Generation Interconnection
Feasibility Study Report
Queue Position Z2-097

The Interconnection Customer (IC) has proposed a 10 MWE (7.1 MWC; 10 MW MFO) solar powered generating facility to be located in Galena, Maryland. PJM studied Z2-097 as a 10 MW injection into the Delmarva Power and Light (DPL) system at the Church 25 kV substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2018.

Point of Interconnection

The Interconnection Customer requested a 25 kV distribution level interconnection. As a result, Z2-097 will interconnect with the Delmarva Power and Light system as follows:

> The first 5 MWs will connect to the existing MD2232 25 kV feeder from the Church Substation T3 transformer; the next 4 MWs will connect to the existing T3 transformer at the Church Substation via a new 25 kV express feeder; the last 1 MW will connect a new T5 transformer at the Church Substation via a new 25 kV express feeder.

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 Work

Transmission Owner work required to accommodate 5 MW of generation on MD2232 from Church Substation T3 transformer includes:

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. The regulators will require adjustments to their controllers.
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. Transfer trip, or appropriate tripping scheme, will be required. The cost included below is to install 48SM ADSS fiber optic cable in conduit from Church substation to the POI, a total distance of about 4 miles.

The estimated cost to perform this work is as follows:

Estimated Costs			
Church Substation T3 Existing Feeder			
Fiber Installation	4	Miles	$200,000
Substation Relaying			$30,000
Recloser at site w/ Relaying and Communications			$50,000
Utility Grade Metering			$20,000
Replace Regulator Controller			$100,000
SCADA Integration into EMS			$10,000
Subtotal Cost			$410,000
Approximate Cost with 18% Overheads			$483,800

Transmission Owner work required to accommodate the next 4 MWs connecting to the existing T3 transformer at the Church Substation via a new 25 kV express feeder includes:

1. Design and construct one new 25 kV feeder with 477 aluminum conductor from Church Substation to the generation site – approximately 3.5 miles
2. One new 25 kV feeder terminal position will be constructed.
3. A utility operated recloser equipped with the proper relaying and communications will be required for each feeder serving the generator.
4. Utility grade primary metering will be required for each feeder.
5. Generation telemetry and remote trip capability will be provided to the control center.
6. A detailed, time-based study may be performed during later study phases.
7. Protection, Planning, and other engineering departments will perform studies, design work, and prepare engineering estimates.
8. Approximately 4 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Church Sub to the PV site.

The estimated cost to perform this work is as follows:

Ball Park Costs			
Church Substation T3 New Feeder			
477 AAC Express Feeder	4	Miles	$1,600,000
Fiber Installation			$200,000
Substation Communication Equipment			$60,000
Recloser w/ Relaying and Communications			$100,000
Utility Grade Metering			$20,000
SCADA Work			$10,000
Time Series Study			$30,000
Various Departments Work			$15,000
Subtotal Cost			$2,035,000
Approximate Cost with 18% Overheads			$2,401,300

Transmission Owner work required to accommodate the last 1 MW connecting to a new T5 transformer at the Church Substation via a new 25 kV express feeder includes:

1. Design and construct one new 25 kV feeder with 477 aluminum conductor from Church Substation to the generation site – approximately 3.5 miles
2. One new 40 MVA 69/25kV transformer will be constructed
3. One new 25 kV feeder terminal position will be constructed.
4. A utility operated recloser equipped with the proper relaying and communications will be required for each feeder serving the generator.
5. Utility grade primary metering will be required for each feeder.
6. Generation telemetry and remote trip capability will be provided to the control center.
7. A detailed, time-based study may be performed during later study phases.
8. Protection, Planning, and other engineering departments will perform studies, design work, and prepare engineering estimates.
9. Approximately 4 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Church Sub to the PV site.

The estimated cost to perform this work is as follows:

Estimated Costs			
Church Substation New T5 Transformer			
477 AAC Express Feeder	4	Miles	$1,600,000
Fiber Installation			$200,000
New Transformer and Feeder Terminal			$3,300,000
Substation Communication Equipment			$60,000
Recloser w/ Relaying and Communications			$100,000
Utility Grade Metering			$20,000
SCADA Work			$10,000
Time Series Study			$30,000
Various Departments Work			$15,000
Subtotal Cost			$5,335,000
Approximate Cost with 18% Overheads			$6,295,300

The estimated time to complete the above work is **24-36 months** after receipt of a fully executed interconnection agreement.

Note: the above cost does not include the Contribution in Aid of Construction (CIAC) tax.

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.

Additional Operating Requirements

1. DPL 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 DPL requires directly to PJM. The Interconnection Customer will grant permission for PJM to send to DPL 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 DPL 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 DPL Distribution Engineering.

5. DPL 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 DPL.

Interconnection Customer Scope of Work

The Interconnection Customer (IC) is responsible for all design and construction related to activities on their side of the Point of Interconnection. 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.

The IC will be required to install metering and telemetry equipment to provide revenue metering and real-time telemetry data to PJM. The requirements for this equipment are listed in Appendix 2, Section 8 of Attachment O to the PJM Tariff, as well as PJM Manuals 01 and 14D. Protective relaying and metering design and installation must comply with PHI's Applicable Standards.

The Interconnection Customer will purchase and install all metering instrument transformers as well as construct a metering structure per PHI's specifications. The secondary wiring connections at the instrument transformers will be completed by the Interconnection Customer's contractors and inspected by PHI, while the secondary wiring work at the metering enclosure will be completed by PHI's meter technicians. The metering control cable and meter cabinets will be supplied by PHI and installed by the Interconnection Customer's contractors. PHI's meter technicians will program and install two solid state multi function meters (Primary & Backup) for the new metering position.

Inverter Requirements and Capabilities

The inverter at the DG location 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 inverters shall operate with a fixed power factor schedule as supplied by the Company.

Transmission Network Impacts

Potential transmission network impacts are 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

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

No issues identified.

Stability Analysis

Not required due to project size.

Light Load Analysis

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

Not Required.

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

Potential Congestion due to Local Energy Deliverability

(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection Request. Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full deliverability for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:

These are ***not*** required reliability upgrades.

None