



Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-121

CRAIN HIGHWAY 13 KV

8.4 MW Capacity / 20 MW Energy

January, 2020

1 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. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. 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 Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification and, where applicable, for compliance with low voltage ride through requirements. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment B of Manual 14G. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a \$10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 4.3 for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment B-1 of Manual 14G) in order to document the request for the study.

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.

2 General

The Interconnection Customer (IC) has proposed a solar powered generating facility to be located in Upper Marlboro, MD 20772, near the intersection of Croom Rd. and Molly Berry Rd. The installed facilities will have a total capability of 20 MW with 8.4 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is November 30, 2021. **This study does not imply a TO commitment to this in-service date.**

Queue Number	AF1-121
Project Name	CRAIN HIGHWAY 13 KV
State	Maryland
County	Prince George's
Transmission Owner	PEPCO
MFO	20
MWE	20
MWC	8.4
Fuel	Solar
Basecase Study Year	2023

2.1 Point of Interconnection

AF1-121 will interconnect with the PEPCO system via one of the following options:

Option 1: The IC requested a distribution level interconnection. As a result, the AF1-121 project will connect to the PEPCO distribution system at the Crain Highway 69/13 kV Substation via (2) Express Feeders to be named 14xxx and 14xxx-(2).

Option 2: The IC requested a transmission level interconnection. As a result, the AF1-121 project will connect to the PEPCO Transmission system via a tap of the Oak Grove – Chalk Point 230 kV line.

2.2 Cost Summary

The AF1-121 project will be responsible for the following costs for the physical interconnection:

Description	Total Cost
PEPCO work to Accommodate First 10 MW	\$ 4,607,434
PEPCO Work to Accommodate Additional 10 MW	\$ 2,843,434
Total Costs	\$ 7,450, 868

In addition, the AF1-121 project may be responsible for a contribution to the following costs for Network Upgrades to mitigate any overloads identified in this report:

Description	Total Cost
System Upgrades	\$ 0

Cost allocations for these upgrades will be provided in the System Impact Study Report.

3 Transmission Owner Scope of Work

3.1 Transmission Owner (TO) Scope of Direct Connection Work

TO work required to accommodate 10.0 MW of generation on new express feeder 14xxx from Crain Highway Substation:

1. A utility operated recloser equipped with the proper relaying and communications.
2. Utility grade primary metering.
3. A new feeder cubicle with breaker and relaying to accommodate new express feeder(s).
4. An express feeder with approximately 5 miles of 500kCM AL PAC conductor to Property Line/Point of Interconnection and supporting pole line equipment. See Note 1.
5. Direct Transfer Trip with approximately 5 miles of ADSS Fiber and Substation Protection and Relaying
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.

Description	Total Cost
3-Phase Express Feeder with Support Pole Equipment (5 Miles)	\$1,601,024
Recloser and Metering with Poles	\$ 60,000
Dual Stack Feeder breaker Cubicle	\$ 670,000
Direct Transfer Trip with Fiber (5 Miles)	\$ 590,000
SCADA Integration into EMS	\$ 10,000
Substation Protection Relaying	\$ 300, 000
Various Departments Work	\$ 60,000
Subtotal Cost	\$ 3,291,024
Approximate Total Cost with 40% Contingency	\$ 4,607,434

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

Additional TO work required to accommodate the remaining 10.0 MW of generation on new express feeder 14xxx-(2) from Crain Highway Substation:

1. A utility operated recloser equipped with the proper relaying and communications.
2. Utility grade primary metering.
3. An express feeder with approximately 5 miles of 500kCM AL PAC conductor to Property Line/Point of Interconnection and supporting pole line equipment. See Note 1.
4. Direct Transfer Trip with Substation Protection and Relaying
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.

Description	Total Cost
3-Phase Express Feeder with Support Pole Equipment (5 Miles)	\$ 1,601,024
Recloser and Metering with Poles	\$ 60,000
SCADA Integration into EMS	\$ 10,000
Substation Protection Relaying	\$ 300, 000
Various Departments Work	\$ 60,000
Subtotal Cost	\$ 2,031,024
Approximate Total Cost with 40% Contingency	\$ 2,843,434

Note 1: Due to limitations in resources for Feasibility Study, express feeder length was based on existing pole lines to substation. Further studies will determine route to best meet the design criteria. and impending costs.

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

3.2.1 Single Phase Limit

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

3.2.2 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.

3.2.3 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.

3.2.4 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

3.2.5 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.

3.2.6 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.)

3.2.7 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.

4 Interconnection Customer Requirements

4.1 Equipment Requirements

Any transformers on the customer's side must be Wye grounded on the utility side or alternatively 3 phase potential transformers and a relay capable of detecting over/under voltage shall be installed to detect an undesirable condition on the high side of the customer's transformer.

4.2 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. 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.

4.3 Additional Operating Requirements

1. The Company 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. Direct Transfer Trip (DTT) will also be required.
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 megawatts, megavars, phase voltages, phase currents, and generator breaker status.
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. The Interconnection Customer will be required to submit a final Relay Coordination Study for review and approval by Company System Protection.
5. 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.

6. 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.
7. Study was performed with the generator on the transformer that it will be served from during normal conditions. Customer will not be allowed to generate when the feeder is served by an alternate transformer.

4.4 High Voltage Warning

Voltage received at the meter from the utility can be 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.

5 Revenue Metering and SCADA Requirements

5.1 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 Section 8 of Attachment O.

5.2 PEPCO Requirements

Refer to section 4: Interconnection Customer Requirements.

6 OPTION 1: Network Impacts

The Queue Project AF1-121 was evaluated as a 20.0 MW (Capacity 8.4 MW) injection at the **Ritchie 69 kV** substation in the PEPCO area. Project AF1-121 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-121 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

Summer Peak Load Flow

7 Generation Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

8 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

9 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

10 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

Affected Systems

11 Affected Systems

11.1 LG&E

LG&E Impacts to be determined during later study phases (as applicable).

11.2 MISO

MISO Impacts to be determined during later study phases (as applicable).

11.3 TVA

TVA Impacts to be determined during later study phases (as applicable).

11.4 Duke Energy Progress

Duke Energy Progress Impacts to be determined during later study phases (as applicable).

11.5 NYISO

NYISO Impacts to be determined during later study phases (as applicable).

Short Circuit

12 Short Circuit

The following Breakers are over duty

None

13 OPTION 2: Network Impacts

The Queue Project AF1-121 was evaluated as a 20.0 MW (Capacity 8.4 MW) injection tapping the **Oak Grove to Chalk Point 230 kV line** in the PEPCO area. Project AF1-121 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-121 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

Summer Peak Load Flow

14 Generation Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

15 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

16 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

17 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

Affected Systems

18 Affected Systems

18.1 LG&E

LG&E Impacts to be determined during later study phases (as applicable).

18.2 MISO

MISO Impacts to be determined during later study phases (as applicable).

18.3 TVA

TVA Impacts to be determined during later study phases (as applicable).

18.4 Duke Energy Progress

Duke Energy Progress Impacts to be determined during later study phases (as applicable).

18.5 NYISO

NYISO Impacts to be determined during later study phases (as applicable).

Short Circuit

19 Short Circuit

The following Breakers are over duty

None