

Generation Interconnection Feasibility Study Report Queue Position AB2-122

The Interconnection Customer (IC) has proposed a 6.2 MW MFO (2.6 MWC) solar generating facility to be located in Egg Harbor, New Jersey. PJM studied AB2-122 as a 6.2 MW injection into the Atlantic City Electric Company's (ACE) system at the Cardiff 3 12 kV Substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2020. The planned in-service date, as stated during the project kick-off call, is December 1, 2017.

Point of Interconnection

The Interconnection Customer requested a distribution level interconnection. As a result, AB2-122 will interconnect with the Atlantic City Electric system as follows:

The first 2.5 MWs of generation will connect to the 12 kV T3 transformer at the Cardiff Substation via a tap of the existing feeder NJ1984; the next 2.0 MWs of generation will connect to the 12 kV T5 transformer at the Cardiff Substation via a tap of the existing feeder NJ1981; the last 1.7 MWs of generation will connect to the 12 kV T3 transformer at the Cardiff Substation via a dedicated 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 MW

- 23 – 25 kV 10 MW
- 33.26 – 34.5 kV 15 MW

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 MW. 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 scope of work required to accommodate 2.5 MWs of generation on feeder NJ1984 from Cardiff Substation T3:

1. Approximately 0.5 miles of single phase conductor must be expanded to three phase conductor.
2. A utility operated recloser equipped with the proper relaying and communications will be required.
3. Utility grade primary metering will be required.
4. Generation telemetry and remote trip capability will be provided to the control center.
5. A detailed, time-based study may be performed during later study phases.
6. Protection, Planning, and other engineering departments will perform studies, design work, and prepare engineering estimates.
7. Direct transfer trip will be required. Approximately 2.25 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Cardiff Substation to the PV site. 69 kV potential transformers will need to be installed if none already in-service.

The estimated cost to perform this work is:

Estimated Costs			
Cardiff Substation T3 NJ1984			
Fiber Installation	2.25	Miles	\$33,750
Substation Regulator & Controller			\$100,000
Three Phase Reconductoring	0.5	Miles	\$200,000
Recloser & Metering			\$80,000
SCADA Integration into EMS			\$10,000
Dynamic Study			\$30,000
Various Departments Work			\$60,000
Subtotal Cost			\$513,750
Approximate Total Cost with 15% Contingency			\$590,813

The estimated time to complete this work is **18-24 months** after receipt of a fully executed interconnection agreement.

Transmission Owner scope of work required to accommodate 2.0 MWs of generation on feeder NJ1981 from Cardiff Substation T5:

1. Approximately 0.25 miles of single phase conductor must be expanded to three phase conductor.
2. Approximately 0.75 miles of three phase conductor must be extended to the site
3. A utility operated recloser equipped with the proper relaying and communications will be required.
4. Utility grade primary metering will be required.
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. Direct transfer trip will be required. Approximately 2.75 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Cardiff Substation to the PV site. 69 kV potential transformers will need to be installed if none already in-service.

The estimated cost to perform this work is:

Estimated Costs			
Cardiff Substation T5 NJ1981			
Fiber Installation	2.75	Miles	\$41,250
Substation Regulator & Controller			\$100,000
Three Phase Reconductoring	0.25	Miles	\$100,000
Extension of Service	0.75	Miles	\$300,000
Recloser & Metering			\$80,000
SCADA Integration into EMS			\$10,000
Dynamic Study			\$30,000
Various Departments Work			\$60,000
Subtotal Cost			\$721,250
Approximate Total Cost with 15% Contingency			\$829,438

The estimated time to complete this work is **18-24 months** after receipt of a fully executed interconnection agreement.

Transmission Owner scope of work required to accommodate 1.7 MWs of generation on an express feeder from Cardiff Substation T3:

1. Design and construct one new 12.47 kV feeder with 477 aluminum conductor from Cardiff Substation to the generation site – approximately 2.25 miles.
2. One new 12.47 kV feeder terminal position will be constructed.
3. A utility operated recloser equipped with the proper relaying and communications will be required.
4. Utility grade primary metering will be required.
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. Direct transfer trip will be required. Approximately 2.25 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Cardiff Substation to the PV site. 69 kV potential transformers will need to be installed if none already in-service.

The estimated cost to perform this work is:

Estimated Costs			
Cardiff Substation T3			
477 AAC Express Feeder	2.25	Miles	\$900,000
Fiber Installation			\$112,500
Feeder Terminal & Substation Work			\$750,000
Substation Relaying & 69 kV PTs			\$250,000
Recloser & Metering			\$80,000
SCADA Integration into EMS			\$10,000
Dynamic Study			\$30,000
Various Departments Work			\$60,000
Subtotal Cost			\$2,192,500
Approximate Total Cost with 15% Contingency			\$2,521,375

The estimated time to complete this work is **24 - 36 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.

Additional Operating Requirements

1. The Company (DPL, ACE, 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 requires directly to PJM. The Interconnection Customer will grant permission for PJM to send the Company the following telemetry that the Interconnection Customer sends to PJM: real time MW, MVAR, volts, amperes, generator breaker status or inverter 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 Company Distribution Engineering.

5. 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 Company.

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.

Protective relaying and metering design and installation must comply with PHI'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 IC 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. Each meter will be equipped with load profile, telemetry, and form-c pulse outputs. The ownership of metering equipment purchased or installed by the IC shall be transferred to the Transmission Owner at Commercial Operation, unless the IC asserts its right to install, own and operate the metering system.

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 PEPSCO) to implement these capabilities with settings acceptable to the Company. 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.

Power Factor Requirement

The inverters used for this project shall be capable of operating at a power factor(s) specified by the Company (0.95 lead to 0.95 lag). It is the responsibility of the developer/customer to obtain inverters that can operate with these requirements while also meeting all applicable requirements of IEEE and UL standards such as but not limited to IEEE 1547 and UL 1741:

Operate inverters at a leading power factor ("PF") of **(0.95)**, absorbing Volt-amperes-reactive ("VARs") continuously

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.

Summer Peak Analysis - 2020

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, 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

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

Steady-State Voltage Requirements

To be determined in later study phases.

Short Circuit

(Summary of impacted circuit breakers)

Not required.

Stability and Reactive Power Requirement

To be performed in later study phases if required.

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 - 2019

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

Facilities Study Estimate

The estimated time for PJM to issue a Facilities Study Report is 7 months. The deposit required project will be \$50,000.