgrade terminals**

Estimate No.	Description	Total with Tax	Tax	Total Cost
PN-S-746	<b>North Meshoppen SS.</b> Upgrade terminal equipment	\$274,100	\$63,500	\$210,600
PN-S-747	<b>Oxbow SS.</b> Upgrade terminal equipment	\$109,400	\$25,400	\$84,000
PN-T-202	<b>North Meshoppen – Oxbow:</b> Rebuild and reconductor the 10.6 mile North Meshoppen-Oxbow 230kV line with 1622 kcmil ACSS.	\$26,929,400	\$6,236,800	\$20,692,600
<b>Total</b>		\$27,312,900	\$6,325,700	\$20,987,200

**Oxbow – Lackawanna 230kV: Rebuild line and upgrade terminal**

<b>Estimate No.</b>	<b>Description</b>	<b>Total with Tax</b>	<b>Tax</b>	<b>Total Cost</b>
PN-S-748	<b>Oxbow SS.</b> Upgrade terminal equipment	\$109,400	\$25,400	\$84,000
PN-T-203	<b>Oxbow – Lackawanna:</b> Rebuild and reconductor the 16.3 mile Lackawanna-Oxbow 230kV line with 1622 kcmil ACSS conductor.	\$42,024,900	\$9,732,900	\$32,292,000
<b>Total</b>		\$42,134,300	\$9,758,300	\$32,376,000

**East Towanda – Canyon 230kV: Reconductor line and upgrade terminal**

<b>Estimate No.</b>	<b>Description</b>	<b>Total with Tax</b>	<b>Tax</b>	<b>Total Cost</b>
PN-S-744	<b>East Towanda SS.</b> Upgrade terminal equipment	\$32,100	\$7,500	\$24,600
PN-S-745	<b>Canyon SS.</b> Upgrade terminal equipment	\$103,600	\$24,000	\$79,600
PN-T-201	<b>East Towanda – Canyon 230kV:</b> Reconductor the 12.3 mile East Towanda - Canyon 230kV line with 1033 kcmil ACSS.	\$14,133,500	\$3,273,300	\$10,860,200
<b>Total</b>		\$14,269,200	\$3,304,800	\$10,964,400

## **Attachment 6**

### **FirstEnergy Revenue Metering Requirements for Generation Interconnection Customer**

The FE operating company (Penelec) shall provide, own, operate, test, and maintain the revenue metering equipment at the Interconnection Customer's (IC) expense. The revenue metering equipment includes, but is not limited to, current transformers, voltage transformers, secondary wires, meter socket, bidirectional revenue meter, and associated devices. The IC shall mount the instrument transformers unless otherwise agreed to by Penelec. The instrument transformers and meter socket shall be installed in a location that is readily accessible to authorized Penelec representatives. Penelec will provide the IC access to bidirectional kWh and kVARh pulses from the Penelec meter at the IC's expense if requested. The IC shall, at its expense, install, own, operate, test, and maintain any metering and telemetry equipment that may be required to provide real-time meter data to FE or PJM.

## **Attachment 7**

### **Applicability**

1. This document defines the technical requirements for the interconnection of parallel-operated generation and related equipment to the FirstEnergy distribution system. For purposes of this document the term “generation” includes rotating and inverter-derived generating sources.
2. These requirements apply to customer-owned generation used to offset energy usage and to distributed generation exporting energy on a wholesale basis.
3. This document also applies to standby generator schemes with a make-before-break transition provided that the duration of parallel operation is 100 milliseconds or more.
4. These requirements apply to new generator interconnections as well as existing facilities being upgraded or expanded.

### **Purpose**

The purpose of this document is to ensure the safety of FirstEnergy employees and the public, to protect FirstEnergy equipment from damage and to ensure the reliability of service to FirstEnergy customers.

### **Applicable Standards**

1. Generator facilities must comply with all requirements of the latest version of the IEEE 1547, “Standard for Interconnecting Distributed Resources with Electric Power Systems<sup>1</sup>.”
2. Inverter systems must comply with all requirements of the latest version of the UL1741, “Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources<sup>2</sup>.”
3. Generator facilities and equipment must comply with all applicable national, state, and local construction codes and all operation and maintenance-related safety codes, such as the National Electrical Code (NEC), the National Electrical Safety Code (NESC), and the Occupational Safety and Health Administration (OSHA) regulations.
4. Generator interconnections are subject to applicable Federal or State interconnection rules and regulations depending upon interconnection type.

### **Relaying and Protection**

- The generator owner is responsible for providing adequate protection to FirstEnergy facilities for conditions arising from the operation of generation under

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<sup>1</sup> IEEE Standard 1547-2003, “IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems,” July 28, 2003.

<sup>2</sup> Underwriters Laboratory U.L. 1741, “Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources,” May 7, 1999.

all FirstEnergy distribution system operating conditions. The generator owner is also responsible for providing adequate protection to their facility under any distribution system operating condition whether or not their generator is in operation. Conditions may include but are not limited to:

- ❑ Loss of a single phase of supply
  - ❑ Distribution system faults
  - ❑ Equipment failures
  - ❑ Abnormal voltage or frequency
  - ❑ Lightning and switching surges
  - ❑ Excessive harmonic voltages
  - ❑ Excessive negative sequence voltages
  - ❑ Separation from supply
  - ❑ Synchronizing generator to the distribution system
  - ❑ Re-synchronizing the generation after electric restoration of the supply.
- The generator must connect to the FirstEnergy system through an interrupting device, which has adequate fault interruption, and withstand capability, and adequate continuous current and voltage rating in accordance with latest IEEE C37 standards. Three-phase generators shall use an interrupting device that interrupts all three phases simultaneously. The tripping control of the circuit interrupting device shall be powered independently of the utility AC source in order to permit operation upon loss of the FirstEnergy supply.
- Non-certified inverters rated 300 kW or larger and rotating machines rated 300 kW or larger will require the use of utility grade relays at the point of interconnection. Utility-grade relays are also required where multiple generators are connected to the FirstEnergy system through a single point of interconnection and the aggregate generation is 2000 kW or larger. For purposes of this policy, utility-grade relays are defined as follows:
  - ❑ Relays comply with the latest IEEE Standard, C37.90, “Relays and Relay Systems Associated with Electric Power Apparatus.”
  - ❑ Relays have appropriate test plugs/switches for testing the operation of the relay without unwiring or disassembly.
  - ❑ Relays have targets to indicate relay operation.
  - ❑ Relays have ability to record and store fault events.
- The generator protection and controls must be designed to coordinate with the reclosing practices of FirstEnergy line protective devices. The generator must cease to energize the FirstEnergy circuit to which it is connected prior to reclosure of any automatic reclosing devices.
- The generator shall cease to energize the FirstEnergy distribution system for

faults on the circuit to which it is connected. The generator shall not reconnect to the FirstEnergy system following a trip from a system protection device, until the FirstEnergy system has been re-energized for a minimum of five minutes.

- The generator protection and controls shall be designed to prevent the generator from being connected to a de-energized FirstEnergy circuit.

**Voltage Control & Flicker**

- The generator shall be capable of paralleling with the FirstEnergy system without causing a voltage fluctuation at the point of common coupling (PCC) greater than 5% of the prevailing voltage level of the FirstEnergy system at the PCC.
- The generator must have adequate protection and controls to ensure the requirements for frequency, voltage, and phase angle shown in Table 1 are met prior to paralleling with the FirstEnergy system.

<b>Table 1: Paralleling requirements for generators connecting to the distribution system.</b>			
Rating of Generator (kVA)	Frequency Difference (Hz)	Voltage Difference (% V)	Phase angle Difference (degrees)
0 - 500	0.3	10	20
500 - 1500	0.2	5	15
> 1500	0.1	3	10

- The generator shall not be a source of excessive harmonic voltage and current distortion and/or voltage flicker. Limits for harmonic distortion (including inductive telephone influence factors) will be as published in the latest issues of IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems<sup>3</sup>." Flicker occurring at the point of common coupling serving other FirstEnergy customers shall remain below the Border Line of Visibility curve shown in fig. 10-3 of the IEEE 519 Standard. (A.k.a. the GE Flicker Curve). Flicker occurring at the secondary of a service transformer serving a sole DG customer shall remain below the Borderline of Irritability curve.
- When there is reasonable cause for concern due to the nature of the generation and its location, FirstEnergy may require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria. The monitoring system, if required, will be installed at the generator owner’s expense. Situations where high harmonic voltages and/or currents originate from the distribution system are to be addressed in the Interconnection Agreement.

<sup>3</sup> IEEE Standard 519-1992, “IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems,” Second printing June 15, 2004

- If high voltage, low voltage, or objectionable voltage flicker arises due to the operation, frequent tripping, and/or frequent starting and stopping of the generator, the generator owner may be required to disconnect its generation equipment from the FirstEnergy system until the problem has been fully investigated and resolved.
- The operation of the generator equipment must not result in harmonic currents or voltages at the point of common coupling that will interfere with FirstEnergy's metering accuracy and/or proper operation of facilities and/or with the loads of other FirstEnergy customers. Such adverse effects may include, but are not limited to heating of wiring and equipment, overvoltage, communication interference, harmonic resonance, etc.
- DC injection from inverters shall be maintained at or below 0.5% of full rated inverter output current into the point of common coupling.
- The generated voltage shall follow, not attempt to oppose or regulate, changes in the prevailing voltage level provided by FirstEnergy at the point of common coupling, unless otherwise mutually agreed to by the generator owner and FirstEnergy.
- The generator must not interfere with the operation of FirstEnergy voltage regulating equipment including voltage regulators and line capacitors such that the service voltage to other FirstEnergy customers falls outside the limits specified in ANSI C84.1<sup>4</sup>, Range A.
- Voltage unbalance at the point of common coupling caused by the generator equipment under any condition shall not exceed 3% (ratio of maximum deviation from average voltage to the average voltage).<sup>5</sup>
- A generator connected to an area network system shall not cause tripping of network protectors due to reversal of power flow.

#### **Response to abnormal voltage**

- The protection functions of the interconnection system shall detect the effective (RMS) or fundamental frequency value of each phase-to-phase voltage, except where the transformer connecting the generator to the FirstEnergy system is a grounded wye-wye configuration, or single-phase installation, the phase-to-neutral voltage shall be detected.
- When any voltage is in a range given in Table 2 the generator shall cease to energize the FirstEnergy system within the clearing time as indicated. Clearing time is the time between the start of the abnormal condition and the

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<sup>4</sup> ANSI C84.1-2006, American National Standard for Electrical Power Systems and Equipment—Voltage Ratings (60 Hertz)

<sup>5</sup> ANSI C84.1-2006, Annex C, Polyphase Voltage Unbalance, Paragraph C.2

generator ceasing to energize the utility system.

- For generators 30 kW or larger, different settings may be used for the under/over voltage trip levels or time delays if approved by FirstEnergy. Field-adjustable set points shall be protected against unauthorized adjustment.

Voltage Range (% of Base Voltage) <sup>[1]</sup>	Clearing time <sup>[2]</sup>
$V < 50 \%$	0.16 Seconds
$50 \% \leq V < 88 \%$	2.00 Seconds
$110\% < V < 120 \%$	1.00 Seconds
$V \geq 120 \%$	0.16 Seconds

[1] Base voltages are the nominal system voltages stated in ANSI C84.1-1995.

[2] For generators  $\geq 30$  kW times may be extended if approved by FirstEnergy.

- Voltages shall normally be detected at the PCC to eliminate the effects of voltage drop or transformer connections between the PCC and the point of generator interconnection. However, under any of the following conditions the voltages may be detected at the point of generator interconnection:
  - The aggregate capacity of the generator system connected to a single PCC is less than or equal to 30 kW,
  - The interconnection equipment is certified to pass a non-islanding test for the system to which it is to be connected,
  - The aggregate generator capacity is less than 50% of the total local electric power system minimum annual integrated electrical demand for a 15 minute time period, and export of real or reactive power by the generator to the FirstEnergy system is not permitted.

### **Response to abnormal frequency**

- When the system frequency is in a range given in Table 3, the generator shall cease to energize the FirstEnergy system within the clearing time as indicated. Clearing time is the time between the start of the abnormal condition and the generator ceasing to energize the FirstEnergy system.
- For generators greater than 30 kW, the frequency and time delay set points shall be field adjustable. Field-adjustable set points shall be protected against unauthorized adjustment.

Generator Size	Frequency Range (Hz)	Clearing time
≤ 30 kW	> 60.5	0.16 Sec
	< 59.3	0.16 Sec
> 30 kW	> 60.5	0.16 Sec
	< 59.3 <sup>[1]</sup>	0.25 Sec <sup>[2]</sup>
	< 57.0	0.16 Sec

[1] < {59.8 – 57.0 Hz} Allowable setting under approval from FirstEnergy.

[2] {0.16 to 300 Sec} Allowable setting under approval from FirstEnergy.

### Islanding Protection

- The generator protection and controls must be able to detect an island condition and disconnect the generator from the FirstEnergy system within two seconds of the formation of an island. The anti-islanding requirement can be satisfied by using any of the following methods, subject to the approval of FirstEnergy.
  - Direct Transfer Trip Scheme,
  - Use of frequency relays and voltage relays,
  - The generator’s protection package or the inverter is certified to pass an anti-islanding test (certified to comply with IEEE 1547),
  - Non-exporting customer generator with reverse power relaying applied at the point of interconnection.

### Direct Transfer Trip (DTT) Scheme

- FirstEnergy will make the determination if a DTT scheme is required on a case-by-case basis. A DTT scheme will typically be required when both of the following are true:
  - The generator is any of the following types; a synchronous machine, a non-certified inverter, or a self-excited induction generator, each capable of sustaining a load when separated from the utility system;
  - The minimum circuit load on the line section connected to the generator following the opening of any automatic sectionalizing devices is not greater than 3 times the aggregate generation capacity.
- The DTT scheme design, equipment and type of communication channel shall be proposed by the generator owner and submitted to FirstEnergy for review and acceptance.
- The DTT scheme must be designed to automatically trip and separate the generator from the FirstEnergy distribution system upon loss of communication channel. The generator shall not reconnect to the system until

the communication channel is proven to be functioning normally.

- Responsibilities for purchase, installation and ownership of DTT equipment will be as follows:
  - ❑ The generator owner shall own and provide a direct-transfer trip receiver(s) at their facility to receive tripping signals originating from a FirstEnergy location(s).
  - ❑ The generator owner shall bear the costs to purchase and install the required DTT transmitting and associated relaying equipment at the required FirstEnergy location(s). FirstEnergy will perform or coordinate the installation of the equipment at the cost of the generator owner. FirstEnergy will own and be responsible to maintain and perform periodic maintenance and testing of this equipment.
  - ❑ The generator owner is responsible for the design, installation and maintenance of a dedicated communication channel(s) between the FirstEnergy location(s) and the generation owner's facility, including any rental, license and attachment fees for the communications channel.
  - ❑ When DTT equipment needs replacement due to age or continued unreliable performance, the generator owner is responsible for purchase and installation costs of the new equipment. This must be established in the Interconnection agreement with the generator owner.
- If the generator owner wishes to install communications cables or equipment on FirstEnergy poles, the generator owner will be responsible to secure a license agreement or pole attachment agreement for those attachments, and assume typical licensed attachment responsibilities in terms of make-ready work costs and annual attachment fees. Cable attachment will be in the communications space on the poles.
- When a DTT tripping signal originates from a FirstEnergy substation breaker, the preferred location for DTT transmitter and associated equipment is within the FirstEnergy substation control room or approved outdoor enclosure within the substation perimeter if a control room is not available.
- FirstEnergy will establish a demarcation point for any DTT communication cables leaving the substation property. FirstEnergy will perform or coordinate the installation of the cable and conduit up to the demarcation point including the box enclosure. FirstEnergy will determine the enclosure location. All material and installation costs will be borne by the generator owner. The generator owner will be responsible to install cable and conduit originating from their end up to the demarcation point. Details of the planned installation including any trenching must be approved by FirstEnergy.
- The generator owner may be responsible to compensate FirstEnergy for any labor expenses involved with troubleshooting or testing of the DTT

communications or protection system. This requirement is to be contractually addressed in the Interconnection Agreement with the generator owner.

### **Disconnect Switch Requirements**

- FirstEnergy requires that a disconnect device with a visibly open means be provided, installed, and paid for by the generator owner, which is readily accessible to and lockable by FirstEnergy personnel, in order to safely disconnect the generator from the FirstEnergy system.<sup>6</sup>
- The disconnect device may be installed either at the primary voltage level or secondary voltage level at the discretion of FirstEnergy. The generator disconnect device must be clearly labeled to show its intended function.

### **Interconnection Transformer Requirements**

- All generation must be isolated from the FirstEnergy primary distribution system by a transformer in order to properly integrate the grounding scheme of the generator to the grounding scheme of the distribution system.
- The grounding scheme of the interconnection transformer shall not cause overvoltages on the un-faulted phases during ground-fault conditions that exceed the rating of equipment connected to the FirstEnergy distribution system.
- The ground source contribution current of the interconnection transformer shall not disrupt the coordination of the overcurrent devices of the distribution circuit whether or not the generator is in operation.

### **Maintenance Requirements**

1. The generator owner shall maintain all equipment associated with the generator system, including DTT communications equipment, according to good utility practices and according to equipment manufacturer's recommendations and keep it in proper working condition.
2. The generator owner shall keep a written log and test records showing the periodic testing of such equipment. These records must be available to FirstEnergy upon request.

### **Acceptance Testing**

1. Test results or equipment pre-certification shall be supplied by the generator owner, that verify, to the satisfaction of FirstEnergy, compliance with the IEEE 1547 Standard, Section 5 "Interconnection Test Specifications and Requirements."

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<sup>6</sup> Exception: In New Jersey, an outdoor disconnect switch is not a requirement for Level 1 interconnections per NJ Net metering regulations. See NJ Administrative Code, NJAC 14:8-4.1 et seq.(2008)

2. The generator owner must provide FirstEnergy the opportunity to perform an inspection prior to interconnection to verify correct protective settings and wiring connections.
3. Acceptance testing shall be performed on all generators and generating equipment not pre-certified by a nationally recognized testing laboratory as suitable for utility interconnection meeting the intent of these technical requirements. A qualified third party testing organization shall perform these tests at the expense of the generator owner.
4. Acceptance testing of the protective schemes, where required, must be completed on new or modified installations.

### **Communications and Control**

1. FirstEnergy may require the generator owner to provide a listing of two or more persons and their telephone numbers such that the FirstEnergy dispatching office can contact the generator owner for emergency switching operations 24 hours a day. This is a necessary safety requirement.
2. For generators rated 2000 kVA or larger, individually or in aggregate, who are exporting energy on a wholesale basis, will require the generator owner to furnish a SCADA remote terminal unit (RTU) which will interface with the FirstEnergy energy management system (EMS). The RTU, the communications channel and all related equipment will be furnished and maintained by the generator owner. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol. The following control, status, and metering points will be required:
  - Tripping control of generator or interconnection breaker.
  - Generator real and reactive power output measured at the high-side of the generator step-up transformer.
  - Generator voltage at the point of interconnection.
  - Indication that a direct-transfer trip operation has occurred where DTT is used.
3. Where tripping control of generator breaker is required, the tripping command originating from the FirstEnergy dispatching office must also activate a closing lockout function which must be manually reset before the generator breaker can be re-connected to the system.

### **Metering Requirements**

1. Metering instrument transformers are to be protected from the distribution system by a fuse or other protective device such that failure of an instrument transformer does not cause a distribution protection device to open.

2. In the case of an existing retail customer that is adding generation their facility, the retail billing meter will need to be replaced with a bi-directional meter. A review of the wiring and current transformers may need to be performed to verify the ampacity ratings are sufficient for the size of the generator. Cost responsibilities for meter replacement are defined in the retail net metering tariffs.
3. Wholesale generation facilities must comply with the metering requirements of the appropriate RTO.
4. Wholesale generation facilities must comply with the FirstEnergy requirements specified in the document entitled “FirstEnergy Revenue Metering Requirements For Generation Facilities Connected 46 kV and Lower.”
5. Generators with an aggregate capacity of 1000 kVA or larger may require the installation of an interval metering system, which will transfer metering data to the FirstEnergy MV-90 system<sup>7</sup>. The meter will be provided by FirstEnergy. The generator owner will be responsible to provide at their cost a dedicated communications channel, which will interface with FirstEnergy’s MV-90 system.
6. Cost responsibilities associated with the purchase, installation, and testing and of revenue metering equipment will be determined on a case-by-case basis under the direction of the FirstEnergy Corporate Metering Department and in accordance with the rules found in filed tariffs. These details are to be addressed in the facilities study.
7. Metering equipment must meet the specifications of FirstEnergy and the appropriate RTO.

## Definitions

Area Network System - A type of electric distribution system served by multiple transformers interconnected in an electrical network circuit, which is generally used in large metropolitan areas that are densely populated, in order to provide highly reliable service. Area network has the same meaning as the term “distribution secondary grid network” found in institute of electrical and electronics engineers (IEEE) standard 1547.

Certified Equipment – Equipment which has been submitted by a manufacturer to an OSHA-approved nationally recognized testing laboratory, and has been tested and listed by the laboratory for continuous interactive operation with an electric distribution system in compliance with the applicable codes and standards listed in the IEEE 1547 and UL 1741 Standards.

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<sup>7</sup> MV-90 is FirstEnergy’s system for collecting interval metering data.

Flicker – A variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity.

Harmonic Distortion – Continuous distortion of the normal sine wave; typically caused by nonlinear loads or by inverters.

Inverter – A device or system that changes direct current power to alternating current power. Inverters that are self-commutating can be configured for stand-alone service. Inverters that are line-commutated cannot be configured for stand-alone service.

Point of Common Coupling – The point at which the generator facility is connected to the shared portion, or potentially shared portion of the FirstEnergy system. The IEEE 1547 standard establishes this point as the location where voltage and harmonic limits are measured and applied.

Regional Transmission Organization (RTO) – An independent, FERC-approved organization of sufficient regional scope, which coordinates the interstate movement of electricity under FERC-approved Tariffs by operating the transmission system and competitive wholesale electricity markets, and ensuring reliability and efficiency through expansion planning and interregional coordination.

Single Phasing Condition – Occurs when one or two phases of the three phase supply line are disconnected.

Unintentional Island - An unplanned condition where one or more generator's and a portion of the FirstEnergy system remain energized solely through the point of interconnection.

## **Appendices**

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gauge other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

## Appendix 1

(PENELEC - PENELEC) The TOWANDA-NO MESHO 115 kV line (from bus 200674 to bus 200677 ckt 1) loads from 98.89% to 100.19% (**DC power flow**) of its emergency rating (172 MVA) for the single line contingency outage of 'B\_PN230-SX-#11'. This project contributes approximately 2.24 MW to the thermal violation.

CONTINGENCY 'B\_PN230-SX-#11' /\* EAST TOWANDA - N

MESHOPPEN (ETP) 230 KV & N MESHOPPEN BK 4

DISCONNECT BRANCH FROM BUS 200675 TO BUS 200924 CKT 1F

DISCONNECT BRANCH FROM BUS 200924 TO BUS 200706 CKT 1F

DISCONNECT BRANCH FROM BUS 200706 TO BUS 200677 CKT 4

END

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.07
203261	BLOSSBCT	0.06
203283	MANOR	< 0.01
293270	N-036 C	0.52
907481	X1-109	3.79
Y2-068	Y2-068	22.18
Y2-082	Y2-082	11.01
Z1-019	Z1-019	26.46
916261	Z1-069 C	0.79
916431	Z1-092	2.05
916611	Z1-110	2.24

## Appendix 2

(PENELEC - PENELEC) The N.MESHPN 230/115 kV transformer (from bus 200825 to bus 200706 ckt 3) loads from 101.07% to 102.08% (**DC power flow**) of its emergency rating (188 MVA) for the single line contingency outage of 'B\_PN230-SX-#11'. This project contributes approximately 2.07 MW to the thermal violation.

CONTINGENCY 'B\_PN230-SX-#11' /\* EAST TOWANDA - N

MESHOPPEN (ETP) 230 KV & N MESHOPPEN BK 4

DISCONNECT BRANCH FROM BUS 200675 TO BUS 200924 CKT 1F

DISCONNECT BRANCH FROM BUS 200924 TO BUS 200706 CKT 1F

DISCONNECT BRANCH FROM BUS 200706 TO BUS 200677 CKT 4

END

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.07
203261	BLOSSBCT	0.06
203283	MANOR	< 0.01
200851	MEHOOP3	0.82
293270	N-036 C	0.62
294572	P-028 C	0.42
293416	V3-042 C	2.33
907991	X1-078	11.73
907481	X1-109	3.41
X3-021	X3-021	12.56
X3-050	X3-050	7.81
913191	Y1-047 OP1	5.79
Y2-044	Y2-044	6.56
914151	Y2-060	1.32
Y2-068	Y2-068	35.3
Y2-082	Y2-082	18.03
915771	Y3-092	19.69
Z1-019	Z1-019	47.69
916061	Z1-038	5.51
916261	Z1-069 C	0.95
Z1-070A	Z1-070A	2.42
Z1-070B	Z1-070B	10.23
916421	Z1-091	5.31
916431	Z1-092	2.37
916611	Z1-110	2.07

### Appendix 3

(PENELEC - NYISO) The E.SAYRE-N.WAV115 115 kV line (from bus 200676 to bus 130836 ckt 1) loads from 112.79% to 114.22% (**DC power flow**) of its emergency rating (128 MVA) for the single line contingency outage of 'B\_PN230-SX-#8'. This project contributes approximately 1.95 MW to the thermal violation.

CONTINGENCY 'B\_PN230-SX-#8' /\* EAST TOWANDA -  
 HILLSIDE (ETH) 230 KV  
 DISCONNECT BRANCH FROM BUS 200675 TO BUS 130763 CKT 1  
 END

Bus Number	Bus Name	Full Contribution
203283	MANOR	0.01
200851	MEHOOP3	0.22
294572	P-028 C	0.11
907481	X1-109	3.93
913191	Y1-047 OP1	1.55
914061	Y2-042	1.71
914151	Y2-060	0.35
914341	Y2-089	11.69
Y3-059	Y3-059	10.61
916061	Z1-038	2.19
Z1-045	Z1-045	18.97
916431	Z1-092	12.2
916611	Z1-110	1.95

## Appendix 4

(PENELEC - PENELEC) The N.MESHNP-OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 114.32% to 115.0% (AC power flow) of its emergency rating (617 MVA) for the single line contingency outage of 'SUSQ 1'. This project contributes approximately 6.24 MW to the thermal violation.

CONTINGENCY 'SUSQ 1'

REMOVE MACHINE 1 FROM BUS 208918

END

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.19
203261	BLOSSBCT	0.18
94106	GRAYMONT	0.01
200828	HNSMLK 1	0.11
200829	HNSMLK 2	0.11
200830	HNSMLK 3	0.11
200831	HNSMLK 4	0.11
200832	HNSMLK 5	0.11
200838	HOMER C2	1.26
200839	HOMER C3	1.34
200849	LAKVU GN	0.01
203283	MANOR	0.02
200851	MEHOOP3	1.02
293270	N-036 C	1.64
294572	P-028 C	0.52
200649	PENNTECH	0.14
290085	Q-036 C	0.02
290113	Q-063 C	0.05
296914	R-092 C	1.18
291011	S-103	0.18
200662	SCRUB GR	0.16
200642	SENECA#1	0.66
200643	SENECA#2	0.61
200644	SENECA#3	0.09
200715	SHAWVL 1	11.24
200722	SHAWVL 2	11.39
200665	SHAWVL 3	16.57
200666	SHAWVL 4	16.39

292391	T-121 C	1.97
292078	V1-034	0.2
293416	V3-042 C	3.62
903651	W3-099 C OP1	1.
907991	X1-078	30.81
907481	X1-109	11.
X3-050	X3-050	19.17
913191	Y1-047 OP1	7.23
Y2-044	Y2-044	16.04
914131	Y2-055	4.29
914151	Y2-060	1.64
Y2-068	Y2-068	90.91
Y2-082	Y2-082	46.18
Y3-032	Y3-032	12.63
915331	Y3-062 C	0.19
Y3-083	Y3-083	12.63
915771	Y3-092	52.68
Z1-019	Z1-019	116.38
916061	Z1-038	6.97
916261	Z1-069 C	2.51
916381	Z1-087	3.41
916421	Z1-091	7.51
916431	Z1-092	5.96
916611	Z1-110	6.24

## Appendix 5

(PENELEC - PL) The OXBOW-LACK 230 kV line (from bus 200708 to bus 208009 ckt 1) loads from 115.28% to 115.97% (AC power flow) of its emergency rating (624 MVA) for the single line contingency outage of 'PL100903'. This project contributes approximately 6.31 MW to the thermal violation.

CONTINGENCY 'PL100903'  
 GEN 1 230KV  
 DISCONNECT BUS 208114  
 END

/\* SUSQUEHANNA-SUSQ

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.19
203261	BLOSSBCT	0.18
94106	GRAYMONT	0.01
200828	HNSMLK 1	0.11
200829	HNSMLK 2	0.11
200830	HNSMLK 3	0.11
200831	HNSMLK 4	0.11
200832	HNSMLK 5	0.11
200838	HOMER C2	1.27
200839	HOMER C3	1.34
200849	LAKVU GN	0.01
203283	MANOR	0.02
200851	MEHOOP3	1.05
293270	N-036 C	1.66
294572	P-028 C	0.54
200649	PENNTECH	0.14
290085	Q-036 C	0.02
290113	Q-063 C	0.05
296914	R-092 C	1.19
291011	S-103	0.18
200662	SCRUB GR	0.16
200642	SENECA#1	0.66
200643	SENECA#2	0.62
200644	SENECA#3	0.09
200715	SHAWVL 1	11.31
200722	SHAWVL 2	11.47
200665	SHAWVL 3	16.68

200666	SHAWVL 4	16.5
292391	T-121 C	1.99
292078	V1-034	0.2
293416	V3-042 C	3.72
903651	W3-099 C OP1	1.01
907991	X1-078	31.58
907481	X1-109	11.11
X3-050	X3-050	19.44
913191	Y1-047 OP1	7.48
913241	Y1-057 C	< 0.01
914061	Y2-042	12.22
Y2-044	Y2-044	16.27
914131	Y2-055	4.33
914151	Y2-060	1.7
Y2-068	Y2-068	90.33
Y2-082	Y2-082	46.12
Y3-032	Y3-032	12.69
915331	Y3-062 C	0.19
Y3-083	Y3-083	12.69
915771	Y3-092	52.95
Z1-019	Z1-019	118.04
916061	Z1-038	9.89
916261	Z1-069 C	2.54
916381	Z1-087	3.44
916421	Z1-091	7.73
916431	Z1-092	6.06
916611	Z1-110	6.31

## Appendix 6

(PENELEC - PENELEC) The N.MESH/ PN-OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 120.78% to 121.84% (**DC power flow**) of its emergency rating (617 MVA) for the bus fault outage of 'C1\_PN230-BS-22B\_A'. This project contributes approximately 6.55 MW to the thermal violation.

CONTINGENCY 'C1\_PN230-BS-22B\_A'

/\* LEWISTOWN 2

230 KV BUS FAULT

DISCONNECT BRANCH FROM BUS 200513 TO BUS 200512 TO BUS 200548  
CKT 2

DISCONNECT BRANCH FROM BUS 200513 TO BUS 200512 CKT 3

DISCONNECT BRANCH FROM BUS 200513 TO BUS 914320 CKT 1

DISCONNECT BRANCH FROM BUS 200513 TO BUS 235248 CKT 1

DISCONNECT BRANCH FROM BUS 200513 TO BUS 200531 CKT 2

END

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.19
203261	BLOSSBCT	0.19
94106	GRAYMONT	0.02
200857	LAURHILL	17.4
203283	MANOR	0.02
200851	MEHOOP3	1.03
293270	N-036 C	1.76
293271	N-036 E	7.05
294572	P-028 C	0.53
294573	P-028 E	57.15
200888	P-047 E	21.1
200649	PENNTech	0.19
296914	R-092 C	1.63
296915	R-092 E	6.52
200642	SENECA#1	0.8
200715	SHAWVL 1	16.38
200722	SHAWVL 2	16.67
200665	SHAWVL 3	24.27
200666	SHAWVL 4	24.14
292391	T-121 C	2.18
292392	T-121 E	8.72
889011	U2-015 C	-0.28

889012	U2-015 E	-1.87
297050	V2-019 E	< 0.01
293416	V3-042 C	3.71
293417	V3-042 E	24.88
901902	W1-111 E	1.84
907481	X1-109	11.29
910522	X3-003 E	9.52
X3-050	X3-050	20.01
913191	Y1-047 OP1	7.33
Y2-044	Y2-044	16.72
914151	Y2-060	1.67
Y2-068	Y2-068	97.54
Y2-082	Y2-082	49.48
Y3-032	Y3-032	15.84
Y3-083	Y3-083	15.84
915642	Y3-104 E	2.96
Z1-019	Z1-019	121.21
916061	Z1-038	7.1
916261	Z1-069 C	2.68
916262	Z1-069 E	10.1
916381	Z1-087	4.15
916421	Z1-091	7.66
916431	Z1-092	6.14
916611	Z1-110	6.55

## Appendix 7

(PENELEC - PENELEC) The TOWANDA-E.SAYRE 115 kV line (from bus 200674 to bus 200676 ckt 1) loads from 128.83% to 130.0% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B\_PN230-SX-#8'. This project contributes approximately 1.95 MW to the thermal violation.

CONTINGENCY 'B\_PN230-SX-#8'  
HILLSIDE (ETH) 230 KV

/\* EAST TOWANDA -

DISCONNECT BRANCH FROM BUS 200675 TO BUS 130763 CKT 1  
END

Bus Number	Bus Name	Full Contribution
203283	MANOR	0.01
200851	MEHOOP3	0.22
294572	P-028 C	0.11
907481	X1-109	3.93
912251	X4-048 OP1	0.89
913191	Y1-047 OP1	1.55
914061	Y2-042	1.71
914151	Y2-060	0.35
914341	Y2-089	12.22
Y3-059	Y3-059	10.61
916061	Z1-038	2.19
Z1-045	Z1-045	18.97
916611	Z1-110	1.95

## Appendix 8

(PENELEC - PENELEC) The E.TWANDA-CNYO&G 230 kV line (from bus 200675 to bus 200924 ckt 1F) loads from 107.4% to 108.46% (AC power flow) of its emergency rating (549 MVA) for the line fault with failed breaker contingency outage of 'C2\_PN115-SB-#19F'. This project contributes approximately 5.83 MW to the thermal violation.

CONTINGENCY 'C2\_PN115-SB-#19F' /\* EAST TOWANDA  
 115 KV STUCK CB - CBE (EAST TOWANDA BUS TIE CB)  
 DISCONNECT BRANCH FROM BUS 200674 TO BUS 200677 CKT 1  
 REDUCE BUS 200674 SHUNT BY 100 PERCENT  
 DISCONNECT BRANCH FROM BUS 200674 TO BUS 200689 CKT 1  
 DISCONNECT BRANCH FROM BUS 200674 TO BUS 200689 CKT 2  
 DISCONNECT BRANCH FROM BUS 200676 TO BUS 200674 CKT 1  
 DISCONNECT BRANCH FROM BUS 200674 TO BUS 200866 CKT 1  
 DISCONNECT BRANCH FROM BUS 200674 TO BUS 200675 CKT 3  
 DISCONNECT BRANCH FROM BUS 200674 TO BUS 200675 CKT 4  
 END

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.1
203261	BLOSSBCT	0.14
200857	LAURHILL	16.48
293270	N-036 C	1.1
293271	N-036 E	4.4
294573	P-028 E	-30.85
200888	P-047 E	10.6
296914	R-092 C	1.12
296915	R-092 E	4.5
200715	SHAWVL 1	11.28
200722	SHAWVL 2	11.42
200665	SHAWVL 3	16.72
292391	T-121 C	1.4
292392	T-121 E	5.59
889011	U2-015 C	-0.89
889012	U2-015 E	-5.93
297050	V2-019 E	< 0.01
901902	W1-111 E	1.38
907481	X1-109	12.3

910522	X3-003 E	-5.14
X3-050	X3-050	12.8
Y2-044	Y2-044	10.61
914131	Y2-055	3.43
Y2-068	Y2-068	66.4
Y2-082	Y2-082	33.43
915642	Y3-104 E	2.26
Z1-019	Z1-019	76.76
916261	Z1-069 C	1.66
916262	Z1-069 E	6.26
916381	Z1-087	2.86
916431	Z1-092	3.29
916611	Z1-110	5.83

## **Appendix 9**

(PENELEC - PL) The OXBOW-LACK 230 kV line (from bus 200708 to bus 208009 ckt 1) loads from 135.32% to 136.13% (AC power flow) of its normal rating (494 MVA) for non-contingency condition. This project contributes approximately 6.32 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.19
203261	BLOSSBCT	0.18
94106	GRAYMONT	0.01
200828	HNSMLK 1	0.11
200829	HNSMLK 2	0.11
200830	HNSMLK 3	0.11
200831	HNSMLK 4	0.11
200832	HNSMLK 5	0.11
200838	HOMER C2	1.28
200839	HOMER C3	1.36
200849	LAKVU GN	0.01
203283	MANOR	0.02
200851	MEHOOP3	1.06
293270	N-036 C	1.67
294572	P-028 C	0.54
200649	PENNTECH	0.14
290085	Q-036 C	0.02
290113	Q-063 C	0.05
296914	R-092 C	1.19
291011	S-103	0.18
200662	SCRUB GR	0.16
200642	SENECA#1	0.67
200643	SENECA#2	0.62
200644	SENECA#3	0.1
200715	SHAWVL 1	11.38
200722	SHAWVL 2	11.54
200665	SHAWVL 3	16.78
200666	SHAWVL 4	16.6
292391	T-121 C	2.
292078	V1-034	0.2

293416	V3-042 C	3.73
903651	W3-099 C OP1	1.02
907991	X1-078	31.29
907481	X1-109	11.13
X3-021	X3-021	32.53
X3-050	X3-050	19.5
913191	Y1-047 OP1	7.49
913241	Y1-057 C	< 0.01
914061	Y2-042	12.23
Y2-044	Y2-044	16.32
914131	Y2-055	4.35
914151	Y2-060	1.7
Y2-068	Y2-068	92.39
Y2-082	Y2-082	46.93
Y3-032	Y3-032	12.83
915331	Y3-062 C	0.19
Y3-083	Y3-083	12.83
915771	Y3-092	53.5
Z1-019	Z1-019	118.39
916061	Z1-038	9.9
916261	Z1-069 C	2.55
Z1-070A	Z1-070A	6.33
Z1-070B	Z1-070B	26.74
916381	Z1-087	3.46
916421	Z1-091	7.74
916431	Z1-092	6.07
916611	Z1-110	6.32

## **Appendix 10**

(PENELEC - PENELEC) The N.MESH/ PN-OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 138.0% to 138.81% (AC power flow) of its normal rating (478 MVA) for non-contingency condition. This project contributes approximately 6.24 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
200887	ARMNA MT P47	0.19
203261	BLOSSBCT	0.18
94106	GRAYMONT	0.01
200828	HNSMLK 1	0.11
200829	HNSMLK 2	0.11
200830	HNSMLK 3	0.11
200831	HNSMLK 4	0.11
200832	HNSMLK 5	0.11
200838	HOMER C2	1.26
200839	HOMER C3	1.34
200849	LAKVU GN	0.01
203283	MANOR	0.02
200851	MEHOOP3	1.02
293270	N-036 C	1.64
294572	P-028 C	0.52
200649	PENNTECH	0.14
290085	Q-036 C	0.02
290113	Q-063 C	0.05
296914	R-092 C	1.18
291011	S-103	0.18
200662	SCRUB GR	0.16
200642	SENECA#1	0.66
200643	SENECA#2	0.61
200644	SENECA#3	0.09
200715	SHAWVL 1	11.24
200722	SHAWVL 2	11.39
200665	SHAWVL 3	16.57
200666	SHAWVL 4	16.39
292391	T-121 C	1.97
292078	V1-034	0.2

293416	V3-042 C	3.62
903651	W3-099 C OP1	1.
907991	X1-078	30.81
907481	X1-109	11.
X3-021	X3-021	32.
X3-050	X3-050	19.17
913191	Y1-047 OP1	7.23
Y2-044	Y2-044	16.04
914131	Y2-055	4.29
914151	Y2-060	1.64
Y2-068	Y2-068	90.91
Y2-082	Y2-082	46.18
Y3-032	Y3-032	12.63
915331	Y3-062 C	0.19
Y3-083	Y3-083	12.63
915771	Y3-092	52.68
Z1-019	Z1-019	116.38
916061	Z1-038	6.97
916261	Z1-069 C	2.51
Z1-070A	Z1-070A	6.23
Z1-070B	Z1-070B	26.31
916381	Z1-087	3.41
916421	Z1-091	7.51
916431	Z1-092	5.96
916611	Z1-110	6.24