

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position X1-104***

***Baptistown-Frenchtown 34.5kV***

**August 2011**

## Preface

The intent of the feasibility study is to determine a plan, with ballpark cost 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 a generator interconnection 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 Feasibility 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.

## General

The Interconnection Customer (IC), has proposed a solar generating facility located in Frenchtown, New Jersey. The installed facilities will have a total capability of 2.45 MW with 0.931 MW of this output being recognized by PJM as capacity. This means that the remaining 1.519 MW will be curtailable should a system reliability constraint occur. The proposed in-service date for this project is February 28, 2012. **This study does not imply a FirstEnergy commitment to this in-service date.**

## Point of Interconnection

X1-104 will interconnect with the Jersey Central Power & Light system at one of two options. Option 1 is to connect at 34kV line A729 between the Baptistown and Frenchtown substations. Option 2 is to connect to the 12.5kV circuit #27720 from the Baptistown substation/

# FirstEnergy Analysis

## Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed X1-104 Project on the FE Transmission System. This study was completed using a 2013 summer peak and light load power flow that contain a detailed representation of the Jersey Central transmission networks in the area of the proposed X1-104 Project. Note that the year 2013 was chosen for study rather than 2016 since this is the first summer period when the X Queue solar projects are scheduled for service. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the Reliability *First*, PJM or FE Planning Criteria and are attributable to this project.

The results of the FE analysis show that there are no network upgrades required for the deliverability of the X1-104 Project generation to the Jersey Central and PJM transmission systems. There also are no reinforcements defined for previous projects for which this project will have an impact. However, the X1-104 Project will be one of fourteen proposed generator attachments to the East Flemington - West Flemington - West Flemington Tap - Baptistown - Frenchtown (A729) 34.5 kV path to date with a total capability of 110.5 MW while the continuous rating of the limiting section of this circuit is only 35 MVA. Specifically as shown on Attachment 5, the FE study results show that the flow on the West Flemington - West Flemington Tap (A729-3) 34.5 kV line section can reach 236.3% of its normal rating for peak load conditions with all of the proposed projects dispatched at their full energy output. For a line end contingency the flow can reach 201.6% of its emergency rating. The study results further show that higher overloads can be expected for off peak conditions. In addition, there is the potential for high voltage during light load periods and voltage criteria violations due to swings in the MW output of the cumulative attached solar generation. A conclusion of this analysis is therefore that a curtailment of the X1-104 Project output to its PJM capacity value can be expected at most times to maintain the Jersey Central system reliability within the NERC, Regional and FE operations and planning standards if all proposed RTEP Projects proceed. If desired, the Interconnection Customer can fund a Jersey Central project to rebuild and reconductor the limiting facilities to eliminate these constraints.

Note that a further conclusion of this study is that it will be mandatory for the X1-104 Project to have a range of dynamic reactive capability that supports its operation from a .95 lead to .90 lag power factor. Without a continuous regulation, the FE studies show that the addition of solar projects can cause voltage swings as their output oscillates with moving clouds and system voltages that can exceed the established limits. Should the Interconnection Customer fail to provide a dynamic reactive capability from the X1-104 Project for any reason once interconnected, the Jersey Central and/or PJM Dispatchers may need to take action to curtail both the energy and capacity portion of its output to prevent a non-compliance with voltage criteria.

## **Short Circuit and Dynamics Analysis**

In accordance with the RTEP process, a short circuit analysis will not be conducted by PJM since the X1-104 Project connection is to the 34.5 kV system. Therefore, the FE Protection staff conducted a short circuit review of the project connection. An assumption of this study was that solar generation projects will contribute no appreciable fault current to the breakers on the FE transmission system. As defined by EPRI: “Inverters are generally designed to limit fault currents to 130% or less of rated current. Thus they can usually be disregarded when conducting fault studies.”<sup>1</sup> Based on this fact, the results of the FE analysis showed that no FE circuit breaker will exceed its interrupting capability with the implementation of the X1-104 Project. Therefore no circuit breaker reinforcements will be required.

Note that stability studies will be conducted by the PJM staff should this project proceed to the Facilities Study stage of the RTEP process.

## **System Protection Analysis**

An analysis was conducted to assess the impact of the X1-104 Project on the system protection requirements in the area. The results of this review have identified the following:

Under the assumption that the X1-104 Project generation will not supply fault current to the Jersey Central transmission system, there will be no protection upgrades needed for the Baptistown - Frenchtown (A729-4) 34.5 kV line. However, the X1-104 Project will be required to have two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

The fault currents on the Baptistown - Frenchtown (A729-4) 34.5 kV path 1.05 miles west of the Baptistown substation (toward Frenchtown), are listed below.

	Three Phase	Line-Ground
X/R Ratio	2.8652	3.9799
Fault Current (Amps)	2,357.5	1,228.1

The fault currents at the point of interconnection 2.3 miles from the tap point on the Baptistown - Frenchtown (A729-4) 34.5 kV path are as follows:

	Three Phase	Line-Ground
X/R Ratio	2.8085	3.8267
Fault Current (Amps)	1984.8	1024.8

These values are for the current system configuration. Any system changes in the area could have a significant impact on these values. It will be an Interconnection Customer responsibility to make any protection upgrades required should this occur.

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<sup>1</sup> EPRI Document TR-111490 “Integration of Distributed Resources in Electric Utility Distribution Systems: Distribution System Behavior Analysis for Suburban Feeder”, published November 1998, page 62

Note that for the 10 MW load, a 50E, S&C SMD-1A, standard fuse must be installed on the tapped connection. A cost estimate of the FE system protection facilities required for the X1-104 is included on Attachment 4.

## **Metering**

The 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 to this report.

## **Compliance Issues**

The proposed interconnection facilities must be designed in accordance with the FirstEnergy “Requirements for Transmission Connected Facilities” located at:

<http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx>

This includes the provision of a reactive power capability sufficient to maintain a composite power delivery for the facility at the interconnection point at a power factor between .95 leading (absorbing .81 MVAR) and .90 lagging (producing 1.19 MVAR). If this capability cannot be provided by the solar units, a dynamic device such as a STATCOM or SVC must be installed at the X1-104 Project substation at the Interconnection Customer’s cost.

The Interconnection Customer will also be responsible for following the requirements of the “FirstEnergy Wholesale Generation Interconnection (WGI) Manual” and the “FE Approved Vendors and Contractors” documents which are also located at the above link.

In addition, the Interconnection Customer will be required to meet all PJM, Reliability*First* and NERC reliability criteria and operating procedures 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 Reliability*First* 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 of the FE analysis shows that no planning criteria violations are attributable to the addition of the X1-104 Project for the conditions studied. Therefore the conclusion is that no Transmission or Distribution system reinforcements will be required to provide the requested service.

## **Network Impacts**

Queue project X1-104 was studied as a(n) 2.45 MW (0.93 MW of which was Capacity) injection into JCPL's system. Project X1-104 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

### **Option 1: W2-085 TAP 34.5 kV substation**

Potential transmission network impacts are as follows:

#### **Generator Deliverability**

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

No violations identified.

#### **Multiple Facility Contingency**

*(Double Circuit Tower Line contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)*

No violations identified.

#### **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.)*

No violations identified.

#### **New System Reinforcements**

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

None required.

#### **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.)*

None required.

#### **Short Circuit**

*(Report over-dutied breakers.)*

None required.

#### **Energy Portion of Interconnection Request**

*PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection request.*

*Note: 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 analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.*

No violations identified.

## **Option 2: BAPTISTN 34.5 kV substation**

Potential transmission network impacts are as follows:

### **Generator Deliverability**

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

No violations identified.

### **Multiple Facility Contingency**

*(Double Circuit Tower Line contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)*

No violations identified.

### **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.)*

No violations identified.

### **New System Reinforcements**

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

None required.

### **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.)*

None required.

## **Short Circuit**

*(Report over-dutied breakers.)*

None required.

## **Energy Portion of Interconnection Request**

*PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection request.*

*Note: 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 analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.*

No violations identified.

## Interconnection Customer Requirements

In addition to the FE facilities, the 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. Since the X1-104 Project will be connected to the 34.5 kV network, the Interconnection Customer will also be responsible for compliance with the FirstEnergy "Technical Requirements for the Interconnection of Parallel-Operated Generation to the FirstEnergy Distribution System". This includes but is not limited to the following:

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 purchase and installation of the standard voice grade (analog) telephone line and associated conduit between the telephone company source and the meter socket or enclosure.
3. A compliance with the FE and PJM generator power factor and voltage control requirements. Note that the X1-104 Project will need to absorb reactive power at the point of interconnection to minimize the voltage change should the units rapidly reduce their output or trip off line
4. The execution of a back-up service agreement to serve the customer load supplied from the Interconnection Customer 34.5 kV substation when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the station load.
5. Any complaints from other customers (e.g. flicker complaints) will have to be corrected by the Interconnection Customer. Correction may include changing operation, reducing generation, disconnecting the generators from the Jersey Central system, or other measures.
6. 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. The RTU, the communications channel and all related equipment will be furnished and maintained by the Interconnection Customer. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.
7. The following status, control and metering points will be required:
  - a. Interconnection breaker position status and trip control.
  - b. Generator real and reactive power output measured at the high-side of the generator step-up transformer.
  - c. Generator voltage at the point of interconnection.
8. An installation of two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

9. A compliance with the inverter standard UL1741 and IEEE 1547, “Standard for Interconnecting Distributed resources with Electrical Power Systems”, in addition to the power quality standards defined by ReliabilityFirst and PJM.
10. A provision of the necessary generator protection, synchronization controls, and fault detection to initiate a trip to protect the X1-104 Project equipment from faults on the Jersey Central System.
11. A compliance with the PJM Manuals and Operating instructions to have a plant operator on call 24/7 to respond within a minute to reduce the output of X1-104 Project when network constraints occur.

The above requirements are in addition to any metering or other requirements imposed by PJM.

Note that an assumption of this study is that the X1-104 Project generation will automatically be disconnected whenever the local area network is islanded. If this assumption is not correct, a direct transfer trip scheme will need to be implemented for such situations at the Interconnection Customer’s cost.

## Summary

The connection of the X1-104 Project to the FE transmission system will require no network upgrades. Therefore the Interconnection Customer will only have a cost responsibility for the Direct Connection of the X1-104 Project to the Jersey Central transmission system. As shown on Attachment 4, the estimated cost of these facilities is \$2,598,000. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of \$629,535. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129.

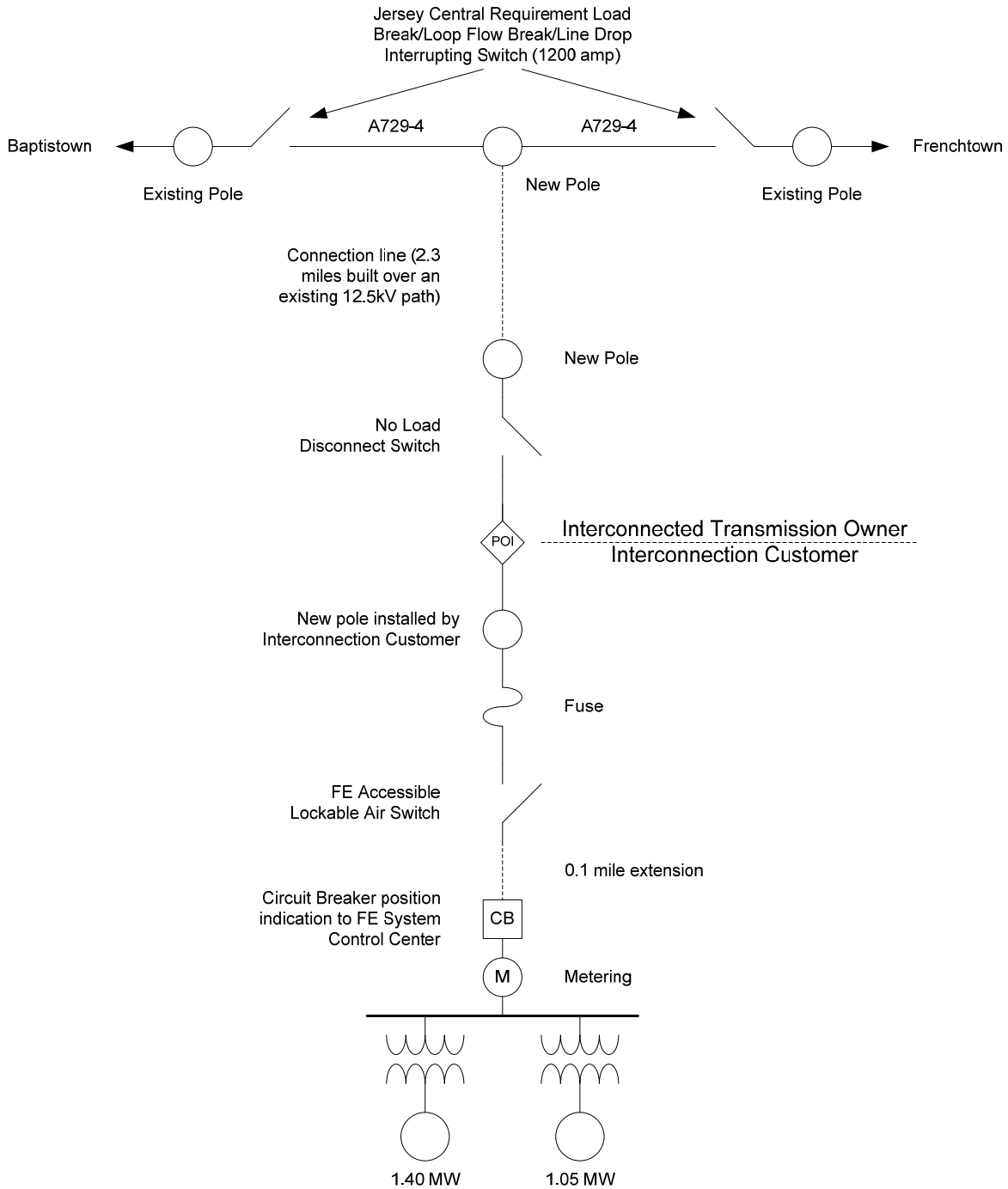
Based on the extent of the FE direct connection and system upgrades required to support this project, it is estimated that it will take one (1) year from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the X1-104 Project. Full payment of the estimated cost of the project will be required upon execution of the Interconnection Service Agreement/Interconnection Construction Service Agreement (ISA/CSA). True up of the actual cost versus estimated cost of the project will be performed by FE at the end of the project. As a requirement, the Interconnection Customer must provide the property for the attachment and right-of-way facilities that will be needed at the project initiation. It is also assumed 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 all 34.5 kV transmission system outages can be scheduled when needed.

Note that the FE findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in the Impact Study. Further note that the cost estimate data contained in this document should be considered as only ballpark since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any connections to the transmission system.

**Attachment 1**  
*Site View*

**Attachment 2**  
*Aerial View*

### Attachment 3 Single Line Diagram



**Attachment 4**  
**Estimated Costs**

Item	Connection Facilities
1	Construct a new pole on the Baptistown - Frenchtown section of the East Flemington - Eaton - West Flemington - West Flemington Tap - Baptistown - Frenchtown (A729) 34.5 kV in a three way dead end tap configuration.
2	Rebuild two poles of the Baptistown - Frenchtown (A729-4) 34.5 kV line with 1200 amp load-break switches, necessary guying, etc.
3	Construct a new 2.3 mile 34.5 kV line from the Baptistown - Frenchtown (A729-4) 34.5 kV line that is overbuilt on a 12.5 kV three phase Distribution circuit to a point that is adjacent to the boundary of the X1-104 Project site with all new poles (primarily replacing existing distribution or Telco poles and using a minimum 397.5 26/7 ACSR conductor.
4	Transfer the underbuilt existing distribution facilities to the new transmission structures.
5	Tree trimming and traffic control.
6	Construct a new pole and extend an approximate 200 foot span of overhead 34.5 kV wire to a new Interconnection Customer owned pole at the X1-104 Project.
7	Install overhead transmission metering equipment provided by the Interconnection Customer to be mounted on the customer owned pole. (Optional to Collector Substation)
8	Miscellaneous Protection, Fuses, Metering, RTU, SCADA.
9	A preliminary review of environmental maps shows probable need for environmental permitting between the tap point and the point of connection. It is estimated that it may take a 6 month lead time for State/Federal review & permit approval, if required. If any protective matting or special vehicles are required for access to poles, there will be additional costs.
10	The Interconnection Customer will be required to obtain any permits and right of way necessary for the Jersey Central 34.5 kV tap and radial overbuild line and the line extension to the X1-104 Project site.
11	The Interconnection Customer will be required to obtain any necessary third party rights of way required to extend the transmission facilities to the X1-104 Project site.
12	The Interconnection Customer to install a 50E, S&C SMD-1A, standard fuse on the tapped connection pole.
<b>Total Substation Costs: \$1,968,465 plus \$629,535 tax - \$2,598,000</b>	

**Attachment 5**  
**Solar Generation Project Analysis**  
**PJM Interconnection Queues U, V, W, and X**  
**2013 Peak and Light Load Conditions – Full Energy Dispatch**

**Peak Load Results**

Outage description	Overloaded Element	Line No.	MVA Rating		% of Rating	
			Normal	Emergency	Normal	Emergency
Base system (n-0) - Normal	East Flemington - West Flemington 34.5 kV	A729	45		140.2	
	West Flemington - West Flemington Tap 34.5 kV	A729	35		236.3	
	West Flemington Tap - Baptistown 34.5 kV	A729	44		188.0	
	Baptistown - Frenchtown 34.5 kV	A729	44		131.2	
Frenchtown - Baptistown (A729) 34.5 kV	East Flemington - West Flemington 34.5 kV	A729		52		132.8
	West Flemington - West Flemington Tap 34.5 kV	A729		44		201.6
	West Flemington Tap - Baptistown 34.5 kV	A729		52		170.6
	Baptistown - Frenchtown 34.5 kV	A729		52		122.3

**Light Load Results**

Outage description	Overloaded Element	Line No.	MVA Rating		% of Rating	
			Normal	Emergency	Normal	Emergency
Base system (n-0) - Normal	East Flemington - West Flemington 34.5 kV	A729	45		169.3	
	West Flemington - West Flemington Tap 34.5 kV	A729	35		256.7	
	West Flemington Tap - Baptistown 34.5 kV	A729	44		204.2	
	Baptistown - Frenchtown 34.5 kV	A729	44		140.4	
Frenchtown - Baptistown (A729) 34.5 kV	East Flemington - West Flemington 34.5 kV	A729		52		152.3
	West Flemington - West Flemington Tap 34.5 kV	A729		44		211.0
	West Flemington Tap - Baptistown 34.5 kV	A729		52		178.6
	Baptistown - Frenchtown 34.5 kV	A729		52		122.6

## **Attachment 6**

### ***FirstEnergy Revenue Metering Requirements For Generation Facilities Connected 46 kV and Lower***

This document addresses the revenue metering requirements for new generation-only facilities connected to FirstEnergy (FE) system voltages 46 kV and lower. This document is not intended for existing retail or wholesale load facilities where behind-the-meter generation is being installed.

The FE operating company (FEOC) shall provide, own, operate, test, and maintain the revenue metering equipment at the Interconnection Customer's (IC) expense. FE reserves the right to review each proposed generation facility design and determine if the IC shall provide, own, operate, test, and maintain the revenue metering equipment at the IC's expense for engineering reasons.

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 revenue metering equipment shall be located at the Point of Interconnection (POI) unless otherwise agreed to by FE and the IC. The revenue metering will be compensated for electrical energy losses if it is not located at the POI.

The IC must provide FE with a facility one line, the estimated bi-directional power flow at the revenue metering point, and any loss compensation data.

The IC shall provide and install the mounting structures (or enclosures) and conduits necessary for the metering installation unless otherwise agreed to by the FEOC. The conduit shall be 1-1/2 inch galvanized rigid steel conduit. Flexible galvanized steel (liquid tight) conduit may be used between instrument transformers. The FEOC will install the wiring in the conduit between the instrument transformers and the meter socket.

The IC shall mount the instrument transformers unless otherwise agreed to by the FEOC. The instrument transformers and meter socket shall be installed in a location that is readily accessible to authorized FEOC representatives. If for any reason the meter socket and/or associated devices must be mounted in a weatherproof enclosure, it shall be provided and installed by the IC. The meter socket shall be installed generally within 50 feet of the instrument transformers unless an alternate design has been approved by the FEOC. The meter socket shall be mounted such that the centerline of the meter is approximately five feet above final grade. Where vehicle traffic may interfere with or damage any revenue metering equipment, the IC must install concrete filled steel barrier posts to protect such equipment.

The bidirectional revenue meter provided and installed by the FEOC will record billing data in intervals typically fifteen minutes or thirty minutes. The IC shall provide, at its sole cost and expense, the installation, operation, and maintenance of the communication link required by the FE billing data collection system for access to the meter. The specifications for the typical telephone communication link are as follows:

- Standard voice grade (analog) with dial tone. No digital telephone lines are permitted.

- Two-pair or four-conductor with RJ-11 / Male termination. The FEOC will make final connection to the meter.
- Must be able to receive incoming calls.
- Must be a direct line to the meter with no operator interception or operation required.
- Install the telephone line and associated conduit between the telephone company source and the meter socket or enclosure.
- The telephone line must be tagged with a phone number, including the area code.
- The telephone line must be installed and operational prior to the IC's service being energized.

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.

The FEOC will provide the IC access to bidirectional kWh and kVARh pulses from the FEOC meter at the IC's expense if requested.

The IC shall provide FE with prior notification of any modifications at the facility that could affect the FEOC revenue meter measurements (substation reconfigurations, generator additions, etc).