Generation Interconnection Combined Feasibility/System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AC1-014

Farmingdale-Bennett I 34.5 kV

April 2017

Preface

The intent of the Combined Feasibility/System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, 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, if any, is included in the System Impact Study.

The 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 associated with them will be addressed when seeking an Interconnection Agreement as outlined below. . Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

The Brick Yard LLC, the Interconnection Customer (IC), has proposed a solar generating facility located at 176 Birdsall Road in Howell, New Jersey. The installed facilities will have a total capability of **4 MW** with **0 MW** of this output being recognized by PJM as capacity. The proposed in-service date for this project is **May 30, 2018**. **This study does not imply a Jersey Central Power & Light (JCP&L) commitment to this in-service date.**

Point of Interconnection

AC1-014 "Farmingdale-Bennett I 34.5 kV" will interconnect with the JCP&L transmission system at a point approximately 1.4 miles from the existing Bennett substation facility. The primary direct connection of this project will be accomplished by tapping the Farmingdale-Bennett (L90) 34.5 kV line, and installing an overhead 34.5 kV line for one span to the point of interconnection ("POI"), 3-34.5 kV gang-operated SCADA controlled switches at the tap location, and 34.5 kV interconnection metering. No alternate point of interconnection was requested to be studied, therefore a secondary point of interconnection was not analyzed. Attachment 2 shows the one-line diagram of the proposed primary direct connection of the AC1-014 generation project to the [Keywords]transmission systems. The Brick Yard LLC will be responsible for constructing all of the facilities on its side of the POI including the attachment

line. The Brick Yard LLC may not install above ground equipment within any JCP&L right-of-way unless permission to do so is expressly granted by JCP&L.

Cost Summary

The AC1-014 project will be responsible for the following costs. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Attachment Facilities	$ 127,500
Direct Connection Network Upgrades	$ 255,000
Non Direct Connection Network Upgrades	$ 10,400
New System Upgrades	$ 0
Previously Identified Upgrades	$ 0
Total Costs	**$ 392,900**

The required Attachment Facilities, Direct Connection, and Non-Direct Connection work for the interconnection ofAC1-014 generation project to the[Keywords] Transmission System is detailed in the following sections. The associated one-line for the generation project attachment facilities and primary direct connection are shown in Attachment 2. Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to change. The Brick Yard LLC will be responsible for the actual cost of the direct connection that is implemented. JCP&L 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 systems.

Attachment Facilities

AC1-014 "Farmingdale-Bennett I 34.5 kV" will interconnect with the JCP&L transmission system at a point approximately 1.4 miles from the existing Bennett substation facility. The interconnection of this project will be accomplished by tapping the Farmingdale-Bennett (L90) 34.5 kV line, and installing an overhead 34.5 kV line for one span to the point of interconnection ("POI"), 3-34.5 kV gang-operated SCADA controlled switches will be installed at the tap location, and 34.5 kV interconnection metering.

The Attachment Facility work is considered to be the installation of the one tap switch, one revenue meter and one span to the point of interconnection with the AC1-014 customer along the generator lead line.

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
L90 LINE- CONSTRUCT 34.5 kV Line Tap/Connection and Install 3-34.5 kV gang-operated SCADA controlled switches at tap location. Build one (1) span of 34.5 kV line from tap to point of interconnection (POI). Pole at POI to be purchased and installed by customer. Revenue Meter to be installed by JCP&L. (Attachment Facility work is to install the tap switch and one span to the point of interconnection with the AC1-014 customer along the generator lead line.) **PJM Network Upgrade Number n5220.**	$127,500
Total Attachment Facilities Cost	**$127,500**

Direct Connection Cost Estimate

The Direct Connection work is considered to be the installation of the two 34.5 kV gang-operated SCADA controlled switches on either side of the tap to the AC1-014 customer. These switches are in network with the Farmingdale-Bennett 34.5 kV line.

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
L90 LINE- CONSTRUCT 34.5 kV Line Tap/Connection and Install 3-34.5 kV gang-operated SCADA controlled switches at tap location. Build one (1) span of 34.5 kV line from tap to point of interconnection (POI). Pole at POI to be purchased and installed by customer. Revenue Meter to be installed by JCP&L. (Direct Connection work is to install two of the switches on either side of the tap to the AC1-014 customer. These switches are in network with the Farmingdale-Bennett 34.5 kV line.) **PJM Network Upgrade Number n5221.**	$255,000
Total Direct Connection Cost	**$255,000**

Non-Direct Connection Cost Estimate

The Non-Direct Connection work will include relay setting changes and functional testing on the 34.5 kV L90 (Bennett) line at Farmingdale Substation for the interconnection of the AC1-014 IC.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Relay setting changes and functional testing on the 34.5 kV L90 (Bennett) line for AC1-014 (The Brick Yard LLC) Interconnection @ Farmingdale SS. **PJM Network Upgrade Number n5222.**	$10,400
Total Non-Direct Connection Cost	**$10,400**

Interconnection Customer Requirements

In addition to the JCP&L facilities, The Brick Yard LLC is will also be responsible for meeting all criteria as specified in the applicable sections of the FirstEnergy (FE) "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 34.5 kV circuit breaker on the high side of the AC1-014 step-up transformer.

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 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 retail service agreement with the electric distribution company to serve the customer load supplied from the AC1-014 generation project interconnection point when the units are out-of-service.

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

Schedule

Based on the extent of the JCP&L primary direct connection and system upgrades required to support the (AC1-014) generation project, it is expected to take a minimum of **19 months** from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes the requirement for The Brick Yard LLC to make a preliminary payment to FE which funds the first three months of engineering design that is related to the

construction of the Direct Connection facilities. It further assumes that The Brick Yard LLC 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.

Revenue Metering and SCADA Requirements

PJM Requirements

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

JCP&L Requirements

The Brick Yard LLC will be required to comply with all FE revenue metering requirements for generation interconnection customers. The FE revenue metering requirements may be found in the FE "Requirements for Transmission Connected Facilities" document located at the following links:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

Compliance Issues

The proposed interconnection facilities must be designed in accordance with the FE "Requirements for Transmission Connected Facilities" document located at:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

The Brick Yard LLC will also be responsible for following the requirements of the FE "Approved Vendors and Contractors" document which is also located at the above link.

The Brick Yard LLC will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, The Brick Yard LLC 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 JCP&L systems.

JCP&L Analysis:

Power Flow Analysis

A power flow study was conducted to determine the reliability impact of the proposedAC1-014 generation project on the JCP&L transmission systems. This study was completed using a 2020 summer peak power flow model that contain a detailed representation of the [Keywords] transmission networks in the area of the proposedAC1-014 generation project. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the ReliabilityFirst, PJM, or FE Planning Criteria and are attributable to this project. Note that in accordance with PJM RTEP study procedures, theAC1-014 generation project under study and earlier active queue projects are considered to be in-service. All active queue projects after the AC1-014 project are considered not in-service.

For the primary point of interconnection (see Attachment 2A), theAC1-014 generation project was studied with a connection to the Farmingdale-Bennett (L90) 34.5 kV line. The results of the FE analysis show that there are no transmission network upgrades required for the deliverability of the AC1-014 generation project generation to the JCP&L transmission systems.

Note that a further conclusion of this study is that it will be mandatory for theAC1-014 generation project to have a range of dynamic reactive capability that supports its operation from a 0.95 leading to 0.95 lagging power factor measured at the generator's terminals. The FE studies show that the addition of solar projects can cause voltage swings as their output oscillates with moving clouds without continuous regulation, and system voltages can exceed the established limits. Should The Brick Yard LLC fail to provide dynamic reactive capability from the AC1-014 generation project for any reason once interconnected, the FE and/or PJM Dispatchers may need to take action to curtail its output to prevent non-compliance with voltage criteria.

Short Circuit and Dynamics Analysis

In accordance with the RTEP process, a short circuit analysis was not conducted by PJM based on the following "no initial short circuit analysis needs to be performed by PJM since the project is an inverter based (solar, flywheel, battery etc.) project which will provide minimal fault current connected to or less than 69 kV (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 JCP&L transmission systems. 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 JCP&L

[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

circuit breaker will exceed its interrupting capability with the implementation of theAC1-014 generation project. Therefore no circuit breaker reinforcements will be required.

A dynamics study was not performed for theAC1-014 generation project since it is an inverter based project less than 70 MW.

System Protection Analysis

An analysis was conducted to assess the impact of theAC1-014 generation project on the system protection requirements in the area. The results of this review have identified that all current relaying and protection at Atlantic, Belmar, Farmingdale, and Oceanview substations are sufficient in protecting the transmission systems. The Brick Yard LLC will still be responsible for meeting the generator interconnection requirements in FE's "Requirements for Transmission Connected Facilities" document.

The fault currents on the Farmingdale - Bennett (L90) 34.5 kV, 1.4 miles from the Bennett substation are listed below.

Three phase fault current:	6627.6 Amps
Single line to ground fault current:	3183.8 Amps
Positive Sequence Thevenin (ohms):	1.09982 + j2.7961
Zero Sequence Thevenin (ohms):	3.23960 + j12.3693

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 responsibility of the Interconnection Customer to make any protection upgrades required should this occur. The proposed interconnection facilities must be designed in accordance with the "FirstEnergy Requirements for Transmission Connected Facilities" document.

Network Impacts (by PJM)

The Queue Project AC1-014 was evaluated as a **4.0 MW** (Capacity **0.0 MW**) injection tapping the X4-031 Tap-Bennett 34.5kV line in the JCP&L area. Project AC1-014 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-014 was studied with a commercial probability of 100%. 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 contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None.

Steady-State Voltage Requirements

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

None.

Short Circuit

(Summary of impacted circuit breakers)

None.

Affected System Analysis & Mitigation

(Summary of impacts on systems external to PJM)

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.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

None.

Light Load Analysis

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

Not applicable.

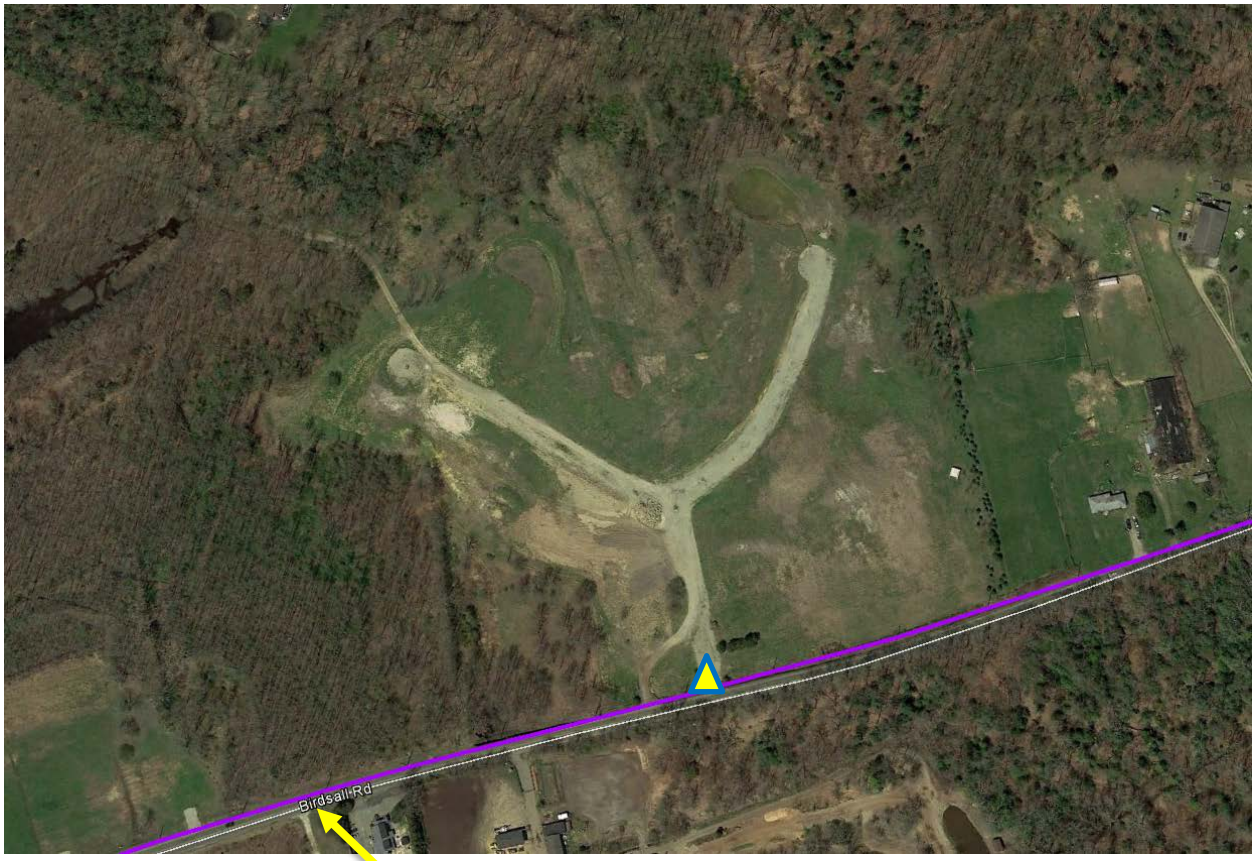
Stability and Reactive Power Requirement for Low Voltage Ride Through

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

None.

Attachment 1. Project Location

Farmingdale-Bennett 34.5 kV (AC1-014) Generation Project

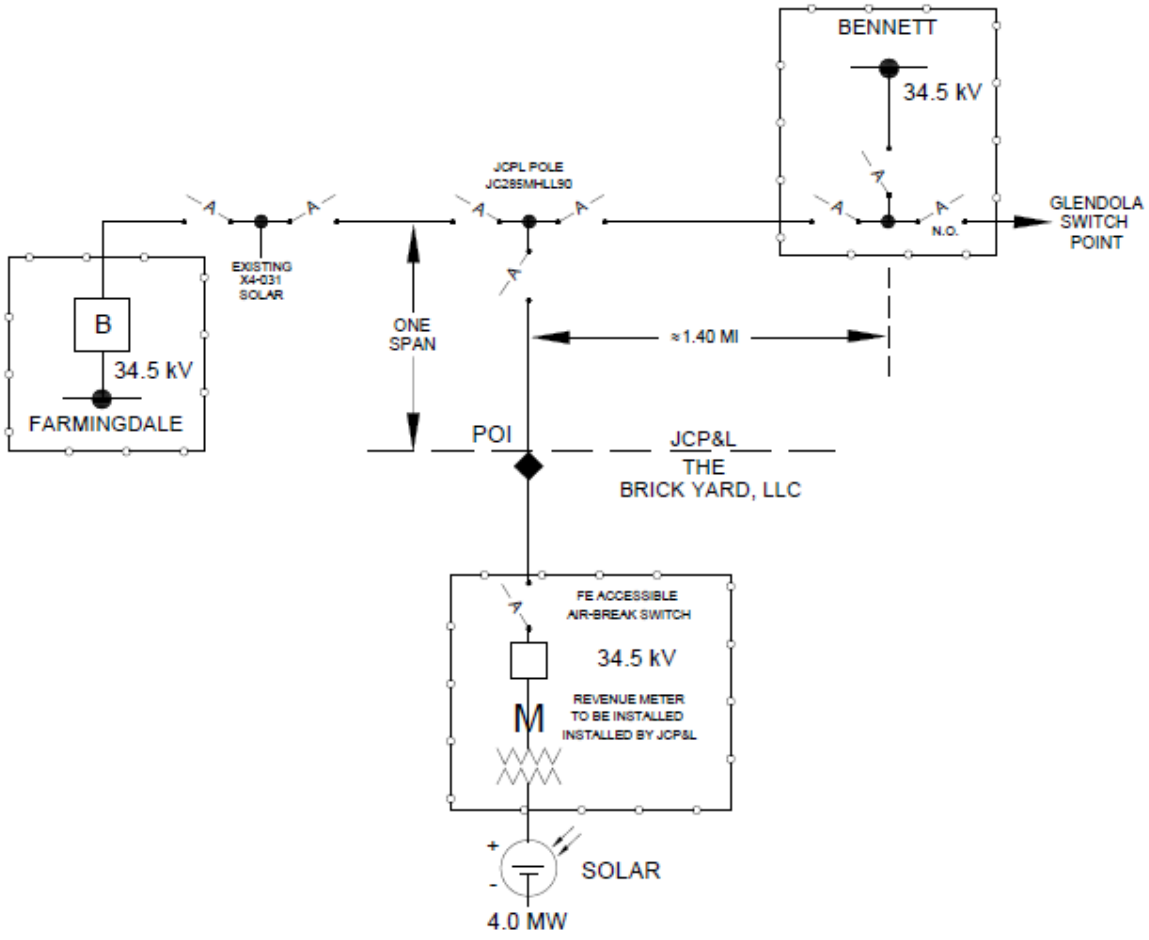


Farmingdale – Bennett L90 34.5 kV Line

Primary Point of Interconnection

Attachment 2 Interconnection Single Line Diagram

Farmingdale-Bennett 34.5 kV (AC1-014) Generation Project



◆ = POI LOCATED AT INTERCONECTION CUSTOMER'S DEAD-END STRUCTURE

M = REVENUE METERING FOR INTERCONNECTION CUSTOMER IS OWNED, OPERATED, AND MAINTAINED BY JCP&L