Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position X4-031

Howell

April 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

TheInterconnection Customer (IC), has proposed a solar generating facility located in Howell, New Jersey. The installed facilities will have a total capability of 2.0 MW with 0.0 MW of this output being recognized by PJM as capacity. This means that the remaining 2.0 MW will be curtailable should a system reliability constraint occur.

Point of Interconnection

X4-012 will interconnect with the Jersey Central Power & Light system at the 34kV line L90 between the Farmingdal and Bennett substations.

FirstEnergy Analysis

As defined by the Interconnection Customer and shown on Attachment 1, the choice of connection for the X4-031 Project will be from a tap of the Farmingdale – Bennett (L90) 34.5 kV line. From this point Jersey Central will construct a one span, 300 foot radial line extension to a pole structure to be constructed, owned, operated and maintained by the Interconnection Customer. The Interconnection Customer will be responsible for the attachment from this point to the X4-031 Project substation. Jersey Central will own, operate and maintain the radial attachment line up to the point of interconnection as defined in Attachment 2 The Interconnection Customer will own, operate and maintain the extension from the point of interconnection to its substation.

In summary, Attachment 2 shows a conceptual one-line diagram of the Direct Connection facilities that will be required for the X4-031 Project. As indicated, it will be studied as a 2.0 MW injection into the Jersey Central 34.5 kV system at the Farmingdale – Bennett (L90) 34.5 kV line. Disconnect switches will be needed on poles as well as the radial tap pole 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 and right of way that may be needed for both the 34.5 kV line tap and the radial line extension line. The Interconnection Customer will also be responsible for acquiring all permits and constructing, owning and operating all facilities on its side of the point of interconnection. A summary of the FE facilities required for the X4-031 Project Direct Connection and their cost estimate is shown on Attachment 3.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed X4-031 Project on the FE Transmission System. This study was completed using a 2013 summer peak and light load power flow that contain a detailed representation of the Jersey Central transmission network in the area of the proposed X4-031 Project. Note that the year 2013 was chosen for study rather than 2016 since this is the first summer period when the X Queue solar projects are scheduled for service. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the Reliability*First*, PJM or FE Planning Criteria and are attributable to this project.

The results of the FE analysis show that there are no network upgrades required for the deliverability of the X4-031 Project generation to the Jersey Central and PJM transmission systems. There also are no common mode outage reinforcements defined for previous projects for which it will have an impact. However, there are numerous other solar generation projects proposed in the vicinity of the X4-031 Project that will contribute to system constraints. In addition, there is the potential for high voltage during light load periods and voltage criteria violations due to swings in the MW output of the cumulative attached solar generation. A conclusion of this analysis is therefore that a curtailment of the X4-031 Project output to its PJM capacity value (zero MW) can be expected at times to maintain the Jersey Central system reliability within the NERC, Regional and FE operations and planning standards if all proposed RTEP Projects proceed. If desired, the Interconnection Customer can fund a Jersey Central project to reinforce the limiting facilities to eliminate these constraints.

Note that a further conclusion of this study is that it will be mandatory for the X4-031 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 that can exceed the established limits. Should the Interconnection Customer fail to provide a dynamic reactive capability from the X4-031 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 detailed short circuit analysis was not conducted by PJM since the X4-031 Project connection is to the Jersey Central 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."[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 X4-031 Project. Therefore no circuit breaker reinforcements will be required.

System Protection Analysis

An analysis was conducted to assess the impact of the X4-031 Project on the system protection requirements in the area. The results of this review have identified the following:

Under the assumption that the X4-031 Project generation will not supply fault current to the Jersey Central transmission system as defined by the PJM staff, there will be no protection upgrades needed for the Farmingdale – Bennett (L90) 34.5 kV line. However, the X4-031 Project will be required to have two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

The fault current values on the Farmingdale - Bennett (L90) 34.5 kV line with Bennett Substation switched towards the Belmar Substation (Summer Configuration) are listed below.

	Three Phase	Line-Ground
X/R Ratio	2.64	3.42
Fault Current (Amps)	3600	1922

The fault current values on the Farmingdale - Bennett (L90) 34.5 kV line with Bennett Substation switched towards the Farmingdale Substation (non-Summer Configuration) are listed below.

[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

	Three Phase	Line-Ground
X/R Ratio	2.45	3.42
Fault Current (Amps)	10098	4824

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 2.0 MW X4-031 Project, a 50E, S&C SMD-2C, standard fuse will be required.

The cost estimate for the required FE system protection facilities is included on Attachment 3.

Metering

The 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
http://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" referenced above.

For the X4-031 Project, 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 0.7 MVAR) and .95 lagging (producing 0.7 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 X4-031 Project substation at Tthe Interconnection Customer's cost.

The Interconnection Customer will 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 X4-031 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 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 X4-031 Project will be connected to the 34.5 kV network, the Interconnection Customer will also be responsible for compliance with the FirstEnergy "Technical Requirements for the Interconnection of Parallel-Operated Generation to the FirstEnergy Distribution System". This includes but is not limited to the following:

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

2. The purchase and installation of the standard voice grade (analog) telephone line and associated conduit between the telephone company source and the meter socket or enclosure.

3. A compliance with the FE and PJM generator power factor and voltage control requirements. Note that the X4-031 Project will need to absorb reactive power at the point of interconnection to minimize the voltage change should the units rapidly reduce their output or trip off line.

4. The execution of a back-up service agreement to serve the customer load supplied from the X4-031 34.5 kV substation when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the station load.

5. Any complaints from other customers (e.g. flicker complaints) will have to be corrected by the Interconnection Customer. Correction may include changing operation, reducing generation, disconnecting the generators from the Jersey Central system, or other measures.

6. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center. The RTU, the communications channel and all related equipment will be furnished and maintained by the Interconnection Customer. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.

7. The following status, control and metering points will be required:

    a. Interconnection breaker position status and trip control.

    b. Generator real and reactive power output measured at the high-side of the generator step-up transformer.

    c. Generator voltage at the point of interconnection.

8. An installation of two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

9. A compliance with the inverter standard UL1741 and IEEE 1547, "Standard for Interconnecting Distributed resources with Electrical Power Systems", in addition to the power quality standards defined by Reliability*First* and PJM.

10. A provision of the necessary generator protection, synchronization controls, and fault detection to initiate a trip to protect the X4-031 Project equipment from faults on the Jersey Central System.

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. 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 X4-031 Project when network constraints occur.

13. The installation of intertie relays at the point of interconnection that either trip the breaker at the point of interconnection or the individual generators beyond the point of interconnection. The function of the intertie relays must include over/under voltage and over/under frequency protection. Note that these intertie relays are in addition to and must be separate from the two relays that provide independent high speed zone of protection to sense and clear faults. They include the installation of an SEL-351-7 (Version 7) relay or its equivalent for power elements, a potential transformer or CCVT's on the high side of the transformer, and current transformers on the high side of the transformer.

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 X4-031 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 cost.

Network Impacts

The Queue Project #X4-031 was studied as a(n) 2.0MW(Capacity 0.0MW) injection as a tap into Farmdale-Bennett 69kV station in the JCPL area. Project #X4-031 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Generator Deliverability

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

None.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

None.

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

Not required.

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

(Results of the steady-state voltage studies should be inserted here)

To be determined during the System Impact Study phase.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

To be determined during the System Impact Study phase.

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)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None.

Delivery of Energy Portion of Interconnection Request

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.

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 will study all overload conditions associated with the overloaded element(s) identified.

None.

Summary

The connection of the X4-031 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 X4-031 Project to the Jersey Central transmission system. As shown on Attachment 3, the estimated cost of these facilities is $262,440. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of $64,267. 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 X4-031 Project. Full payment of the estimated cost of the project will be required upon execution of the Interconnection Service Agreement/Interconnection Construction Service Agreement (ISA/CSA). True up of the actual cost versus estimated cost of the project will be performed by FE at the end of the project. As a requirement, the Interconnection Customer must provide the property for the attachment and right-of-way facilities that will be needed at the project initiation. It is also assumed that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and network upgrades, and that all 34.5 kV transmission system outages can be scheduled when needed.

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

Attachment 1
Aerial View

Attachment 2
Single Line Diagram

Attachment 3
Estimated Costs

Item	
1	Install new tap at pole in a three way dead end configuration. Rebuild and install two SCADA controlled 1200 pole-mounted load break switches on adjacent poles.
2	Construct single circuit 34.5kV line tap from new three-way dead end tap pole on the L90 line to a new pole to be located on developer's property located approximately 300 feet from tap pole.
3	Install no load 34.5kV in-line disconnect switches on tap pole to customer.
4	Miscellaneous Protection, Fuses, Metering, RTU, SCADA
5	Preliminary review of environmental map shows no need for environmental permitting at the preliminary service point indicated on applicant's submitted sketch. If permitting is needed, and additional $50,000 will be added to estimate.
6	Estimate includes $20,000 for metering to be installed in customers cubicle.
7	Applicant is required to obtain any and all third party rights of way (ROW) required to extend the electric facilities to their sites. This includes vegetation management, environmental compliance, wetland preservation, and any other state or local permitting required to extend facilities to their site.
	Total Connection Costs: $198,173 plus $64,267 tax = $262,440