Generation Interconnection System Impact Study Report

for

PJM Generation Interconnection Request Queue Position Z2-077

"Worcester North 25 kV"

March 2015

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

Community Energy Renewables, LLC, the Interconnection Customer (IC), has proposed a 6.0 MWE (3.99 MWC; 6.0 MW MFO) solar powered generating facility to be located in Whaleyville, Maryland. PJM studied Z2-077 as a 6.0 MW injection into the Delmarva Power and Light (DPL) system at the Worcester 25 kV substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2018. The planned in-service date, as stated in the Attachment N, is May 1, 2016.

Point of Interconnection

The Interconnection Customer requested a 25 kV level interconnection for the Z2-077 project. As a result, the Z2-077 project will interconnect with the Delmarva Power and Light Company distribution system at a tap of the existing 25 kV feeder MD2224 emanating from the 69/25 kV T2 transformer at the Worcester Substation (see Attachment 1).

Direct Connection Requirements

Criteria Limits for Distributed Energy Resource (DER) Connections to the ACE, DPL and Pepco Distribution Systems (less than 69kV)

1. Single Phase Limit

Any DER with a capacity that exceeds 100kW shall be a balanced 3 phase system.

2. Voltage Limits

DER's are permitted to cause a voltage fluctuation of up to 2% at the Point of Interconnection, ½ the band width of any voltage regulator at its terminals, and ½ the net dead band of a switched capacitor bank at its connection point. When a DER is at maximum output, it shall not raise the feeder voltage above the ANSI C84.1 or state limit, whichever is more conservative.

3. Existing Distribution Circuit Capacity Limits
The aggregate limit of large (250 kW and over) generators running in parallel with a single, existing distribution circuit is 0.5 MWs on the 4kV, 3MWs on the 12 kV, 6 MWs on the 25 kV, and 10 MWs on the 34 kV.

4. Express Circuit Capacity Limits
Distributed generation installations which exceed the limit for an existing circuit require an express circuit.

The maximum generator size for express circuits shall be:

- 4 kV 0.5 MW
- 12 – 13.8 kV 10 MWs
- 23 – 25 kV 10 MWs
- 33.26 – 34.5 kV 15 MWs

5. Distribution Power Transformer Limit
The aggregate limit of large (250 kW and over) generator injection to a single distribution transformer of 22.5 MVA nameplate or larger is 10 MWs. Transformers with nameplate ratings lower than 22.5 MVA will be given lower ratings on an individual basis. If the transformer rating is significantly greater than 40 MVA it may be possible to consider a greater generation capacity.

Adding a new transformer will be considered if there is no availability on any of the existing transformers and space is available in an existing substation. Any proposed transformers would be PHI's standard distribution transformer.

6. Express Circuit Length Limit
If there is no space for an additional transformer at the closest substation, the next closest substation will be considered. The length of an express circuit is limited to 5 miles, or for the sake of the feasibility study, 3.8 straight line miles to the substation. This simplification is used because the feasibility study phase does not allow for the time and resources to examine routes in detail (including existing pole lines, easements, ROW, and environmental issues etc.)

7. When a New Substation is Required
If a distribution express circuit can't be built from an existing substation for a project, it will be necessary to construct a new distribution substation with a standard ring bus design. It will be supplied by extending existing transmission lines. It is the developer's responsibility to verify eligibility of this configuration for solar renewable energy certificates.

All limits, given above in MWs, are subject to more detailed study to ensure feasibility.

Transmission Owner Scope of Direct Connection Work

TO scope of work required to accommodate 6 MW of generation on existing feeder MD2224 from Worcester Substation T2:

1. A utility operated recloser equipped with the proper relaying and communications will be installed.
2. Utility grade primary metering will be installed.
3. The voltage regulators in the substation are not properly equipped to handle the reverse power flow that the generator will cause and will require adjustments to their controllers. If regulator cannot operate with controller, entire regulator will be upgraded.
4. Generation telemetry and remote trip capability will be provided to PHI's Energy Management System with future capability to adjust output and power factor if needed.
5. Protection, Planning, and other engineering departments will perform studies, design work, and prepare engineering estimates.
6. A distribution regulator upgrade will be required to accommodate reverse power flow.
7. Transfer trip will be required. The cost included below is to install 48SM ADSS fiber optic cable in conduit from Worcester substation down Old Ocean City Road to the POI, a total distance of about 5 miles. 69 kV potential transformers will need to be installed.

Estimated Costs			
Worcester Substation T2 MD2224			
Fiber Installation	5	Miles	$250,000
Distribution Regulator Upgrade			$120,000
Substation Relaying & 69 kV PTs			$200,000
Substation Regulator & Controller			$100,000
Recloser & Metering			$80,000
SCADA Integration into EMS			$10,000
Various Department Work			$10,000
Subtotal Cost			$770,000
Subtotal Cost with 18% Overheads			$908,600

The estimated time to complete this work is **12-18 months** after receipt of a fully executed interconnection agreement.

High Voltage Warning

Voltage received at the meter from the utility can be 104% or 105% of nominal. Normal operating procedures dictate that voltage at the substation be raised to the higher end of an acceptable bandwidth in order to provide adequate supply to distant customers. Transformers with no load taps should be used to reduce the voltage by 2.5% to avoid the possibility of inverter trips. Failure to account for this may result in lost energy production.

Interconnection Customer Scope of Direct Connection Work

The Interconnection Customer (IC) is responsible for all design and construction related to activities on their side of the Point of Interconnection (POI). Site preparation, including grading and an access road, as necessary, is assumed to be by the IC. Route selection, line design, and right-of-way

acquisition of the direct connect facilities is not included in this report, and is the responsibility of the IC.

Protective relaying and metering design and installation must comply with DPL's applicable standards. The IC is also required to provide revenue metering and real-time telemetering data to PJM in conformance with the requirements contained in PJM Manuals M-01 and M-14 and the PJM Tariff.

The Interconnection Customer will purchase and install all metering instrument transformers as well as construct a metering structure per DPL's specifications. The secondary wiring connections at the instrument transformers will be completed by the interconnection customer's contractors and inspected by DPL, while the secondary wiring work at the metering enclosure will be completed by DPL's meter technicians. The metering control cable and meter cabinets will be supplied by DPL and installed by the interconnection customer's contractors. DPL's meter technicians will program and install two solid state multi-function meters (Primary & Backup) for the new metering position. Each meter will be equipped with load profile, telemetry, and DNP output. The ownership of metering equipment purchased or installed by the IC shall be transferred to DPL at time of commercial operation, unless the IC asserts its right to install, own, and operate the metering system.

Special Operating Requirements

1. The Company (ACE, DPL, Pepco) will require the capability to remotely disconnect the generator from the grid by communication from its System Operations facility. This will be accomplished with a line recloser.

2. It is the Interconnection Customer's responsibility to send the data that PJM and the Company require directly to PJM. The Interconnection Customer will grant permission for PJM to send to the Company the following telemetry that the Interconnection Customer sends to PJM: real time MW, MVAR, volts, amperes, generator/status, and interval MWH and MVARH.

3. The Interconnection Customer will be required to make provisions for a voice quality phone line within approximately 3 feet of each Company metering position to facilitate remote interrogation and data collection.

4. A mutually acceptable means of interrupting and disconnecting the generator with a visible break, able to be tagged and locked out, shall be worked out with the Company's Distribution Engineering.

5. The Company reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering and telecommunications facilities, owned by the Company.

Inverter Requirements and Capabilities

The inverter at the customer facility shall have the following capabilities:

- Voltage flicker reduction through dynamic VAR or fixed PF response
- Ramp rate control
- SCADA communications
- Curtailment or other mitigation ability if high voltage were to occur
- Low voltage and system disturbance ride through
- Ability to receive and respond to a transfer trip signal
- Ability to adjust PF or VARs based on utility signal
- Ability to Adjust Real Power Output based on utility signal

The inverter shall operate in accordance with the IEEE 1547 series of standards that have been approved. While inverters should be capable of voltage stabilization thru dynamic VAR response and capable of low voltage and system disturbance ride through, neither of these capabilities shall be implemented until such time that the IEEE 1547 series of standards are revised and approved to include standards for these capabilities. At such time as these revised standards become available, the PV owner/operator shall cooperate with the Company (the 'Company' referring to ACE, DPL, or PEPCO) to implement these capabilities with settings acceptable to the Company. Until such time, the following must be implemented:

1. *Operate inverters at a leading power factor ("PF") of (**0.96**), absorbing Volt-amps-reactive ("VARs").*

It is the responsibility of the owner to secure the inverter from any unauthorized access (including physical and remote access) which could alter settings or adversely affect the inverter's ability to operate as required. Security measures should include utilizing secure password settings and/or physical locks on cabinet doors.

Network Impacts

Potential network impacts were as follows:

Generator Deliverability

*(Single or N-1 contingencies for the **Capacity** portion 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

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.) Studied at ***Full*** *energy output.*

None

Light Load Analysis

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

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

New System Reinforcements

(Upgrades ***required*** *to mitigate reliability criteria violations, i.e. "Network Impacts,"* ***initially*** *caused by the addition of this project's generation)*

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project.)

None

Short Circuit

No issues identified.

Stability and Low Voltage Ride Through Analysis

Not required.

Time Based Studies

Results of a time based study will be reviewed and the proposed project will be evaluated for protection and coordination issues. Other required upgrades may be identified at that time.

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 Interconnection Customer 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.

These are not required reliability upgrades.

None

Attachment 1

Z2-077

Worcester 69/25 kV Sub
6 MW PV Solar Generator