

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position X1-116***

***Frankford #2***

**September 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 Frankford Township, New Jersey. The installed facilities will have a total capability of 7.00 MW with 2.66 MW of this output being recognized by PJM as capacity. This means that the remaining 4.34 MW will be curtailable should a system reliability constraint occur. The proposed in-service date for this project is March 31, 2013. **This study does not imply a FirstEnergy commitment to this in-service date.**

## Point of Interconnection

X1-116 will interconnect with the Jersey Central Power & Light system at the 34.5kV line F708 between the North Newton and Branchville substations.

## **FirstEnergy Analysis**

As defined by the Interconnection Customer and shown on Attachment 2, the X1-116 Project will be located south of the Branchville 34.5 kV substation. Attachment 3 shows a conceptual one-line diagram of the Direct Connection facilities that will be required for the X1-116 Project. As indicated, it will be studied as a 8 MW injection into the Jersey Central 34.5 kV system at the North Newton - Branchville (F708-1) section of the Newton – Branchville (F708) 34.5 kV line. Both line and radial disconnect switches will be needed at the point of attachment in addition to a circuit breaker and switch on the system side of the generator step-up transformer. The Interconnection Customer will be responsible for acquiring all permits that may be required for constructing all of the tap facilities and the facilities on its side of the point of interconnection including the attachment line that extends from the connection point. A summary of the FE facilities required for the X1-116 Project Direct Connection and their cost estimate is shown on Attachment 4.

## **Power Flow Analysis**

A Power Flow study was conducted to determine the reliability impact of the proposed X1-116 Project on the FE Transmission System. This study was completed using a 2013 summer peak load power flow that contains a detailed representation of the Jersey Central transmission networks in the area of the proposed X1-116 Project. Note that the year 2013 was chosen for study rather than 2015 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 X1-116 Project will be one of eighteen proposed generators in the Kittatinny - Newton - Franklin area to date.

The results of the FE analysis show that a network upgrade is required for the Capacity deliverability of the X1-116 Project generation to the Jersey Central transmission systems. Specifically, the FE study results show that with the eighteen solar projects at their Capacity output the Newton - Mohawk (Z702) 34.5 kV line section could load up to 111% of its emergency rating of 31 MVA upon loss of the Newton - Montville (N2214) 230 kV line. There are two components on the Z702 line that will overload, the transmission line conductor itself and a switch at Mohawk substation. Because the transmission line conductor overload is a pre-existing criteria violation, the X1-116 Project does not have a financial responsibility for reconductoring the line. However, the X1-116 Project generation contributes to the overload of the switch at Mohawk substation that is caused by a PJM generation project with an earlier queue position. Therefore, PJM may allocate some of the cost of replacing the overloaded switch to the X1-116 project; or, if one or more PJM generation projects with earlier queue positions withdraw from the queue, the X1-116 project could be responsible for the full cost of replacing the switch. The total cost of this reinforcement, including taxes, is estimated at \$103,800.

As shown on Attachment 5, the FE study results show that with all solar projects at their full energy output the F708, Q719, and Z702 lines will have both normal and contingency overloads for peak and light load conditions. The worst normal overload is the Newton - North Newton section of the F708 34.5 kV line, which will exceed its normal rating of 44 MVA by 41% under

light load conditions. The worst contingency overload occurs for loss of the Newton – North Newton section of the F708 34.5 kV line, which results in the Hamburg - Sussex section of the Q745 34.5 kV line exceeding its emergency rating of 52 MVA by 142%. Note that solar generation projects have a 38% capacity credit, and no reinforcements are required for violations caused by Energy output. The optional mitigation that can be implemented by the developer to alleviate this congestion is to rebuild and reconductor the limiting F708, Q745, and Z702 34.5 kV lines and also replace substation conductors, components, and switches. If the developer wishes to pursue this option, further studies will be required to determine the full scope of the work.

In addition, voltage criteria violations such as high voltage under light load conditions and high and low voltages caused by swings in MW output of the attached generation may be constraining. A conclusion of this analysis is therefore that the curtailment of the X1-116 Project output can be expected at times to maintain the Jersey Central system reliability within the NERC, Regional and FE operations and planning standards.

Note that a further conclusion of this study is that it will be mandatory for the X1-116 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 X1-116 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 X1-116 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 X1-116 Project. Therefore no circuit breaker reinforcements will be required.

Note that stability studies will be conducted by the PJM staff as part of the Impact Study stage of the RTEP process.

### **System Protection Analysis**

An analysis was conducted to assess the impact of the X1-116 Project on the system protection requirements in the area. The results of this review have identified the following:

---

<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

Under the assumption that the X1-116 will not supply fault current to the JCP&L system, there will be no protection upgrades needed for the F708 line. The Solar project will be required to have two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

Fault current on the 34.5kV F708 line at the tap point, 1.75 miles from the Branchville substation (toward North Newton), are listed below.

	THREE-PHASE	SINGLE-LINE
X/R	3.2267	4.1641
Fault Current (Amps)	5448.1	2238.7

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 the Interconnection Customer's responsibility to make any protection upgrades required should this occur.

For the 7 MW generation, it is not recommended to add fusing on the tap due to the low magnitude of maximum fault current available by the system.

A cost estimate of the FE system protection facilities required for the X1-116 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 2.30 MVAR) and .90 lagging (producing 3.39 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 X1-116 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 X1-116 Project for the conditions studied. However, the X1-116 Project generation contributes to an overload of a switch at Mohawk substation that is caused by a PJM generation project with an earlier queue position. Therefore, PJM may allocate some of the cost of replacing the overloaded switch to the X1-116 project; or, if one or more PJM generation projects with earlier queue positions withdraw from the queue, the X1-116 project could be responsible for the full cost of replacing the switch. The total cost of this reinforcement, including taxes, is estimated at \$103,800.

## **Network Impacts**

Queue project X1-116 was studied as a(n) 7.0 MW (2.66 MW of which was Capacity) injection into JCPL's system at the W3-145 TAP 34.5 kV substation. Project X1-116 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

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 X1-116 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. A compliance with the FE and PJM generator power factor and voltage control requirements. Note that the X1-116 Project may 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. An installation of two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.
8. 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.

9. A provision of the necessary generator protection, synchronization controls, and fault detection to initiate a trip to protect the X1-116 Project equipment from faults on the Jersey Central System.
10. 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 X1-116 Project when network constraints occur.
11. The Interconnection Customer will not excavate, construct facilities or locate solar panels under the existing FE transmission facilities or on FE right-of-ways without the express permission of FE.
12. 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.

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 X1-116 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 X1-116 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 X1-116 Project to the Jersey Central transmission system. As shown on Attachment 4, the estimated cost of these facilities is \$243,000. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of \$59,300. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129.

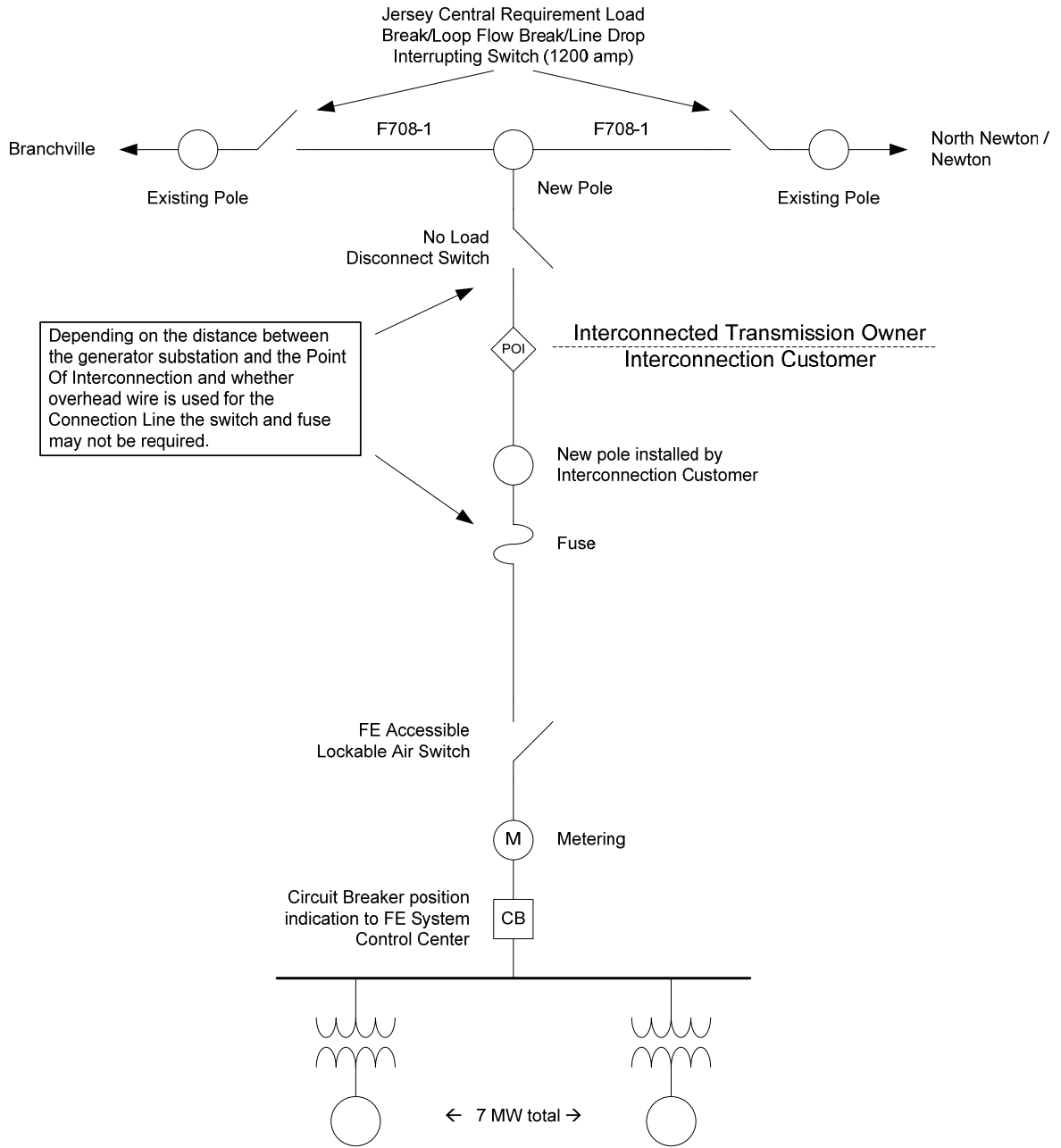
Based on the extent of the FE Direct Connection and system upgrades required to support this project, it is estimated that it will take one (1) year from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the X1-116 Project. Full payment 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. It further assumes that the Interconnection Customer will provide the property for the attachment and right-of-way facilities 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 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 Facility						
1	Construct approximately 300 feet of new overhead 34.5kV line from a point on the F708-1 34.5kV line (North Newton - Branchville).						
2	Construct a new tap pole, switch on the tap, (single blade disconnects included in estimate), installation of load break switches on two poles, necessary guying, etc. and a span of wire to a customer owned pole beyond the switch pole.						
3	Install metering to be mounted in the customer owned substation - Estimate at \$23,000						
4	Miscellaneous Protection, Fuses, Metering, RTU, SCADA						
5	No environmental review was conducted as part of this cost estimate. If environmental permitting is needed, an additional \$50,000 will be added to estimate.						
	<table style="width: 100%; border: none;"> <tr> <td style="width: 60%;"><b>Direct Connection Costs:</b></td> <td style="text-align: right;"><b>\$ 183,700</b></td> </tr> <tr> <td><b>Taxes (if Applicable):</b></td> <td style="text-align: right;"><b>\$ 59,300</b></td> </tr> <tr> <td> <b>Total:</b></td> <td style="text-align: right;"> <b>\$ 243,000</b></td> </tr> </table>	<b>Direct Connection Costs:</b>	<b>\$ 183,700</b>	<b>Taxes (if Applicable):</b>	<b>\$ 59,300</b>	 <b>Total:</b>	 <b>\$ 243,000</b>
<b>Direct Connection Costs:</b>	<b>\$ 183,700</b>						
<b>Taxes (if Applicable):</b>	<b>\$ 59,300</b>						
 <b>Total:</b>	 <b>\$ 243,000</b>						

**Attachment 5**  
**Solar Generation Project Analysis**

**2013 Peak Load Conditions – Full Energy Dispatch**

Outage Description	Overloaded Element	Line ID	MVA Rating		% of Rating	
			Normal	LTE	Normal	LTE
Normal Operating Conditions	Newton - North Newton 34.5 kV	F708	44	52	105.1	
	Hamburg - Sussex 34.5 kV	Q745	44	52	111.6	
	Newton - Mohawk 34.5 kV	Z702	23	31	120.4	
Franklin - Hamburg (Q745) 34.5 KV	Newton - North Newton 34.5 kV	F708	44	52		175.2
Newton - North Newton (F708) 34.5 kV	Hamburg - Sussex 34.5 kV	Q745	44	52		184.1
Newton - Montville (N2214) 230 kV	Newton - Mohawk 34.5 kV	Z702	23	31		126.1

**2013 Light Load Conditions – Full Energy Dispatch**

Outage Description	Overloaded Element	Line ID	MVA Rating		% of Rating	
			Normal	LTE	Normal	LTE
Normal Operating Conditions	Newton - North Newton 34.5 kV	F708	44	52	141.3	
	Hamburg - Sussex 34.5 kV	Q745	44	52	110.5	
Franklin - Hamburg (Q745) 34.5 KV	Newton - North Newton 34.5 kV	F708	44	52		205.1
Newton - North Newton (F708) 34.5 kV	Hamburg - Sussex 34.5 kV	Q745	44	52		242.1

**2013 Peak Load Conditions – Capacity Dispatch**

Outage Description	Overloaded Element	Line ID	MVA Rating		% of Rating	
			Normal	LTE	Normal	LTE
Newton - Montville (N2214) 230 kV	Newton - Mohawk 34.5 kV	Z702	23	31		111.2

## **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).