

***Generation Interconnection  
Combined Feasibility/Impact Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position AC1-015***

***“Farmingdale-Bennett II 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 80 Birdsall Road in Howell, New Jersey. The installed facilities will have a total capability of **0.4 MW** with **0 MW** of this output being recognized by PJM as capacity. The proposed in-service date for this project is **September 1, 2017**. **This study does not imply a Jersey Central Power & Light Company (JCP&L) commitment to this in-service date.**

## Point of Interconnection

**AC1-015 “Farmingdale-Bennett II 34.5 kV”** will interconnect with the JCP&L transmission system will be located at a point approximately 1.9 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 to the point of interconnection (“POI”), 2-34.5 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 AC1-015 generation project to the Jersey Central Power & Light 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 AC1-015 “Farmingdale-Bennett II 34.5 kV” project will be responsible for the following costs:

<b>Description</b>	<b>Total Cost</b>
Attachment Facilities	\$ 149,400
Direct Connection Network Upgrades	\$ 149,400
Non Direct Connection Network Upgrades	\$ 10,400
<b>Total Costs</b>	<b>\$ 309,200</b>

Note that the FE findings were made from a conceptual review of this project. Further note that the cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

## Attachment Facilities

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

The Attachment Facility cost estimate for the AC1-015 project is approximately **\$149,400**. This scope of work to interconnect the AC1-015 IC includes the installation of a 34.5 kV gang-operated SCADA controlled switch, one revenue meter, and span of conductor on the tap to the POI with the IC.

This report assumes that the Interconnection Customer will build and own its own generator lead line up to the POI.

Description	Total Cost
L90 LINE- CONSTRUCT 34.5 kV Line Tap/Connection and Install 2-34.5 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 portion of work is considered to be the one new tap switch and span to the POI with the IC). PJM Network Upgrade Number n5223.	\$ 149,400
<b>Total Attachment Facility Costs</b>	<b>\$ 149,400</b>

## Direct Connection Cost Estimate

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 2-34.5 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 portion of work is considered to be the one new switch in the Farmingdale-Bennett 34.5 kV line that is on the Farmingdale side of the tap to the IC). PJM Network Upgrade Number n5224.	\$ 149,400
<b>Total Direct Connection Facility Costs</b>	<b>\$ 149,400</b>

The Direct Connection cost estimate for the AC1-015 project is approximately **\$149,400**. This scope of work to interconnect the AC1-015 IC includes the installation of a 34.5 kV gang-operated SCADA controlled switch in the Farmingdale-Bennett 34.5 kV line that is on the Farmingdale side of the tap to the IC.

## Non-Direct Connection Cost Estimate

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 AC1-015 (The Brick Yard LLC) Interconnection @ Farmingdale SS. <b>PJM Network Upgrade Number n5225.</b>	\$ 10,400
<b>Total Non-Direct Connection Facility Costs</b>	<b>\$ 10,400</b>

The substation non-direct connection cost estimate for the AC1-015 project is approximately **\$10,400**. The scope of work to interconnect the AC1-015 IC includes relay setting changes and functional testing on the 34.5 kV Bennett terminal at the Farmingdale Substation.

## 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:

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

1. The purchase and installation of fully rated 34.5 kV circuit breaker on the high side of the AC1-015 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 AC1-015 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 AC1-015 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.

## **Network Impacts (from JCP&L)**

### **Power Flow Analysis**

A power flow study was conducted to determine the reliability impact of the proposed AC1-015 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 Jersey Central Power & Light transmission networks in the area of the proposed AC1-015 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, the AC1-015 generation project under study and earlier active queue projects are considered to be in-service. All active queue projects after the AC1-015 project are considered not in-service.

For the primary point of interconnection (see Attachment 2), the AC1-015 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 AC1-015 generation project generation to the JCP&L transmission systems.

Note that a further conclusion of this study is that it will be mandatory for the AC1-015 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 AC1-015 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.”<sup>1</sup> Based on this statement, the results of the FE analysis showed that no JCP&L circuit breaker will exceed its interrupting capability with the implementation of the AC1-015 generation project. Therefore no circuit breaker reinforcements will be required.

A dynamics study was not performed for the AC1-015 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 the AC1-015 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, 1.9 miles from the Bennett substation are listed below.

Three phase fault current: 7425 Amps

Single line to ground fault current: 3535 Amps

Positive Sequence Thevenin (ohms):  $0.9715 + j 2.5000$

Zero Sequence Thevenin (ohms):  $2.8905 + j 11.2080$

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.

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<sup>1</sup> 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

## **Network Impacts (by PJM)**

The Queue Project AC1-015 was evaluated as a 0.4 MW (Capacity 0.0 MW) injection tapping the Farmingdale-Bennett 34.5kV line (X4-031 Tap) in the JCP&L area. Project AC1-015 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-015 was studied with a commercial probability of 100%. Potential network impacts were as follows:

### **Summer Peak Analysis - 2020**

#### **Generator Deliverability**

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

None

#### **Multiple Facility Contingency**

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

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**

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

None.

#### **Short Circuit**

*(Summary of impacted circuit breakers)*

None.

### **Affected System Analysis & Mitigation**

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.

## **Light Load Analysis - 2020**

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

Not applicable.

## **System Reinforcements**

### **Short Circuit**

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

None required.

### **Stability and Reactive Power Requirement**

*(Results of the dynamic studies should be inserted here)*

None required.

## **Summer Peak Load Flow Analysis Reinforcements**

### **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)*

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

None required.

## **Light Load Flow Analysis Reinforcements**

**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)*

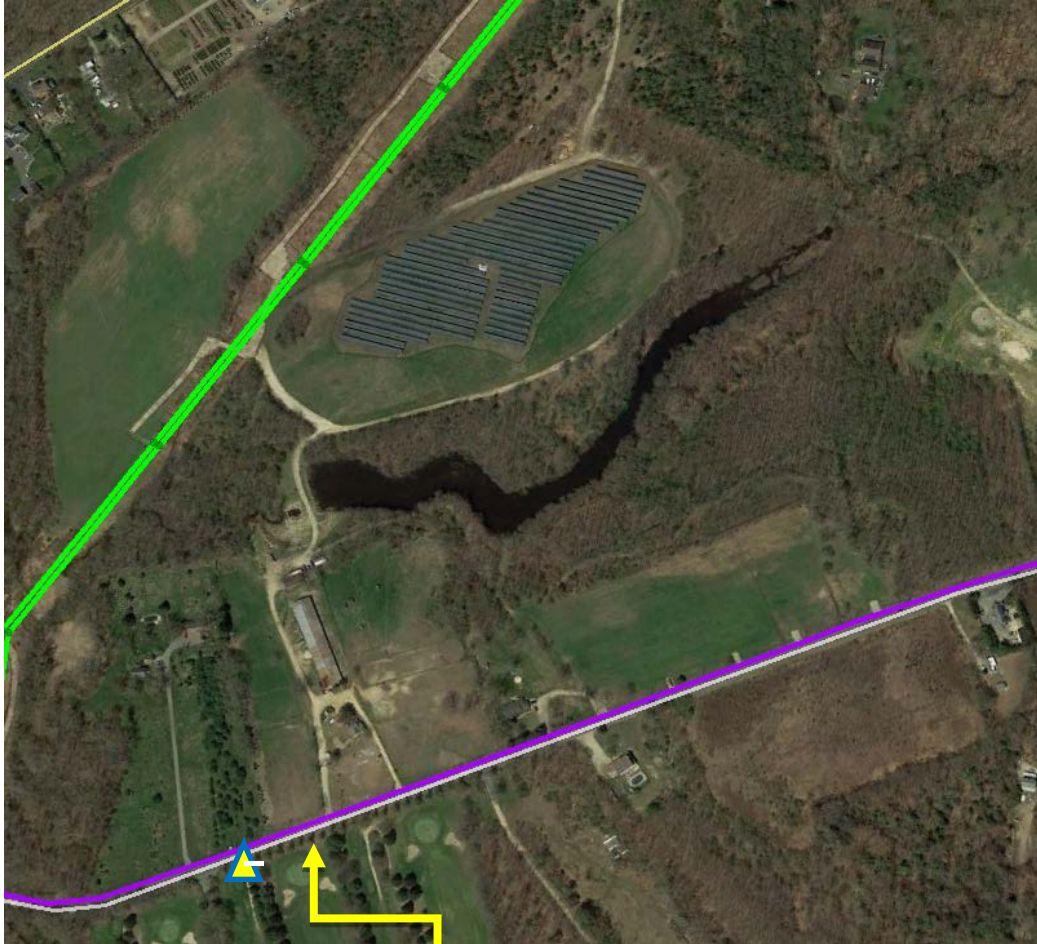
*(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)*

None required.

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**Attachment 1: Site Diagram**

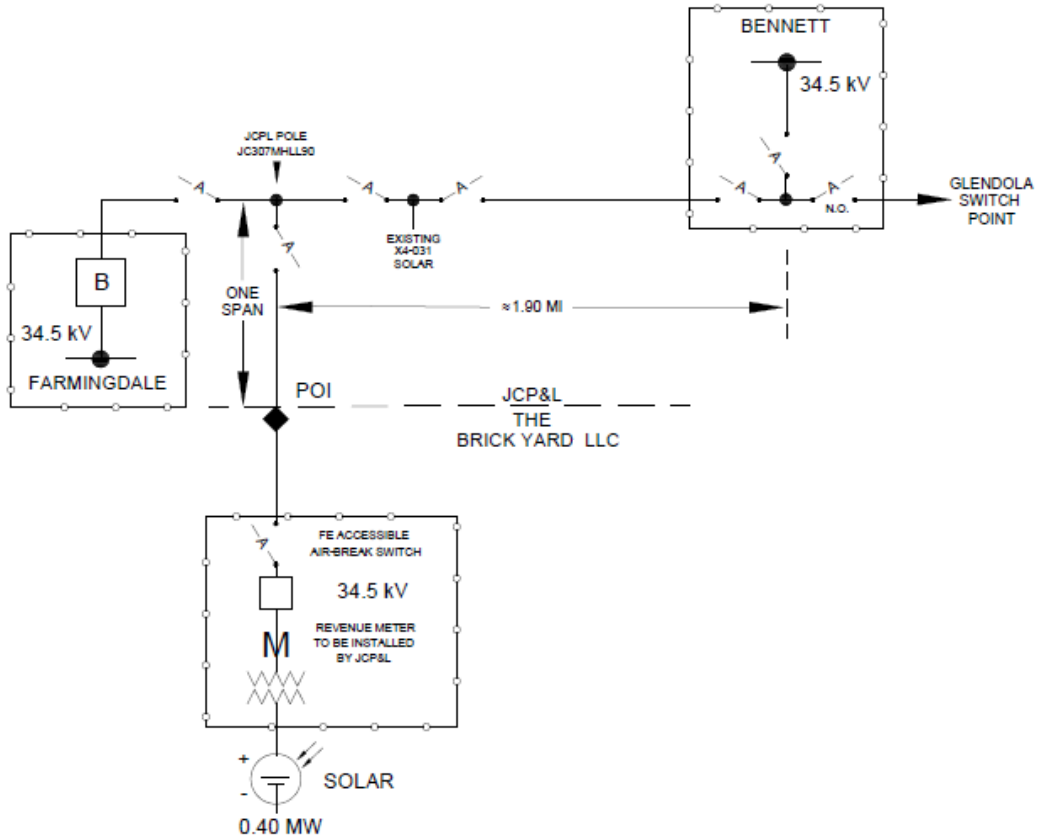
**AC1-015 'Farmingdale-Bennett II 34.5 kV'**



Farmingdale  
– Bennett L90  
34.5 kV Line

 Primary Point of  
Interconnection

## Attachment 2: Interconnection Single Line Diagram AC1-015 'Farmingdale-Bennett II 34.5 kV'



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

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