Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position X1-082

Hazen Switch Point-Warren 34kV

January 2012

Preface

The intent of the 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 will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The Interconnection Customer 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

Oxford Solar 2, LLC, the Interconnection Customer (IC), has proposed a solar generating facility located along Quarry Road in Oxford, New Jersey. The installed facilities will have a total capability of 12.0 MW with 4.56 MW of this output being recognized by PJM as capacity. This means that the remaining 7.44 MW will be curtailable should a system reliability constraint occur. The proposed in-service date for this project is December 31, 2012. **This study does not imply a FirstEnergy commitment to this in-service date.**

Attachment facilities and local upgrades (if required) along with terms and conditions to interconnect X1-082 will be specified in a separate two party Interconnection Agreement (IA) between FirstEnergy and the Interconnection Customer as this project is considered FERC non-jurisdictional per the PJM Open Access Transmission Tariff (OATT). From the transmission system perspective, no network impacts were identified as detailed below.

Point of Interconnection

X1-082 will interconnect with the Jersey Central Power & Light system at the 34.5kV line C705 between the Pequest and Washington substations.

FirstEnergy Analysis

As defined by the Interconnection Customer and shown on Attachment 2, the X1-082 Project will be located about 2.3 miles east of the 34.5 kV Hazen Switch Point. Attachment 3 shows a conceptual one-line diagram of the Direct Connection facilities that will be required for the X1-082 Project. As indicated, it will be studied as a 12 MW injection into the Jersey Central 34.5 kV system at pole NJ38-9WHC705 of the Oxford Quarry tap (C705-4) section of the Pequest – Washington (C705) 34.5 kV line. Both line and radial disconnect switches will be needed at the point of attachment 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 easements, and rights-of-way that may be required for constructing all of the tap facilities and the facilities on its side of the point of interconnection including the attachment line that extends from the connection point. A summary of the FE facilities required for the X1-082 Project Direct Connection and their cost estimate is shown on Attachment 4.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed X1-082 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 X1-082 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.

The results of the FE analysis show that there are no network upgrades required for the deliverability of the X1-082 Project generation to the Jersey Central transmission system. There also are no reinforcements defined for previous projects for which this project will have an impact. However, the X1-082 Project will be one of four proposed generators to the Pequest – Washington (C705) 34.5 kV line to date.

As shown on Attachment 5, the FE study results show that with all four generation projects at their full Energy output the C705 and the Pohatcong - Washington (Q719) 34.5 kV lines will have contingency overloads for both peak and light load conditions. The worst overload occurs under light load for loss of Morris Park - Captive Plastics (W23) 34.5 kV line section, which results in the Pequest – Hazen Switch Point section of the C705 line exceeding its emergency rating of 46 MVA by 49.7%.

Note that because solar generation projects have a 38% capacity credit, no reinforcements are required for violations caused by Energy output. The optional mitigation that can be implemented by the Interconnection Customer to alleviate this congestion is to rebuild and reconductor the limiting C705 and Q719 34.5 kV lines and also replace substation conductors, components, and switches. If the Interconnection Customer wishes to pursue this option, further studies will be required to determine the full scope of the work.

In addition, voltage criteria violations such as high voltage under light load conditions and high and low voltages caused by swings in MW output of the attached generation may be

constraining. A conclusion of this analysis is therefore that the curtailment of the X1-082 Project output can be expected at times to maintain the Jersey Central system reliability within the NERC, Regional and FE operations and planning standards.

Note that a further conclusion of this study is that it will be mandatory for the X1-082 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 the X1-082 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.

Short Circuit and Dynamics Analysis

In accordance with the RTEP process, a short circuit analysis will not be conducted by PJM since the X1-082 Project connection is to the 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 X1-082 Project. Therefore no circuit breaker reinforcements will be required.

System Protection Analysis

An analysis was conducted to assess the impact of the X1-082 Project on the system protection requirements in the area. The results of this review have identified the following:

Under the assumption that the X1-082 project will not supply fault current to the JCP&L system, there will be no protection upgrades needed for the C705 line. The solar project will be required to have two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

Fault currents at the tap point are listed below.

	THREE-PHASE	SINGLE-LINE
X/R	4.1769	4.1594
Fault Current (Amps)	6771.6	3722.8

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.

[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

For the 12 MW load, it is not recommended to add fusing on the tap due to the low magnitude of maximum fault current available by the system.

A cost estimate of the FE system protection facilities required for the X1-082 is included on Attachment 4.

Metering

The FirstEnergy Revenue Metering Requirements may be found in the FirstEnergy Requirements for Transmission Connected Facilities document located at the following links:

www.firstenergycorp.com/feconnect
www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Compliance Issues

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

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

This includes the provision of a reactive power capability sufficient to maintain a composite power delivery for the facility at the interconnection point at a power factor between .95 leading (absorbing 3.94 MVAR) and .95 lagging (producing 3.94 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 X1-082 Project substation at the Interconnection Customer's cost.

The Interconnection Customer will also be responsible for following the requirements of the "FirstEnergy Wholesale Generation Interconnection (WGI) Manual" and the "FE Approved Vendors and Contractors" documents which are also located at the above link.

In addition, 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 X1-082 Project for the conditions studied. Therefore the conclusion is that the X1-082 Project will not be responsible for any transmission or distribution reinforcements to provide the requested service.

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 the X1-082 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. This includes 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 of 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.

2. A compliance with the FE and PJM generator power factor and voltage control requirements. Note that the X1-082 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. The execution of a back-up service agreement to serve the customer load supplied from the Interconnection Customer 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.

4. 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.

5. 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. 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.

6. 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.

7. An installation of two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

8. 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 Reliability*First* and PJM.

9. A provision of the necessary generator protection, synchronization controls, and fault detection to initiate a trip to protect the X1-082 Project equipment from faults on the Jersey Central System.

10. 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 X1-082 Project when network constraints occur.

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. 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.

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 X1-082 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.

Network Impacts

The Queue Project #X1-082 was studied as a 12.0MW (Capacity 4.6MW) injection into the Furnace Brook Tap – Warren C 34.5 kV line in the JCPL area. Project #X1-082 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. 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, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

None.

Short Circuit

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

Not required

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

None.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

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)

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

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.

Summary

The connection of the X1-082 Project to the FE transmission system will require no network upgrades. Therefore the Interconnection Customer will only have a cost responsibility for the Direct Connection of the X1-082 Project to the Jersey Central transmission system. As shown on Attachment 4, the estimated cost of these facilities is $328,000. This cost includes a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge of $80,300. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129.

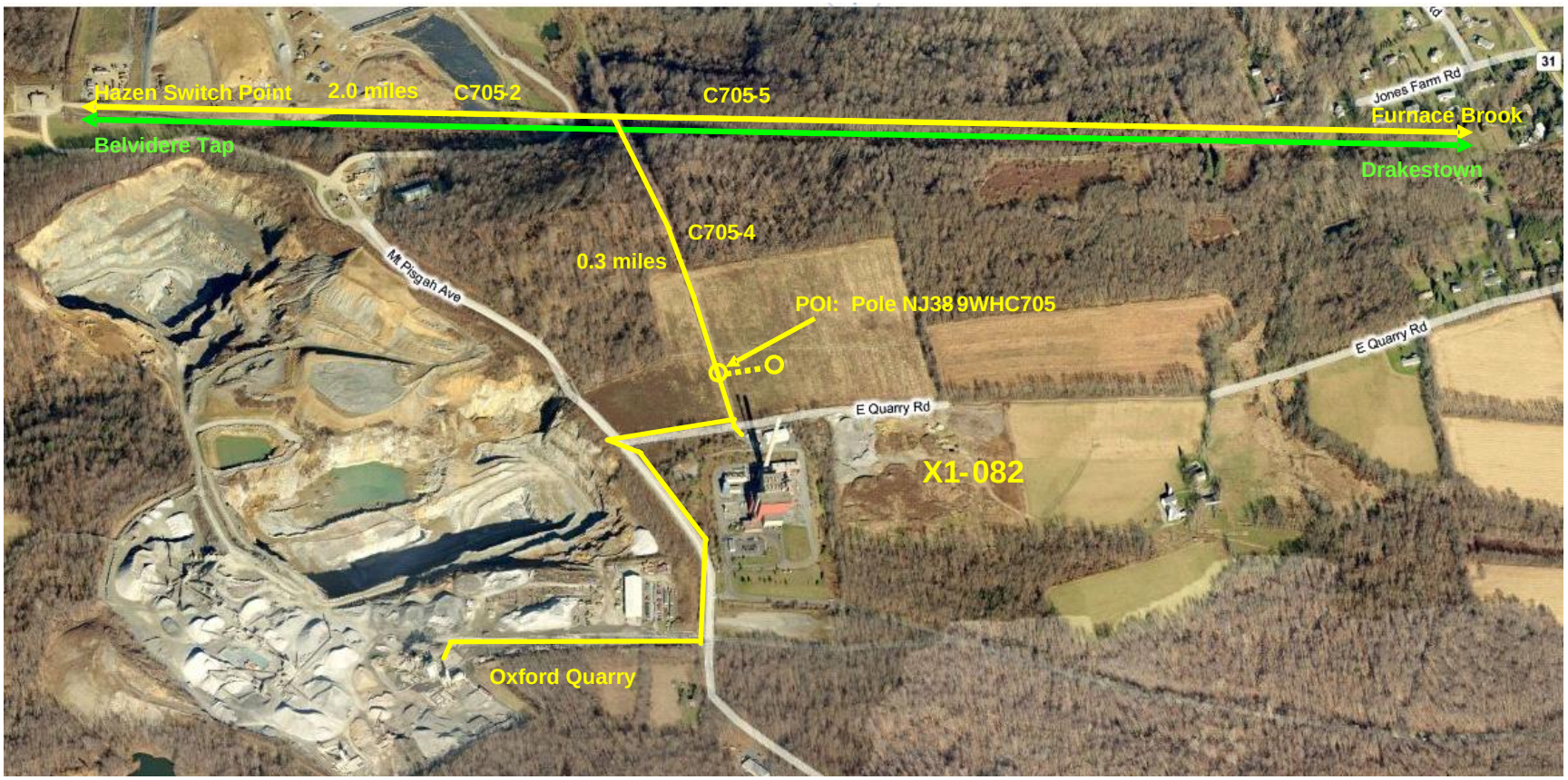
Based on the extent of the FE Direct Connection and system upgrades required to support this project, it is estimated that it will take one (1) year from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the X1-082 Project. Full payment of the estimated cost of the project 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. It further assumes that the Interconnection Customer will provide the property for the attachment 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 Facilities 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

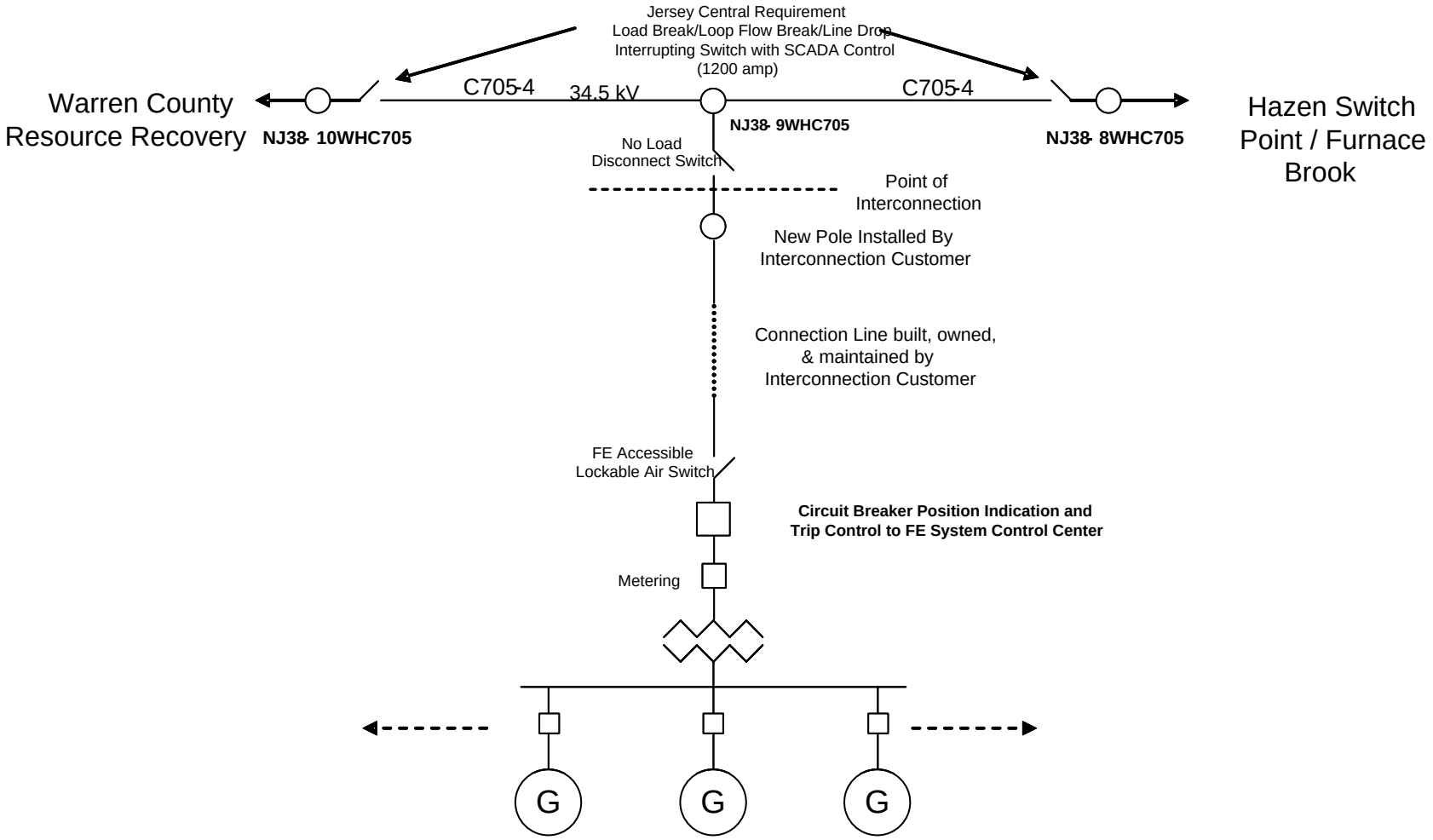
Site View

Attachment 2
Aerial View



Attachment 3

Single Line Diagram



12 MW Total Solar Photo Voltaic Generation

Attachment 4
Estimated Costs

Item	Connection Facilities
1	Construct approximately 300 feet of new overhead 34.5kV line from a point near pole NJ38-9WHC705 on the C705-4 34.5kV line (Pequest – Washington).
2	Construct a new tap pole, switch on the tap, (single blade disconnects included in estimate), install Motor Operated/SCADA controlled load break switches on pole NJ38-8WHC705 & pole NJ38-10WHC705, necessary guying, etc. and a span of wire to a customer owned pole beyond the switch pole.
3	Install metering to be mounted in the customer owned substation - Estimate at $23,000
4	Miscellaneous Protection, Fuses, Metering, RTU, SCADA
5	Preliminary review of environmental maps does not show need for environmental permitting at the preliminary service point indicated on applicant's submitted sketch. However, if permitting is needed, an additional $50,000 will be added to estimate.
	Direct Connection Costs: $ 247,700 **Taxes (if Applicable): $ 80,300** **Total: $ 328,000**

Attachment 5

Solar Generation Project Analysis – Full Energy Output

2013 Peak Load Conditions

Outage description	Overloaded Element	ID	MVA Rating		% of Rating	
			Normal	LTE	Normal	LTE
Morris Park - Captive Plastics (W23) 34.5 kV	Pequest - Hazen Switch Point	C705	39	46		114.5
Kittatinny - Pohatcong (L2012) 230 kV & Pohatcong Bank 1	Cooke Color - Newburg tap	Q719	44	52		102.7

2013 Light Load Conditions

Outage description	Overloaded Element	ID	MVA Rating		% of Rating	
			Normal	LTE	Normal	LTE
Morris Park - Captive Plastics (W23) 34.5 kV	Pequest - Hazen Switch Point	C705	39	46		149.7
Morris Park - Captive Plastics (W23) 34.5 kV	Cooke Color - Newburg tap	Q719	44	52		102.8