Generation Interconnection Feasibility Study Report (Web Version)

For

PJM Generation Interconnection Request Queue Position W3-067

Gardners-Hunterstown 115kV Project

January, 2011

Overview

The Interconnection Custom (IC) has submitted an Attachment N to propose the interconnection of 20 MW of solar powered generation for the purpose of selling up to 20 MW energy and 7.6 MW of Capacity into the PJM market via the MetEd (FirstEnergy) network.
The Commercial Operation date for this project is July 1, 2012. The analysis was performed using a 2014 base year. This project will be FERC Jurisdictional and will receive a PJM Interconnection Service Agreement.

PJM Report on the Transmission System

This portion of the report addresses the impacts on and the required reinforcements to that part of the transmission system under PJM jurisdiction.

Network Impacts

Queue project W3-067 was studied as a 20.0 MW (7.6 MW of which was Capacity) injection into ME's system at the W1-075 Tap 115.0 kV substation. Project W3-067 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Potential transmission network impacts are as follows:

POI Option 1: W1-075 Tap 115.0 kV substation

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.

POI Option 2: Hunterstown 115 kV substation

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.

FirstEnergy Feasibility Analysis Report

This portion of this Feasibility Study Report has been prepared for PJM by MetEd (FirstEnergy). It addresses the impacts on and required reinforcements, if needed, including the attachment and direct connection facilities. It also presents the FIrstEnergy standards-based requirements for interconnection.

Connection Facilities

In compliance with the Regional Transmission Expansion Planning (RTEP) protocol, IC has submitted a "Form of Generation Interconnection Feasibility Study Agreement" to PJM that identifies its plan to construct a W3-067 Gardners-Hunterstown 115 kV Project comprised of photo-voltaic solar panels and inverters. 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 curtailable should a system reliability constraint occur. The proposed in-service date for this W3-067 Gardners-Hunterstown 115 kV Project is July 1, 2012.

The requested primary point of connection will be onto the Hunterstown - Gardners (991) 115 kV line. In compliance with the FE Connection Requirements, a new 115 kV three breaker ring bus will be constructed for the project attachment. A transmission line loop will be built from the line to the new three breaker ring bus.

While FE will construct, own and operate the new 115 kV substation and the facilities required for its attachment to the FE system, IC will be responsible for acquiring all easements, properties and permits that will be needed. IC will also be responsible for providing a level graded site for the new 115 kV substation and an access road as a prerequisite before work can begin. Note that the developer's proposed site for the new 115 kV three breaker ring bus substation is on the site of the W3-064 project, which is owned by the same developer. However, for the purposes of this Feasibility Study, the developer has specified that the W3-064 project will not connect to this ring bus.

IC will be responsible for constructing all of the facilities on its side of the point of interconnection including the attachment line.

Note that IC has chosen a Secondary POI of connecting directly to the 115 kV Hunterstown substation. While it has been determined that this connection is feasible, a cost estimate for this option will not be provided in this Feasibility Study Report. In compliance with the FE Requirements for Connected Facilities document, the Hunterstown 115 kV substation must be reconfigured to a ring bus as a minimum standard for the Secondary POI, at IC's cost. IC will be responsible for acquiring all easements, properties and permits that will be needed, and also for constructing a radial attachment line to the Hunterstown 115 kV substation.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed W3-067 Gardners-Hunterstown 115 kV Project on the FE Transmission System. This study was

completed using a 2014 summer peak load power flow that contains a detailed representation of the Met-Ed transmission networks in the area of the proposed W3-067 Gardners-Hunterstown 115 kV 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.

The results of the FE analysis show that there are no network upgrades required for the deliverability of the W3-067 Gardners-Hunterstown 115 kV Project generation to the Met-Ed transmission system. There also are no reinforcements defined for previous projects for which this project will have an impact. However, 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 result in curtailment of the energy portion of the W3-067 Gardners-Hunterstown 115 kV Project at times.

Note that a further conclusion of this study is that it will be mandatory for the W3-067 Gardners-Hunterstown 115 kV 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 IC fail to provide a dynamic reactive capability from the W3-067 Gardners-Hunterstown 115 kV Project for any reason once interconnected, the Met-Ed 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

A short circuit analysis was conducted by PJM and confirmed by the FE Protection staff. 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."[1] 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 Point Breeze (W1-076) 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 Impact Study stage of the RTEP process.

System Protection Analysis

An analysis was conducted to assess the impact of the W3-067 Gardners-Hunterstown 115 kV Project on the system protection requirements in the area. Note than an RTEP Project in an earlier queue also intends to connect to the Hunterstown – Gardners (991) 115 kV line. This analysis was performed under the assumption that the upgrades required for the earlier RTEP

[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

Project are already in service. The results of this review have identified the following requirements:

New W3-067 Substation (FE Owned):

Line to Gardners:

Protection:

SEL - 311C Prim	Primary Protection (Carrier) DCB
SEL - 311B	Backup Line
SEL 501	Breaker Failure
SEL 279H	Reclosing (Shared Breaker – and Sync Check)

Communication and metering equipment:

Wave Trap	(Tuned to 155 kHz carrier & XXX TT freq)
Line Tuner	
RFL 9785	(For DCB carrier) Include Carrier Checkback module
RFL 9780	(For DTT Anti Islanding and breaker failure)
Set of 115kV CCVT's	(Sync Check and Carrier Signal)
SATEC meter	

Line to proposed earlier queue RTEP Project:

Protection:

SEL - 311C Prim	Primary Protection (Carrier) DCB
SEL - 311B	Backup Line
SEL 501	Breaker Failure
SEL 279H	Reclosing (Shared Breaker – and Sync Check)

Communication and metering equipment:

Wave Trap	(Tuned to XXX kHz carrier & XXX TT freq)
Line Tuner	
RFL 9785	(For DCB carrier) Include Carrier Checkback module
RFL 9780	(For DTT Anti Islanding and breaker failure)
Set of 115kV CCVT's	(Sync Check and Carrier Signal)
SATEC meter	

Shared Line Breaker:

SEL 501	Breaker Failure

Generation line exit:

Protection:

SEL - 311L Prim	(Line exit , B.U. Mho and T.T.)
SEL - 387L B.U.	(B.U. Line exit Protection)

Communication and metering equipment:

Fiber connection	Two independent fiber optic cables required.
PT's or CCVT's	(Sync Check and B.U Mho element into plant via 311L)

Substation equipment:

SEL 2032 Communication processor, Raymar Hidex Modem from SEL [240-0205] , C220 cable

Arbiter Systems, Inc., GPS satellite-controlled clock Model 1094B with option 1094OPT10

Required cabling to connect new SEL devices to the communication processor

RTU

Remote Control and Indication of substation equipment is required (RTU)

Customer owned W3-067 Substation (customer responsibility):

Generation line exit:

Protection:

SEL - 311L Prim (Line exit , B.U. Mho and T.T.)
SEL - 387L B.U. (B.U. Line exit Protection)

Communication and metering equipment:

Fiber connection Two independent fiber optic cables required.
PT's or CCVT's (Sync Check and B.U Mho element into plant via 311L)

If the earlier RTEP Project and its associated protection upgrades are not put into service, the following upgrades at Hunterstown and Gardners substations will be required for the W3-067 Gardners-Hunterstown 115 kV Project:

Existing Gardners Substation:

Line to W3-067:

Protection (Install the following equipment):

SEL - 311C Prim Primary Protection (Carrier) DCB
SEL - 311B Backup Line
SEL 501 Breaker Failure
SEL 279H Reclosing (Shared Breaker – and Sync Check)

Remove existing line relaying

Existing Communication equipment to be utilized:

Wave Trap (Tuned to 155 kHz and TT Freq)
*Reconfigure TT Circuit for line purposes, not Texas Eastern Line OL
Line Tuner
Guard 8000 (for Carrier and DTT) –
*Purchase a Carrier card to replace the functionality of the CS-27 Carrier set SEL 2020 communication processor and Arbiter GPS clock

Substation equipment:

Required cabling to connect new SEL devices to the communication processor

Existing Hunterstown Substation:

Line to W3-067:

Protection (Install the following equipment):
SEL - 311C Prim Primary Protection (Carrier) DCB
SEL - 311B Backup Line
SEL 501 Breaker Failure
SEL 279H Reclosing (Shared Breaker – and Sync Check)
Remove existing line relaying

Communication and metering equipment:
Existing Communication equipment to be utilized
Wave Trap (Tuned to 155 (would need to be changed) kHz and TT Freq)
*Reconfigure TT Circuit for line purposes, not Texas Eastern Line OL
Line Tuner
Guard 8000 (for Carrier and DTT) –
*Purchase a Carrier card to replace the functionality of the CS-27 Carrier set
SATEC meter

Substation equipment:
SEL 2032 Communication processor, Raymar Hidex Modem from SEL [240-0205] , C220 cable
Arbiter Systems, Inc., GPS satellite-controlled clock Model 1094B with option 1094OPT10
Required cabling to connect new SEL devices to the communication processor

Under the assumption that the W3-067 Gardners-Hunterstown 115 kV Project generation will not supply fault current to the Met-Ed transmission system, there will be no protection upgrades needed due to short circuit duty for the proposed project connection to the Hunterstown – Gardners (991) 115 kV line.

Fault currents at the new W3-067 Gardners-Hunterstown 115 kV Project substation are listed below:

Three phase : 7316 amperes (X/R = 8.9085)
Line-to Ground: 5482 amperes (X/R = 5.4553)

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 IC responsibility to make any protection upgrades required should this occur.

Metering

IC will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers.

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 6.6 MVAR) and .90 lagging (producing 9.7 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 W3-067 Gardners-Hunterstown 115 kV Project substation at IC's cost.

IC 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, IC will be required to meet all PJM, ReliabilityFirst 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 ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

FE Facility Upgrades and Costs

The results of the FE analysis shows that no planning criteria violations are attributable to the addition of the W3-067 Gardners-Hunterstown 115 kV Project for the conditions studied. Therefore the conclusion is that no transmission or distribution reinforcements will be required to provide the requested service.

Interconnection Customer's Requirements

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

1. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

2. A compliance with the FE and PJM generator power factor and voltage control requirements. Note that the W3-067 Gardners-Hunterstown 115 kV 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 34.5 kV substation when the units are out-of-service. This assumes the intent of IC 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 IC. 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 IC. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.

6. The following status and metering points will be required:
   a. Interconnection breaker position.
   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 W3-067 Gardners-Hunterstown 115 kV Project equipment from faults on the Met-Ed 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 W3-067 Gardners-Hunterstown 115 kV Project when network constraints occur.

11. IC will not excavate, construct facilities or locate solar panels under FE transmission facilities or on FE right-of-ways without the express permission of FE.

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 W3-067 Gardners-Hunterstown 115 kV 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 IC's cost.

Summary

The connection of the W3-067 Gardners-Hunterstown 115 kV Project to the FE transmission system will require no network upgrades. Therefore IC will only have a cost responsibility for the Direct Connection of the W3-067 Gardners-Hunterstown 115 kV Project to the Met-Ed transmission system. The estimated cost of the facilities for the primary connection to the Hunterstown – Gardners (991) 115 kV line is $5,755,600.

Based on the extent of the FE direct connection and system upgrades required to support this project, it is estimated that it will take sixteen (16) months from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the W3-067 Gardners-Hunterstown 115 kV Project. It further assumes that IC 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 PJM will allow all 115 kV transmission system outages 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 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.