Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position X1-106

Sussex

October 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 along in Wantage Township, New Jersey. The installed facilities will have a total capability of 16.8 MW with 6.384 MW of this output being recognized by PJM as capacity. This means that the remaining 10.416 MW will be curtailable should a system reliability constraint occur. The proposed in-service date for this project is January 31, 2012. **This study does not imply a FirstEnergy commitment to this in-service date.**

Point of Interconnection

X1-106 will interconnect with the Sussex Rural Electric Co-operative system.

FirstEnergy Analysis

This Feasibility Study report provides the documentation of a system assessment performed by FirstEnergy (FE) in response to a request made by the Interconnection Customer for the connection of a 16.8 MW solar generation project to the Sussex Rural Electric Cooperative, Inc. (Sussex REC). Note that the Sussex REC is an independent consumer-owned local distribution entity that receives its energy supply solely from three 34.5 kV transmission line interconnections with Jersey Central. Jersey Central is therefore directly impacted by any generation connections to the Sussex REC system that impact on its tie line flows. While the Sussex REC is not a member of PJM, the Interconnection Customer or its designated agent will be required to become a member and meet all of the PJM obligations and requirements to participate in the regional wholesale energy market. The X1-106 Project will therefore receive its local transmission service from the Sussex REC and its PJM interconnection service through the Jersey Central tie lines with the Sussex REC.

Due to its tie line impact, the installation of the X1-106 Project by the Interconnection Customer will also impact on the existing Jersey Central wheeling and supply interconnection agreement with the Sussex REC.

The Interconnection Customer will be required to fund all of the Sussex REC interconnection and FE network upgrades that will be required for the X1-106 Project. This includes the provision of any permits, easements and properties that may be required.

Connection Facilities

As defined by the Interconnection Customer and shown on Attachment 2, the proposed connection point for the X1-106 Project will be in the Sussex REC service territory. The Sussex REC will therefore be responsible for the installation of the Direct Connection facilities to support the X1-106 Project by means of a separate two party agreement. However, the Sussex REC interconnection with the Jersey Central will be used to wheel the output of the X1-106 Project to PJM through the Sussex (REC) 34.5 kV substation as identified on Attachment 3. As shown the FE delivery point for the X1-106 Project will be modeled at the Sussex (REC) substation. The Sussex REC and the Interconnection Customer will be expected to comply with the "FE Requirements for Transmission Connected Facilities" document at this delivery point.

From an operating perspective, the Interconnection Customer will also be required to provide the Jersey Central Regional Dispatchers with a supervisory trip control of the X1-106 Project attachment breaker in order to open it if required during a system emergency. The purpose is to assure the continued reliability and safety of the transmission system and field personnel by providing the Regional Dispatchers with the capability to disconnect a generation project when immediate action is required. Should such action be necessary, the Jersey Central Regional Dispatcher will communicate the reason to the X1-106 plant operators as soon as practicable. They will also give notice when the X1-106 Project can be safely returned to service. Note that this procedure is only to be implemented for emergency situations. The Interconnection Customer will need to coordinate the project synchronization and daily operation with the Sussex REC Dispatch staff for normal system conditions.

In summary, the X1-106 Project will be studied as a 16.8 MW injection at the Sussex REC 34.5 kV substation. Although the X1-106 Project will not be connected directly to the Jersey Central 34.5 kV transmission system, it will be responsible for any modifications needed at the interconnection between Jersey Central and Sussex REC to support the X1-106 Project. This includes any substation configuration upgrades, metering changes and system protection revisions that may be necessary. By PJM process, any such Jersey Central or PJM network upgrade attributable to the X1-106 Project will be the Interconnection Customer's responsibility. These system reinforcements will be defined as a part of the Power Flow Analysis in this Feasibility Study.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed X1-106 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 X1-106 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.

Independent from the PJM protocol, the Sussex REC will also be responsible for performing the Power Flow analysis and defining the network upgrades required for the deliverability of the X1-106 Project generation to the Jersey Central point of interconnection. The requirements and cost estimates for these facilities will be addressed by a separate connection service study and agreement between the Interconnection Customer and the Sussex REC.

With respect to the FE studies performed, the results show that during off peak periods the addition of the X1-106 Project generation can cause a power flow of 65.1 MW from the Sussex REC at its Sussex (REC) substation delivery point to the Jersey Central system based on the information available. The exact value must be verified by the Sussex REC. While a power flow of greater than 20 MW from the Sussex REC at its Sussex (REC) substation delivery point to the Jersey Central system creates the need for a ring bus at the connection point as per the "FE Requirements for Transmission Connected Facilities" document, this requirement is caused by a PJM RTEP generation project with an earlier queue position. If any solar generation projects with earlier queue positions withdraw or reduce output, this network upgrade could become the responsibility of the X1-106 Project. A conceptual single-line diagram of this network upgrade, if implemented on the FE side of the FE-Sussex REC POI, is shown on Attachment 4.

The results of the FE Power Flow analysis further show that there are no other network upgrades required for the deliverability of the X1-106 Project generation from the Sussex REC point of interconnection to the Jersey Central and PJM transmission systems. However, the X1-106 Project will be one of eighteen proposed generators in the Kittatinny - Newton - Franklin area to date. Specifically as shown on Attachment 6, the FE study results show that the flow on the Newton - North Newton (F708), Hamburg - Sussex (Q745), and Newton - Mohawk (Z702) 34.5 kV lines will exceed their normal rating for peak load conditions with all of the proposed projects dispatched at their full energy output. For a line contingency the flow on the Hamburg - Sussex (Q745) 34.5 kV line can reach 184.1% of its emergency rating. The study results further

show that higher overloads can be expected for off peak conditions. 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. To minimize these voltage violations, the X1-106 Project must provide a dynamic reactive capability between .95 leading (absorbing 5.52 MVAR) and .95 lagging (producing 5.52 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 X1-106 Project substation at the Interconnection Customer's cost.

A conclusion of this analysis is therefore that a curtailment of the X1-106 Project output to its PJM capacity value 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 rebuild and reconductor the limiting transmission facilities and replace substation conductors, components, and switches to eliminate these constraints. If the Interconnection Customer wishes to pursue this option, further studies will be required to determine the full scope of the work.

As information, the MVA line ratings modeled in the FE analysis and identified on Attachment 6 reflect the current values that are used by Jersey Central when operating the transmission system. This includes the Newton - Mohawk (Z702) 34.5 kV line which is shown as constraining when all units generate to their capacity output. However, Jersey Central plans to reconductor the limiting section of the Newton - Mohawk (Z702) 34.5 kV line by the end of 2013. This action will mitigate the criteria violation identified. While FE will assume all cost responsibility for this upgrade, the X1-106 Project could be constrained if it is installed before the Newton - Mohawk (Z702) 34.5 kV line reconductor project is complete.

Short Circuit and Dynamics Analysis

In accordance with the RTEP process, a short circuit analysis was not conducted by PJM since the X1-106 Project connection is to the Sussex REC 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 X1-106 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 X1-106 Project on the system protection requirements in the area. Under the assumption that the X1-106 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 on existing FE owned facilities.

[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.

Note that if the FE assumption that the X1-106 Project will not provide fault current is invalid, the Interconnection Customer will have a cost responsibility for any network upgrades that may be required to comply with the FE and PJM planning criteria.

Metering

The X1-106 Project will be Directly Connected to the Sussex REC transmission system. Therefore, the Interconnection Customer must comply with the Sussex REC Revenue Metering Requirements for Generation Interconnection Customers. It will also be responsible for communicating the hourly MWH output of the X1-106 Project to both FE and PJM in the approved format for monitor and billing purposes.

Since the X1-106 Project will impact on the Sussex REC interchange with Jersey Central, an analysis was performed to determine whether any metering upgrades at the points of interconnection will be required. Based on the FE review, it was determined that the existing interconnection metering equipment at the Sussex REC 34.5 kV substation and the JCPL Vernon 34.5 kV substation will require upgrades. The need for these upgrades is caused by PJM RTEP generation projects with earlier queue positions. However, if projects with earlier queue positions withdraw from the queue or reduce output, the X1-106 project could become responsible for these upgrades.

With respect to the billing of the Sussex REC for transmission service and customer load, the hourly metered interconnection at the Sussex REC and Vernon 34.5 kV substations will be adjusted by the X1-106 Project output for every hour of operation. For comparability and compliance, no net metering on a billing period basis will be made when calculating the transmission service that is provided by Jersey Central to the Sussex REC customers.

Compliance Issues

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 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 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 X1-106 Project for the conditions studied. The X1-106 Project will be responsible for the cost of integrating the required supervisory control and data acquisition (SCADA) points into the FE Energy Management System (EMS). As shown in Attachment 5, the cost of these upgrades is $10,594.

As previously mentioned, a PJM RTEP generation project with an earlier queue position causes the need for a new ring bus at the Sussex REC 34.5 kV substation delivery point, as shown on Attachment 4. If other solar generation projects with earlier queue positions withdraw or reduce

size, the X1-106 Project could become responsible for the full cost of this network upgrade. The cost of this upgrade is $5,275,100.

Also, PJM RTEP generation projects with earlier queue positions cause the need for metering upgrades at both the Sussex REC 34.5 kV substation and the JCPL Vernon 34.5 kV substation. If other solar generation projects with earlier queue positions withdraw or reduce size, the X1-106 Project could become responsible for the full cost of these metering upgrades. The cost of the metering upgrades at the Sussex REC substation is $69,000, and the cost of the metering upgrades at the JCPL Vernon substation is $52,575.

Network Impacts

Queue project X1-106 was studied as a(n) 16.8 MW (6.38 MW of which was Capacity) injection into JCPL's system at the SUSSEX B 34.5 kV substation. Project X1-106 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)

1. (PJM) The West Wharton-West Wharton 115/230 kV transformer (from bus 206254 to bus 206255 ckt 1) loads from 98.14% to 100.79% (DC power flow) of its emergency rating (275 MVA) for the tower contingency 'C5_NJC2-DCT-#18'. This project contributes approximately 7.29 MW to the thermal violation.

```
CONTINGENCY 'C5_NJC2-DCT-#18'
     /* KITTATINNY-NEWTON & NEWTON-MONTVILLE 230 KV
  DISCONNECT BRANCH FROM BUS 206242 TO BUS 206260 CKT 1
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206211 CKT 1
  REDUCE BUS 206211 SHUNT BY 100 PERCENT
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206264 CKT 1
  DISCONNECT BRANCH FROM BUS 206264 TO BUS 206244 CKT 1
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206211 CKT 2
  DISCONNECT BUS 206260
  DISCONNECT BUS 206211
END
```

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.)

2. (PJM) The Franklin J-West Wharton 115 kV line (from bus 206232 to bus 206254 ckt 1) loads from 182.39% to 186.96% (DC power flow) of its emergency rating (160 MVA) for the tower contingency 'C5_NJC2-DCT-#18'. This project contributes approximately 7.31 MW to the thermal violation.

```
CONTINGENCY 'C5_NJC2-DCT-#18'
     /* KITTATINNY-NEWTON & NEWTON-MONTVILLE 230 KV
  DISCONNECT BRANCH FROM BUS 206242 TO BUS 206260 CKT 1
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206211 CKT 1
  REDUCE BUS 206211 SHUNT BY 100 PERCENT
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206264 CKT 1
  DISCONNECT BRANCH FROM BUS 206264 TO BUS 206244 CKT 1
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206211 CKT 2
  DISCONNECT BUS 206260
  DISCONNECT BUS 206211
END
```

3. (PJM) The Franklin D-West Wharton 115 kV line (from bus 206231 to bus 206254 ckt 1) loads from 153.44% to 157.32% (DC power flow) of its emergency rating (160 MVA) for the tower contingency 'C5_NJC2-DCT-#18'. This project contributes approximately 6.21 MW to the thermal violation.

```
CONTINGENCY 'C5_NJC2-DCT-#18'     /* KITTATINNY-NEWTON & NEWTON-
MONTVILLE 230 KV
  DISCONNECT BRANCH FROM BUS 206242 TO BUS 206260 CKT 1
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206211 CKT 1
  REDUCE BUS 206211 SHUNT BY 100 PERCENT
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206264 CKT 1
  DISCONNECT BRANCH FROM BUS 206264 TO BUS 206244 CKT 1
  DISCONNECT BRANCH FROM BUS 206260 TO BUS 206211 CKT 2
  DISCONNECT BUS 206260
  DISCONNECT BUS 206211
END
```

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

1. The purchase and installation of a revenue class meter for the X1-106 Project interconnection in coordination with the Sussex REC to measure the power delivered to the PJM system in compliance with the FE standards. The installation must comply with all Sussex REC metering requirements.

2. A compliance with the Sussex REC generator power factor and voltage control requirements. Note that the X1-106 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. Any complaints from other customers (e.g. flicker complaints) will have to be corrected by the Interconnection Customer. The correction may include changing operation, reducing generation, disconnecting the generators, or other measures.

4. The purchase and installation of supervisory control and data acquisition (SCADA) equipment that will provide revenue quality data and system information to FE in a compatible format to the FE Transmission System Control Center and Billing standards. 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.

5. The following status and metering points will be required:

    a. Interconnection breaker position status and trip control. If trip control is not provided to FE, under emergency conditions FE may need to open the Sussex REC delivery point.

    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.

6. A compliance with the inverter standard UL1741 and IEEE 1547 in addition to the power quality standards defined by Reliability*First* and PJM.

7. The provision of a telephone number for the X1-106 Plant Operator who must be available on a 24/7 basis to respond to FE or PJM Dispatch orders and requests for information.

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 X1-106 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 X1-106 Project to the Sussex REC transmission system will require no network upgrades. Note that the Interconnection Customer will have a cost responsibility for the Direct Connection of the X1-106 Project to the Sussex REC transmission system (to be determined by Sussex REC) and the provision of SCADA and billing information to FE and PJM in the defined formats. The Sussex REC will be responsible for the engineering and construction activities required for the Direct Connection of the X1-106 Project by separate agreement. The cost of integrating the required SCADA points into the FE EMS system is $10,594, as shown on Attachment 5. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of $2594. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129. There will be no interconnection metering upgrades required at the Jersey Central and Sussex REC points of interconnection.

Further note that the Interconnection Customer will have a cost responsibility for the Direct Connection of the X1-106 Project to the Sussex REC transmission system (to be determined by Sussex REC) and the provision of SCADA and billing information to FE and PJM in the defined formats. The Sussex REC will be responsible for the engineering and construction activities required for the Direct Connection of the X1-106 Project by separate agreement.

Based on the extent of the FE network upgrades required to support this project, it is estimated that it will take six (6) months from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the X1-106 Project. Full payment of the estimated cost of the project will be required upon execution of the Construction Service Agreement (CSA). A 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 new Sussex Junction substation 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
Existing Network Configuration

Attachment 4
Propose Network Configuration

Attachment 5
Estimated Costs

Item	Description	
1	EMS/SCADA integration	
	Substation Costs:	**$ 8,000**
	Taxes (if applicable):	**$ 2,594**
	Total:	**$ 10,594**

Attachment 6

Solar Generation Project Analysis

2013 Peak Load Conditions –Energy Dispatch

Outage Description	Overloaded Element	Line No.	MVA Rating Normal	MVA Rating Emerg.	% of Rating Normal	% of Rating Emerg.
Base system (n-0) – Normal	Newton – North Newton 34.5 kV	F708	44		105.1	
	Hamburg – Sussex 34.5 kV	Q745	44		111.6	
	Newton – Mohawk 34.5kV	Z702	23		120.4	
Franklin – Hamburg (Q745) 34.5 kV	Newton – North Newton 34.5 kV	F708		52		175.2
Newton – North Newton (F708) 34.5 kV	Hamburg – Sussex 34.5 kV	Q745		52		184.1
Newton – Montville (N2214) 34.5 kV	Newton – Mohawk 34.5 kV	Z702		31		126.1

2013 Peak Load Conditions – Capacity Dispatch

Outage Description	Overloaded Element	Line No.	MVA Rating Normal	MVA Rating Emerg.	% of Rating Normal	% of Rating Emerg.
Newton – Montville (N2214) 34.5 kV	Newton – Mohawk 34.5kV	Z702		31		111.2

2013 Light Load Conditions –Energy Dispatch

Outage Description	Overloaded Element	Line No.	MVA Rating Normal	MVA Rating Emerg.	% of Rating Normal	% of Rating Emerg.
Base system (n-0) – Normal	Newton – North Newton 34.5 kV	F708	44		141.3	
	Hamburg – Sussex 34.5 kV	Q745	44		110.5	
Franklin – Hamburg (Q745) 34.5 kV	Newton – North Newton 34.5 kV	F708		52		205.1
Newton – North Newton (F708) 34.5 kV	Hamburg – Sussex 34.5 kV	Q745		52		242.1