

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position Z2-102***

Argonne-New Lisbon 34.5kV

August 2014

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 in Burlington County, New Jersey. The installed facilities will have a total capability of 13.00 MW with 4.84 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is May 2016. **This study does not imply a Jersey Central Power & Light (JCPL) commitment to this in-service date.**

Point of Interconnection

Z2-102 will interconnect with the JCPL distribution system at one of two options. Option 1 is to connect to the New Lisbon-Argonne (W75) 34kV line. Option 2 is to connect to the Pemberton-Browns Mill Road (K11) 34kV line.

Cost Summary

The Z1-102 project will be responsible for the following costs (for the Primary Point of Interconnection, Option 1):

Description	Total Cost
Transmission Owner facilities	\$ 1,235,600
Transmission Upgrades	\$ 0
Total Costs	\$ 1,235,600

Transmission Owner Scope of Work

Primary Point of Interconnection

As defined by the Interconnection Customer and shown on Attachment 1, the primary point of interconnection (POI #1) for the Z2-102 Project will be from a tap of the New Lisbon - Argonne section of the New Lisbon – Argonne – Cookstown (W75) 34.5 kV line. From this point Jersey Central will construct a 2.0 mile radial line tap, over built on an upgraded distribution pole line and on a new pole line, dead ending at a new pole just north of the Z2-102 Project site. From this dead end pole, Jersey Central will construct a one span radial line extension of about 200 feet to a switch pole structure to be constructed, owned, operated and maintained by the Interconnection Customer. The Interconnection Customer will be responsible for the attachment from this point to the Z2-102 Project substation. Jersey Central will own, operate and maintain the radial attachment line up to the point of interconnection as defined in Attachment 2. The Interconnection Customer will own, operate and maintain the extension from the point of interconnection to its substation.

In summary, Attachment 2 shows a conceptual one-line diagram of the primary choice Direct Connection facilities that will be required for the Z2-102 Project. As indicated, it will be studied as a 13.0 MW injection into the Jersey Central 34.5 kV system at the New Lisbon – Argonne - Cookstown (W75) 34.5 kV line. Supervisory control and data acquisition (“SCADA”) controlled disconnect switches will be needed on two poles as well as the radial tap pole in addition to a circuit breaker and switch on the system side of the generator step-up transformer. The Interconnection Customer will be responsible for acquiring all permits and right of way that may be needed for both the 34.5 kV line tap and the radial line extension line. The Interconnection Customer will also be responsible for acquiring all permits and constructing, owning and operating all facilities on its side of the point of interconnection.

Estimated costs for POI #1

Description	Total Cost
Tap W75, 34.5kV and construct new overhead line (approximately 2 miles) replacing poles and overbuilding as needed and install metering equipment. Note: this estimate may increase when actual siting and environmental studies are complete.	\$ 1,221,800
Engineering oversight and commissioning.	\$ 13,800
Total Attachment Facility Costs	\$ 1,235,600

Power Flow Analysis – Subtransmission (34.5kV) System

The results of the FE analysis show that there are no network upgrades required for the deliverability of the Z2-102 Project generation to the Jersey Central and PJM transmission systems. There also are no common mode outage reinforcements defined for previous projects for which it will have an impact. These results are applicable to both POI #1 and POI #2. However, there are numerous other solar generation projects proposed in the vicinity of the Z2-

102 Project that will contribute to system constraints. In addition, there is the potential for high voltage during light load periods and voltage criteria violations due to swings in the MW output of the cumulative attached solar generation. A conclusion of this analysis is therefore that a curtailment of the Z2-102 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 reinforce the limiting facilities to eliminate these constraints.

Note that a further conclusion of this study is that it will be mandatory for the Z2-102 Project to have a range of dynamic reactive capability that supports its operation from a .95 lead to .95 lag power factor. Without a continuous regulation, the FE studies show that the addition of solar projects can cause voltage swings as their output oscillates with moving clouds and system voltages that can exceed the established limits. Should the Interconnection Customer fail to provide a dynamic reactive capability from Z2-102 Generation Project for any reason once interconnected, the Jersey Central and/or PJM Dispatchers may need to take action to curtail both the energy and capacity portion of its output to prevent a non-compliance with voltage criteria.

System Protection Analysis

An analysis was conducted to assess the impact the Z2-102 Project will have on the system protection requirements in the area. The results of this review have identified the following:

Under the assumption that the Z2-102 Generation Project generation will not supply fault current to the Jersey Central transmission system as defined by the PJM staff, there will be no protection upgrades needed for the New Lisbon - Argonne – Cookstown (W75) 34.5 kV line. However, the Z2-102 Project will be required to have two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

For POI #1, the fault current values on the New Lisbon - Argonne – Cookstown (W75) 34.5 kV line, 4.3 miles from New Lisbon substation are listed below.

	Three Phase	Line-Ground
X/R Ratio	2.95	4.02
Fault Current (Amps)	3720	2070

These values are for the current system configuration. Any system changes in the area could have a significant impact on these values. It will be the Interconnection Customer’s responsibility to make any protection upgrades required should this occur.

For the 13 MW Z2-102 Project, a standard speed SMD-2C 200E fuse would be appropriate.

For POI #2, the fault current values on the New Lisbon - Upton – Whitings (K11) 34.5 kV line, 400 feet from New Lisbon substation are listed below.

	Three Phase	Line-Ground
X/R Ratio	2.91	4.12
Fault Current (Amps)	4310	2215

Schedule

Based on the extent of the FE Direct Connection, it is estimated that it will take one (1) year from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the Z2-102 Generation Project. Full payment of the estimated cost of the project Direct Connection will be required upon execution of the Interconnection Service Agreement/Interconnection Construction Service Agreement (ISA/CSA). True up of the actual cost versus estimated cost of the project will be performed by FE at the end of the project. As a requirement, the Interconnection Customer must provide the property for the attachment and right-of-way facilities that will be needed at the project initiation. It is also assumed that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and network upgrades, and that all 34.5 kV transmission system outages can be scheduled when needed.

Secondary Point of Interconnection

The Interconnection Customer has chosen a second point of interconnection (POI #2). POI #2 is a tap of the New Lisbon – Upton section of the New Lisbon – Upton – Whitings (K11) 34.5 kV line. From this point Jersey Central will construct a 1.5 mile radial line tap, over built on an upgraded distribution pole line just south of the Z2-102 Project site. From this dead end pole, Jersey Central will construct a one span radial line extension of about 200 feet to a switch pole structure to be constructed, owned, operated and maintained by the Interconnection Customer. The Interconnection Customer will be responsible for the attachment from this point to the Z2-102 Project substation. Jersey Central will own, operate and maintain the radial attachment line up to the point of interconnection. The Interconnection Customer will own, operate and maintain the extension from the point of interconnection to its substation.

System Protection Analysis

For POI #2, the fault current values on the New Lisbon - Upton – Whitings (K11) 34.5 kV line, 400 feet from New Lisbon substation are listed below.

	Three Phase	Line-Ground
X/R Ratio	2.91	4.12
Fault Current (Amps)	4310	2215

Interconnection Customer Requirements

In addition to the FE facilities, the Interconnection Customer will also be responsible for meeting all criteria as specified in the applicable sections of the FE “Requirements for Transmission Connected Facilities” document. Since Z2-102 Project will be connected to the 34.5 kV network, the Interconnection Customer will also be responsible for compliance with the FirstEnergy “Technical Requirements for the Interconnection of Parallel-Operated Generation to the FirstEnergy Distribution System”. This includes but is not limited to the following:

1. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
2. The purchase and installation of the standard voice grade (analog) telephone line and associated conduit between the telephone company source and the meter socket or enclosure.
3. A compliance with the FE and PJM generator power factor and voltage control requirements. Note that the Z2-102 Project will need to absorb reactive power at the point of interconnection to minimize the voltage change should the units rapidly reduce their output or trip off line.
4. The execution of a back-up service agreement to serve the customer load supplied from the Z2-102 Project 34.5 kV substation when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the station load.
5. Any complaints from other customers (e.g. flicker complaints) will have to be corrected by the Interconnection Customer. Correction may include changing operation, reducing generation, disconnecting the generators from the Jersey Central system, or other measures.
6. The purchase and installation of SCADA equipment to provide information in a compatible format to the FE Transmission System Control Center. The RTU, the communications channel and all related equipment will be furnished and maintained by the Interconnection Customer. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.
7. The following status, control and metering points will be required:
 - a. Interconnection breaker position status and trip control.
 - b. Generator real and reactive power output measured at the high-side of the generator step-up transformer.
 - c. Generator voltage at the point of interconnection.
8. An installation of two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.
9. A compliance with the inverter standard UL1741 and IEEE 1547, “Standard for Interconnecting Distributed resources with Electrical Power Systems”, in addition to the power quality standards defined by ReliabilityFirst and PJM.
10. A provision of the necessary generator protection, synchronization controls, and fault detection to initiate a trip to protect the Z2-102 Project equipment from faults on the Jersey Central System.
11. The Interconnection Customer will not excavate, construct facilities or locate solar panels under the existing FE transmission facilities or on FE right-of-ways without the express permission of FE.

12. A compliance with the PJM Manuals and Operating instructions to have a plant operator on call 24/7 to respond within a minute to reduce the output of the Z2-102 Generation Project when network constraints occur.
13. The installation of intertie relays at the point of interconnection that either trip the breaker at the point of interconnection or the individual generators beyond the point of interconnection. The function of the intertie relays must include over/under voltage and over/under frequency protection. Note that these intertie relays are in addition to and must be separate from the two relays that provide independent high speed zone of protection to sense and clear faults. They include the installation of an SEL-351-7 (Version 7) relay or its equivalent for power elements, a potential transformer or CCVT's on the high side of the transformer, and current transformers on the high side of the transformer.

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

Note that an assumption of this study is that the Z2-102 Generation Project generation will automatically be disconnected whenever the local area network is islanded. If this assumption is not correct, an anti-islanding, direct transfer trip scheme will need to be implemented for such situations at the Interconnection Customer's cost.

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.

FirstEnergy Requirements

The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

<http://www.firstenergycorp.com/feconnect>

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

Network Impacts

Option 1

The Queue Project Z2-102 was studied as a 13.0 MW (Capacity 4.9 MW) injection as a tap of the New Lisbon – Ft Dix 34.5 kV line in the JCPL area. Project Z2-102 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project Z2-102 was studied with a commercial probability of 53%. A Summer 2018 case was used for this analysis.

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.

Short Circuit

(Summary of impacted circuit breakers)

None.

Potential Congestion due to Local Energy Deliverability

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.

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)

None.

Option 2

The Queue Project Z2-102 was studied as a 13.0 MW (Capacity 4.9 MW) injection as a tap of the New Lisbon – Upton 34.5 kV line in the JCPL area. Project Z2-102 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project Z2-102 was studied with a commercial probability of 53%. A Summer 2018 case was used for this analysis.

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.

Short Circuit

(Summary of impacted circuit breakers)

None.

Potential Congestion due to Local Energy Deliverability

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.

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)

None.

Attachment 1. Project Location

Attachment 2. Single Line Diagram