

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

For

***PJM Generation Interconnection Request
Queue Position X3-062***

Upton 34.5 kV Project

February 2012

Feasibility Study Report

Upton 34.5 kV Generation Project

Introduction

This Feasibility Study report provides the documentation of an assessment that has been performed by PJM Interconnection, L.L.C. (PJM) and FirstEnergy (FE) in response to a request made by the Interconnection Customer (IC) for the connection of a 20 MW (7.6 MW Capacity) solar PV generation project to the West Penn Power sub-transmission system. This assessment was accomplished by: 1. Evaluating the reliability impact of the proposed facilities and connection on the interconnected sub-transmission and transmission systems by the performance of a power flow study; 2. Ensuring compliance with the NERC, ReliabilityFirst, PJM and FE Reliability Standards by identifying the system reinforcements that will need to be installed for an interconnection of the proposed project; 3. Coordinating and cooperating with the PJM staff and Interconnection Customer by conducting meetings and issuing this report as a part of the PJM study process; 4. Performing a Steady State, Short-Circuit and Dynamics Study as necessary; 5. Conducting all studies in accordance with the PJM Manuals and the "FE Requirements for Transmission Connected Facilities" documents to assure that the assessment performed incorporates study assumptions, follows the documented system performance procedures, considers alternative connection and reinforcement plans, and jointly coordinates the study recommendations.

Connection Facilities

In compliance with the PJM Interconnection Planning protocol, Interconnection Customer has submitted a "Form of Generation Interconnection Feasibility Study Agreement " to PJM that identifies its plan to construct the Upton 34.5kV (X3-062) Project comprised of photo-voltaic solar panels and inverters on a property that is approximately 7.0 miles from the existing Upton 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 Interconnection Customer the proposed Interconnection Customer site will be located at near Upton substation. The primary direct connection of this project will be accomplished by establishing a 34.5kV bus and adding a new 34.5 kV line terminal at Upton substation. An alternate point of interconnection would be accomplished by tapping the Mercersburg – Milnor 34.5kV line. Interconnection Customer will be responsible for constructing a radial 34.5kV attachment line from the X3-062 generation 34.5kV export bus to the 34.5kV point of interconnection. Interconnection Customer may not install above ground

equipment within any FirstEnergy right-of-way unless permission to do so is expressly granted by FirstEnergy.

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 Upton 34.5kV (X3-062) Project primary connection and cost estimate are shown on Attachment 1.

PJM Interconnection Study Results

The following is the report describing the results of the analysis performed by PJM engineers with respect to the transmission system impacts.

Network Impacts

Queue project X3-062 was studied as a 20.0 MW (7.6 MW of which was Capacity) injection into APS's system. Project X3-062 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

Option 1: UPTON 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.)

Not 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: 56.0% tap between UPTON and ROUTE 1634.5 kV line

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.)

Not 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.

Transmission Owner's Analysis Results

The following is the report generated by the Transmission Owner (TO) based upon its analysis of the project's impacts on the lower voltage system, if any, and the costs and schedules for any transmission and distribution system upgrades.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed Upton 34.5kV (X3-062) Project on the FE transmission and sub-transmission 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 sub-transmission networks in the area of the proposed Upton 34.5kV (X3-062) 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 study procedures, the Upton 34.5kV (X3-062) Project under study and earlier active queue projects are considered to be in service. Therefore, all active queue projects after the Upton 34.5kV (X3-062) Project are considered not in service.

For the primary point of interconnection, the 20 MW Upton 34.5kV (X3-062) Project connected at Upton substation which is served by a radial tap of the Mercersburg – Milnor 34.5kV line. For the secondary point of interconnection (alternate), the 20 MW Upton 34.5kV (X3-062) Project connected by tapping the Mercersburg – Milnor 34.5kV line approximately 1 mile from Upton substation. The results of the FE analysis show that there are no network upgrades required for the deliverability of the Upton 34.5kV (X3-062) Project generation to the FE transmission system for either the primary or the secondary (alternate) point of interconnection.

FE's study of the underlying sub-transmission system did not identify any contingency violations. Further, 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 Upton 34.5kV (X3-062) 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 Interconnection Customer fail to provide a dynamic reactive capability from the Upton 34.5kV (X3-062) 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.

Short Circuit and Dynamics Analysis

In accordance with the PJM process, a short circuit analysis was not conducted by PJM since the Upton 34.5kV (X3-062) Project connection is to the West Penn Power sub-transmission 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 or sub-transmission system. As stated 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.”¹ Based on this statement, the results of the FE analysis showed that no FE circuit breaker will exceed its interrupting capability with the implementation of the Upton 34.5kV (X3-062) Project. Therefore no circuit breaker reinforcements will be required.

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

System Protection Analysis

An analysis was conducted to assess the impact of the Upton 34.5kV (X3-062) Project on the system protection requirements in the area. The results of this review have identified the following:

- Anti-Islanding Scheme between Mercersburg, Milnor, Upton, and the Interconnection Customer substations to remove the customer generation from service should both breakers at Mercersburg and Milnor open, or if the breaker at Upton opens.
- Standard 34.5kV Line protection for new line terminals at Upton SS to FirstEnergy Mercersburg-Milnor 34.5kV Line and the Interconnection Customer 34.5kV line.

Metering

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

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

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>

¹ 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

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.

Interconnection Customer will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, 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.

FE Facility Upgrades and Costs

The results of the FE power flow analysis show that the Upton 34.5kV (X3-062) Project does not attribute to any planning criteria violations

The primary direct connection for the Upton 34.5kV (X3-062) Project to the West Penn Power sub-transmission system is detailed 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. 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 sub-transmission line between the point of interconnection and the Upton 34.5 kV (X3-062) Project collector station, as Interconnection Customer will own this sub-transmission 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 sub-transmission systems.

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 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 Upton 34.5 kV (X3-062) Project metering point when the units are out-of-service. This assumes the intent of 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.

Summary

The Upton 34.5kV (X3-062) Project primary direct connection will require the facility upgrades defined in Attachment 1. As shown, the estimated cost of the primary direct connection facilities is \$2,076,000. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of \$312,300. 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 primary direct connection and system upgrades required to support this project, it is expected to take a minimum of eighteen (18) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation required for the Upton 34.5kV (X3-062) Project. This includes the requirement for 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 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 sub-transmission systems.

Attachment 1
Upton 34.5kV (X3-062) Project
Primary Direct Connection Requirements

Upgrade ID	Description	Cost	Tax (If applicable)	Total Cost
WP-S-44-1 (X3-062)	Mercersburg SS: Install 34.5kV transfer trip facilities including wave trap, CVT, tuner, and new line relay panel.	\$ 148,900	\$ 26,400	\$ 175,300
WP-S-44-2 (X3-062)	Milnor SS: Install 34.5kV transfer trip facilities including wave trap, CVT, tuner, and new line relay panel.	\$ 148,900	\$ 26,400	\$ 175,300
WP-S-44-3A (X3-062)	Upton SS: Expand fence and grid on existing property. Install 2-34.5kV bays, 1-34.5kV 3000A breaker, 4-34.5kV CVT's, 2-34.5kV wave traps, 6-34.5kV hooksticks, control building with AC/DC panels and battery, charger, SCADA, telephone, 34.5kV station service, 5-34.5kV fuses, 1-34.5kV LB transformer switch, 34.5kV arresters, control cables and panels, grounding, and associated material. Connect Mercersburg-Milnor 34.5kV line to new 34.5kV bus. Reconnect existing transformer to new 34.5kV bus.	\$ 1,255,400	\$ 222,200	\$ 1,477,600
WP-S-44-4 (X3-062)	X3-062 Collector SS: Procure and install FE 34.5kV metering equipment in the developer's collector SS. Developer to provide mounting structures and phone line	\$ 77,200	\$ 13,700	\$ 90,900
EOC	Engineering Oversight and Commissioning	\$ 133,300	\$ 23,600	\$ 156,900
TOTAL		\$ 1,763,700	\$ 312,300	\$ 2,076,000