Generation Interconnection Combined Feasibility/System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AC2-134

"Hamburg 34.5 kV"

August 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

Imperatore Sussex Partnership L.P., the Interconnection Customer (IC), has proposed **solar** generating facilities located at 1 McDole Road in Hamburg, New Jersey. The installed facilities for the **AC2-134 "Hamburg 34.5 kV"** request will have a total capability of **9 MW** with **1.8 MW** of this output being recognized by PJM as capacity.

The proposed in-service date for this project is **December 31, 2018**. **This study does not imply a Jersey Central Power & Light (JCPL) commitment to this in-service date.**

Point of Interconnection:

The IC requested the study of a primary Point of Interconnection (POI) only for this project. This report contains detailed connection requirements, costs and schedule, power flow analysis, short circuit analysis, and a cost and schedule for any associated system reinforcements for the Primary POI.

The proposed POI for the **AC2-134 "Hamburg 34.5 kV"** generation project will be located on the Franklin-Sussex Q745 34.5 kV line. The direct connection of (AC2-134) will be accomplished by building a new three switch tap on the Franklin-Sussex 34.5 kV line. **Attachment 1** shows a conceptual one-line diagram of the proposed connection of (AC2-134) to the JCP&L transmission system. **Attachment 2** provides the proposed location for the point of interconnection. The Imperatore Sussex Partnership L.P. will be responsible for constructing all

facilities on its side of the POI including the attachment line. Imperatore Sussex Partnership L.P. may not install above ground equipment within any JCP&L right-of-way unless permission to do so is expressly granted by JCP&L. The JCP&L facilities required to be upgraded for the interconnection of the generation project and the associated cost estimate are identified in this report.

See Attachment 1 for the One Line Diagram of the proposed interconnection.

Cost Summary

The **AC2-134 "Hamburg 34.5 kV"** project will be responsible for the following costs. These costs do not include CIAC Tax Gross-up:

Description	Total Cost
Attachment Facilities	$ 156,200
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 250,300
Total Costs	**$ 406,500**

In addition, the AC2-134 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$ 0
Previously Identified Upgrades	$ 0
Total Costs	**$ 0**

The transmission and substation costs given above exclude any applicable state or federal taxes. If at a future date Federal CIAC (contribution in aid of construction) taxes are deemed necessary by the IRS for this project, JPCL shall be reimbursed by the Interconnection Customer for such taxes. JPCL estimates the tax, if applicable, would be approximately **$62,200**.

The required Attachment Facilities, Direct Connection, and Non-Direct Connection work for the interconnection of the AC2-134 generation project to the JCPL Transmission System is detailed in the following sections. The associated one-line with the generation project attachment facilities and primary direct connection are shown in Attachment 1.

Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to change. Imperatore Sussex Partnership L.P. will be responsible for the actual cost of the direct connection that is implemented. JCPL 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 or subtransmission systems.

Attachment Facilities

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

Description	Total Cost
Tap the Q745 34.5KV line to a new solar field AC2-134 @ POI pole#NJ55HYNQ745) in Hamburg NJ. Install 1 SCADA-controlled MOAB switch on the tap and all required metering. PJM Network Upgrade Number: n5432	$ 156,200
Total Attachment Facility Costs	**$ 156,200**

The transmission Attachment Facility cost estimate for the AC2-134 "Hamburg 34.5 kV" project is approximately **$156,200**. JCPL plans to tap the Q745 34.5 kV line and install three SCADA-controlled Motor Operated Air Break Switches (MOABs) to interconnect the AC2-134 project. The SCADA-controlled MOAB switch covering the generator lead line will be considered an Attachment Facility.

Direct Connection Cost Estimate

No Direct Connection work is required for this project.

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
Install 2 SCADA-controlled MOAB switches on the Franklin-Sussex 34.5 kV line on either side of the tap to the AC2-134 customer. PJM Network Upgrade Number: n5433	$ 234,300
Adjust Remote Relay and Metering Settings at Franklin Substation. PJM Network Upgrade Number: n5434	$ 8,000
Adjust Remote Relay and Metering Settings at Branchville Substation. PJM Network Upgrade Number: n5435	$ 8,000
Total Non-Direct Connection Facility Costs	**$ 250,300**

The total Non-Direct Connection cost estimate for the AC2-134 project is approximately **$250,300**.

Of the total, the transmission Non-Direct Connection cost estimate for the AC2-134 "Hamburg 34.5 kV" project is approximately **$234,300**. JCPL plans to tap the Q745 34.5 kV line and install three SCADA-controlled Motor Operated Air Break Switches (MOABs) to interconnect the AC2-134 project. Two of the SCADA-controlled MOAB switches will be considered Non-Direct Connection facilities (the two switches that are in network with the main circuit).

Of the total, the substation Non-Direct Connection cost estimate for the AC2-134 project is approximately **$16,000**. Remote relay and metering setting changes will need to be made at Franklin and Branchville Substations to facilitate the interconnection of the new generation.

Interconnection Customer Requirements

In addition to the JCP&L facilities, Imperatore Sussex Partnership L.P. will also be responsible for meeting all criteria as specified in the applicable sections of the FE "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 34.5 kV circuit breakers on the high side of the (AC2-134) 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 service agreement to serve the customer load supplied from the (AC2-134) generation project metering point when the units are out-of-service. This assumes the intent of Imperatore Sussex Partnership L.P. is to net the generation with the load.

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 AC2-134 generation project, it is expected to take a minimum of **10 months** from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes the requirement for Imperatore Sussex Partnership L.P. to make a preliminary payment to FE which funds the Non-Direct Connection work and the first three months of engineering design that is related to the construction of the Attachment Facilities. It further assumes that Imperatore Sussex Partnership L.P. 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 Attachment Facilities and Non-Direct Connection work, 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.

JPCL Requirements

Imperatore Sussex Partnership L.P. 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 link:

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

Compliance Issues

Imperatore Sussex Partnership L.P. will be responsible for meeting all FE criteria as defined in the FE "Requirements for Transmission Connected Facilities" document.

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

Imperatore Sussex Partnership L.P. must also meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures required for standards compliance. For example, Imperatore Sussex Partnership L.P. will need to properly locate and report the over and under-voltage and over and under-frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

JCPL Analysis:

Power Flow Analysis

A power flow study was conducted to determine the reliability impact of the proposed Hamburg 34.5 kV (AC2-134) generation project on the JCP&L transmission system. This study was completed using a 2020 summer peak load power flow model that contains a detailed representation of the JCP&L transmission network in the area of the proposed Hamburg 34.5 kV (AC2-134) 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, this Hamburg 34.5 kV (AC2-134) generation project under study and earlier active generation queue projects are considered to be in service. Therefore, all active generation queue projects after (AC2-134) are considered not in service.

The results of the FE analysis show that there are no transmission network upgrades required for the Hamburg 34.5 kV (AC2-134) generation project.

Note that a further conclusion of this study is that it will be mandatory for the (AC2-134) 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 Imperatore Sussex Partnership L.P. fail to provide dynamic reactive capability from the (AC2-134) generation project for any reason once interconnected, the FE and/or PJM Dispatchers may need to curtail its output to prevent non-compliance with voltage criteria.

Short Circuit 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 circuit breaker will exceed its interrupting capability with the implementation of the (AC2-134) generation project. Therefore no circuit breaker reinforcements will be required.

[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

System Protection Analysis

An analysis was conducted to assess the impact of the (AC2-134) generation project on the system protection requirements in the area. The results of this review have identified that there will be no protection upgrades needed for the Franklin-Branchville (Q745) 34.5kV line. However, Project AC2-134 will be required to have two independent high-speed zones of protection (SEL-351s) to sense and clear faults beyond the POI breaker. There should be two levels of anti-island protection. If the inverters comply with IEEE-1547.1 and are UL1741 listed or certified, Anti-islanding Direct Transfer Trip will not be required and the inverters themselves have one level of anti-island protection.

The second level of anti-island protection, the intertie relay, could be a third SEl-351-7 and provide just the intertie functionality (over and under voltage, over and under frequency and ground overvoltage) but this functionality can be place inside the SEL-351-7s that are used for the fault protection.

All relays, relay schemes, and relay settings that include 34.5 kV voltages or currents, or trip any 34.5 kV circuit breakers shall require the review and approval of FirstEnergy.

FirstEnergy will complete detailed relay coordination studies to identify off-site relay setting changes required due to this generation interconnection. This may result in additional individual relay replacements being required. These relay replacements will be done at the cost of the developer. Imperatore Sussex Partnership L.P. will still be responsible for meeting the generator interconnection requirements in FE's "FirstEnergy Requirements for Transmission Connected Facilities" document.

The fault currents on the Hamburg 34.5 Q745 kV, 2.0 miles from the Franklin substation are listed below.

Three phase fault current:	7,067 Amps
Single line to ground fault current:	4,661 Amps
Positive Sequence Thevenin (ohms):	0.64918 + j2.74250
Zero Sequence Thevenin (ohms):	1.10082 + j7.10915

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.

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

A dynamics study was not performed for the (AC2-134) generation project since it is an inverter based project less than 70 MW.

Network Impacts

The Queue Project AC2-134 was evaluated as a 9.0 MW (Capacity 1.8 MW) injection/withdrawal at the Franklin 34.5 kV substation in the JCPL area. Project AC2-134 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-134 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

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 required for this solar project.

System Reinforcements

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

None

Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

None

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

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

Light Load 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

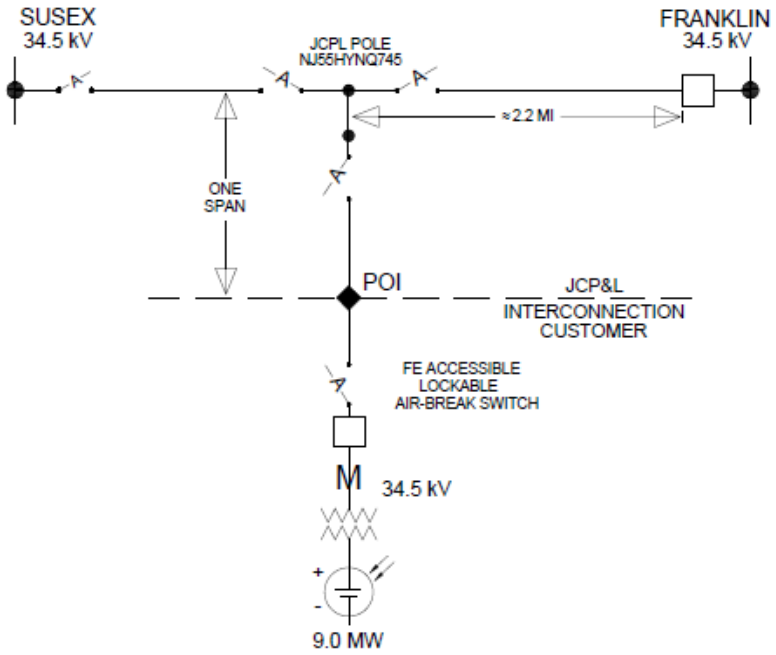
Contribution to Previously Identified System Reinforcements

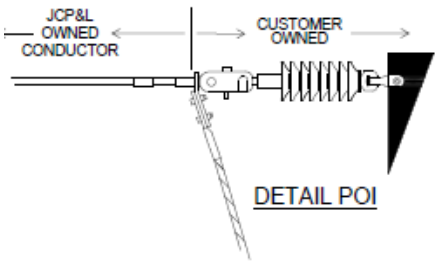
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

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

None

Attachment 1. One Line Diagram
"AC2-134 "Hamburg 34.5 kV"





◆ = POI (POINT OF INTERCONNECTION) LOCATED AT INTER-CONNECTION CUSTOMER OWNED DEAD-END STRUCTURE WHERE JCP&L OWNED TRANSMISSION LINES TERMINATE.

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

Attachment 2. Site Plan