Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position X4-002

St. Thomas - Guilford 34.5kV

August 2012

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 St. Thomas Township in Franklin County, Pennsylvania. The installed facilities will have a total capability of 20.0 MW with 7.6 MW of this output being recognized by PJM as capacity. This means that the remaining 12.4 MW will be curtailable should a system reliability constraint occur. The proposed in-service date for this project is December 31, 2012. **This study does not imply a First Energy commitment to this in-service date.**

Point of Interconnection

X4-002 will interconnect with the West Penn Power Company's distribution system at one of two options.

Option 1 is to connect via a tap of the Guilford-LeMasters Junction 34.5 kV line 2.5 miles east of Saint Thomas substation.

Option 2 is to connect via a tap of the Guilford-LeMasters Junction 34.5 kV line 0.75 miles west of Saint Thomas substation.

Cost Summary

The X4-002 project will be responsible for the following costs:

Description	Total Cost
Transmission Owner facilities	$ 3,714,333
Total Costs	**$ 3,714,333**

In addition, the X4-002 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$ 2,650,000
Previously Identified Upgrades	$ 0
Total Costs	**$ 2,650,000**

Cost allocations for these upgrades will be provided in the System Impact Study Report.

Transmission Owner Scope of Work

Connection Facilities

In compliance with the Regional Transmission Expansion Planning (RTEP) protocol, the Interconnection Customer has submitted a "Form of Generation Interconnection Feasibility Study Agreement " to PJM that identifies its plan to construct the St. Thomas - Guilford 34.5kV (X4-002) Project comprised of photo-voltaic solar panels and inverters on a property that is approximately 2.5 miles from Saint Thomas substation. The installed facilities will have a total capability of 20 MW with 7.6 MW of this output being recognized by PJM as capacity. This means that the remaining 12.4 MW will be subject to curtailment should a system reliability constraint occur.

As defined by the Interconnection Customer, the proposed St. Thomas - Guilford 34.5kV (X4-002) Project site will be located at a point approximately 2.5 miles from Saint Thomas substation. The primary direct connection of this project will be accomplished by the construction of a new 34.5kV, 3-breaker ring bus and looping the Guilford – LeMasters Jct. 34.5KV line into the new breaker station, 2.5 miles from Saint Thomas substation at the same location as the X4-001 Tap. An alternate point of interconnection would be accomplished by tapping the Guilford – LeMasters Jct. 0.75 miles west of Saint Thomas substation. The Interconnection Customer will be responsible for constructing a radial 34.5kV attachment line from the X4-002 generation 34.5kV export bus to the 34.5kV point of interconnection. The Interconnection Customer may not install above ground equipment within any FirstEnergy right-of-way unless permission to do so is expressly granted by FirstEnergy.

Attachment 1 shows a conceptual one-line diagram of the primary 34.5kV interconnection to accommodate the attachment of the St. Thomas - Guilford 34.5kV (X4-002) Project.

The Interconnection Customer will be responsible for constructing all of the facilities on its side of the point of interconnection including the attachment line. A summary of the FE facilities required for the St. Thomas - Guilford 34.5kV (X4-002) Project primary connection and cost estimate are shown on Attachment 2.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed St. Thomas - Guilford 34.5kV (X4-002) Project on the FE transmission and subtransmission systems. This study was completed using a 2015 summer peak load power flow that contains a detailed representation of the West Penn Power transmission and subtransmission networks in the area of the proposed St. Thomas - Guilford 34.5kV (X4-002) Project. 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 ReliabilityFirst, PJM or FE Planning Criteria and are attributable to this project. Note that in accordance with PJM RTEP study procedures, the St. Thomas - Guilford 34.5kV (X4-002) Project under study and earlier active queue projects are considered to be in service. Therefore, all active queue projects after the St. Thomas - Guilford 34.5kV (X4-002) Project are considered not in service.

For the primary point of interconnection (see Attachment 1), the 20 MW St. Thomas - Guilford 34.5kV (X4-002) Project connected to the Guilford – LeMasters Jct. 34.5kV line between CNG Tap and Saint Thomas substation at a point approximately 2.5 miles east of Saint Thomas substation, at the X4-001 tap point. For the secondary point of interconnection (alternate), the 20 MW St. Thomas - Guilford 34.5kV (X4-002) Project connected by tapping the Guilford – LeMasters Jct. 34.5kV line approximately 0.75 miles west of Saint Thomas substation with the remaining X4 queue generation projects at their primary points of interconnections. The results of the FE analysis show that there are no transmission network upgrades required for the deliverability of the St. Thomas - Guilford 34.5kV (X4-002) Project generation to the FE transmission system for either the primary or the secondary (alternate) point of interconnection.

FE's study of the underlying subtransmission system identified several contingency violations. The Interconnection Customer will therefore have an allocated cost responsibility for the subtransmission network upgrades required to mitigate these violations. Furthermore, with the inverters operating at unity power factor, there were not any voltage violations identified.

Note that a further conclusion of this study is that it will be mandatory for the St. Thomas - Guilford 34.5kV (X4-002) Project to have a range of dynamic reactive capability that supports its operation from a .95 lead to .95 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 can exceed the established limits. Should the Interconnection Customer fail to provide a dynamic reactive capability from the St. Thomas - Guilford 34.5kV (X4-002) Project for any reason once interconnected, the FE 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.

System Protection Analysis

An analysis was conducted to assess the impact of the St. Thomas - Guilford 34.5kV (X4-002) Project on the system protection requirements in the area. The results of this review have identified the following:

- Anti-Islanding Scheme between McConnellsburg, Mercersburg, Guilford, and Interconnection Customer Substations to remove the customer generation from service should both breakers at McConnellsburg and Mercersburg open or if the breaker at Guilford opens.

The specific power and protection equipment requirements are shown below:

RELAY AND COMMUNICATION EQUIPMENT SPECIFICATIONS

- Upgrade Relaying at Guilford, McConnellsburg, and Mercersburg Substations on the existing LeMasters Jct. line terminals to provide standard 34.5kV microprocessor relaying including 311B primary relay, 311A backup relay, and Satec digital multimeter for installation of the Grapevine SS.
- Change CT ratio if necessary and develop and apply new relay settings.
- No additional protection upgrades will be needed provided the X4-001 Project upgrades to Guilford, McConnellsburg, and Mercersburg substations are in-service.

FE Facility Upgrades and Costs

The results of the FE power flow analysis show that the St. Thomas - Guilford 34.5kV (X4-002) Project causes overloads on the Guilford – CNG Tap and the Saint Thomas – X4-001 Tap 34.5kV lines under certain contingencies. Therefore, a total of 6.1 miles of line must be reconductored with a larger conductor (Attachment 3). The estimated total cost of the reconductoring is shown in the New System Reinforcements section. The Interconnection Customer will have an allocated cost responsibility for these upgrades.

The primary direct connection for the St. Thomas - Guilford 34.5kV (X4-002) Project to the West Penn Power subtransmission system is detailed in Attachment 2. The associated one-line with the St. Thomas - Guilford 34.5kV (X4-002) Project primary direct connection is shown in Attachment 1. 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 System Impact Study. The Interconnection Customer will be responsible for the actual cost of the direct connection that is implemented. In addition, the Interconnection Customer is responsible to provide the subtransmission line between the point of interconnection and the St. Thomas - Guilford 34.5kV (X4-002) Project collector station, as the Interconnection Customer will own this subtransmission line. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission or subtransmission systems.

Interconnection Customer Requirements

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

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.

The Interconnection Customer will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, the Interconnection Customer 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. Also, the developer will need to provide documentation that its inverters meet the requirements of UL1741 and IEEE Standard 929. 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.

Other 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 including:

1. The purchase and installation of a fully rated 34.5kV circuit breaker to permit tripping of the entire plant.

2. 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.

3. 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.

4. The establishment of dedicated communication circuits for SCADA report to the FE Transmission System Control Center.

5. A compliance with the FE and PJM generator power factor and voltage control requirements.

6. The execution of a back-up service agreement to serve the customer load supplied from the St. Thomas - Guilford 34.5kV (X4-002) Project metering point when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the load.

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

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

First Energy Requirements

The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

http://www.firstenergycorp.com/feconnect
http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Summary

The St. Thomas - Guilford 34.5kV (X4-002) Project primary direct connection will require the facility upgrades defined in Attachment 2. As shown, the estimated cost of the primary direct connection facilities is $3,714,333. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of $968,142. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129.

The Interconnection Customer will also have an allocated cost responsibility for the reinforcement upgrades. The estimated total cost of the upgrades is shown in the New System Reinforcements section.

Based on the extent of the FE primary direct connection and system upgrades required to support this project, it is expected to take a minimum of fourteen (14) months from the date of a fully executed IA/CA to complete the installation required for the St. Thomas - Guilford 34.5kV (X4-002) Project. This includes the requirement for the Interconnection Customer to make a preliminary payment to FE which funds the first three months of engineering design that is related to the construction of the Direct Connection facilities. It further assumes that the Interconnection Customer will provide all rights-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 all system outages will be allowed when requested.

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 System 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 reinforcements to the transmission or subtransmission systems.

Network Impacts

Option 1

The Queue Project #X4-002 was studied as a(n) 20.0MW(Capacity 7.6MW) injection at St.Thomas 34.5kV substation in the APS area. Project #X4-002 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

See FE Contingency Analysis Results section below.

Generator Deliverability

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

None.

FE Contingency Analysis Results

#	Type	Contingency Name	Facility Description	Normal/4-Hr Rating (MVA)	MVA Flow	% Rating
1	Single	Loss of Saint Thomas – X4-001 TAP 34.5kV Line	Guilford – CNG Tap 34.5kV Line	31.3/36.8	52.3	142.2
2	Single	Loss of Guilford – CNG Tap 34.5kV Line	Saint Thomas – X4-001 Tap 34.5kV Line	31.3/36.8	50.1	136.0

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None.

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None.

Contributions to previously identified circuit breakers found to be over-duty:

None.

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)

None.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

To be determined.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

To be determined.

New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
#1	Guilford – CNG Tap 34.5kV Line	Reconductor 3.6 miles of 34.5kV line.	None	**$ 1,570,000**
#2	Saint Thomas – X4-001 Tap 34.5kV Line	Reconductor 2.5 miles of 34.5kV line	None	**$ 1,080,000**
			Total New Network Upgrades	**$ 2,650,000**

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.

Potential Congestion due to Local Energy Deliverability

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.

Note: Only the most severely overloaded conditions are listed below. 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 shall study all overload conditions associated with the overloaded element(s) identified.

None.

Network Impacts

Option 2

The Queue Project #X4-002 was studied as a(n) 20.0MW(Capacity 7.6MW) injection at St.Thomas 34.5kV substation in the APS area. Project #X4-002 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

None.

Generator Deliverability

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

None.

FE Contingency Analysis Results

No Overloaded Facilities

Secondary POI studied with remaining X4 Queue at Primary Points of Interconnections

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None.

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None.

Contributions to previously identified circuit breakers found to be over-duty:

None.

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)

None.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

To be determined.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

To be determined.

New System Reinforcements

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

None.

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.

Potential Congestion due to Local Energy Deliverability

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.

Note: Only the most severely overloaded conditions are listed below. 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 shall study all overload conditions associated with the overloaded element(s) identified.

None.

Attachment 1

System Configuration

Attachment 2

Primary Direct Connection Requirements

Upgrade ID	Description	Cost	Tax (If applicable)	Total Cost
WP-S-48-1 (X4-002)	**Grapevine SS:** Construct 3-breaker, 34.5kV ring bus SS for PJM Queue X4-002. Install 3-34.5kV bays, structures, foundations, fence, ground grid, 3-34.5kV breakers, 18-34.5kV hookstick disconnects, 2-34.5kV CCVT's, 2-1200A, 34.5kV wave traps, 9-34.5kV PT's, 2-34.5kV station service XFMR's, 34.5kV fuses and arresters, 1-1200A, 34.5kV GOAS, control building with AC/DC panels and battery , charger, telephone, SCADA, grounding, control panels and cables, and associated equipment. Assume developer to provide property at no cost to FE. Developer to provide fiber link to X4-002.	$2,449,400	$861,200	$3,310,600
WP-S-48-2 (X4-002)	**Guilford SS:** Revise relay settings for X4-002.	$23,700	$8,300	$32,000
WP-S-48-3 (X4-002)	**Mercersburg SS:** Revise relay settings for X4-002.	$23,700	$8,300	$32,000
WP-S-48-4 (X4-002)	**McConnellsburg SS:** Revise relay settings for X4-002.	$23,700	$8,300	$32,000
WP-S-48-5 (X4-002)	**X4-002 Collector SS:** Install FE 34.5kV metering in the developer's station. PJM Queue X4-002.	$78,900	$27,700	$106,600
WR# - 1619311	**Line Loop:** Loop 34.5kV Line into proposed Grapevine Switching Station.	$17,591	$8,942	$26,533
EOC	Engineering Oversight and Commissioning	$129,200	$45,400	$174,600
TOTAL		$2,746,191	$968,142	$3,714,333

Attachment 3

Network Facility Reinforcement Conceptual One Line Diagrams