



Generation Interconnection

Feasibility Study Report

for

Queue Project AF2-174

TABERNACLE 12 KV

4.62 MW Capacity / 11 MW Energy

July 2020

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1 Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the Feasibility Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is AEC.

2 Preface

The intent of the Feasibility 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 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.

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.

3 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Burlington County, New Jersey. The installed facilities will have a total capability of 11 MW with 4.62 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is September 30, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AF2-174
Project Name	TABERNACLE 12 KV
State	New Jersey

Queue Number	AF2-174
County	Burlington
Transmission Owner	AEC
MFO	11
MWE	11
MWC	4.62
Fuel	Solar
Basecase Study Year	2023

Any new service customers who can feasibly be commercially operable prior to June 1st of the basecase study year are required to request interim deliverability analysis.

4 Point of Interconnection

AF2-174 will interconnect with the AEC on distribution system at the Tabernacle 12 kV substation.

5 Cost Summary

The AF2-174 project will be responsible for the following costs:

Description	Total Cost
Total Physical Interconnection Costs	\$7,416,689
Allocation towards System Network Upgrade Costs*	\$0
Total Costs	\$7,416,689

*As your project progresses through the study process and other projects modify their request or withdraw, then your cost allocation could change.

This cost excludes a Federal Income Tax Gross Up charges. This tax may or may not be charged based on whether this project meets the eligibility requirements of IRS Notice 88-129. If at a future date it is determined that the Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

Note 1: PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. The allocation of costs for a network upgrade will start with the first Queue project to cause the need for the upgrade. Later queue projects will receive cost allocation contingent on their contribution to the violation and are allocated to the queues that have not

closed less than 5 years following the execution of the first Interconnection Service Agreement which identifies the need for this upgrade.

Note 2: For customers with System Reinforcements listed: If your present cost allocation to a System Reinforcement indicates \$0, then please be aware that as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, the cost responsibilities can change and a cost allocation may be assigned to your project. In addition, although your present cost allocation to a System Reinforcement is presently \$0, your project may need this system reinforcement completed to be deliverable to the PJM system. If your project comes into service prior to completion of the system reinforcement, an interim deliverability study for your project will be required.

6 Transmission Owner Scope of Work

Direct Connection Requirements

Criteria Limits for Distributed Energy Resource (DER) Connections to the ACE Distribution System (less than 69 kV)

1. Single Phase Limit

The largest capacity single phase generator or DER (battery) operating in parallel with the grid is 100kW. Above that size, a balanced 3 phase system is required. If 3 phase is available, balanced 3 phase shall be used.

2. Voltage Limits

DERs are permitted to cause up to 3% (primary) or 5% (secondary) voltage fluctuation at the Point of Interconnection and ½ the band width of any voltage regulator or ½ the net dead band of a capacitor bank. DERs in maximum output, are permitted to raise feeder voltage to the ANSI or state limit whichever is more conservative. An absorbing PF may be required to mitigate voltage rise or fluctuation impact.

3. Existing Distribution Circuit Capacity Limits

The aggregate limit of “large” generators running in parallel with a single, existing distribution circuit is:

Circuit Voltage	Aggregate Limit	Large DER Size
4 kV	1 MW	250 kW
12 – 13.8 kV	3 MW	250 kW
23 – 25 kV	6 MW	500 kW
33.26 – 34.5 kV	10 MW	1 MW

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:

Circuit Voltage	DER Limit
4 kV	1 MW
12 – 13.8 kV	10 MW
23 – 25 kV	10 MW
33.26 – 34.5 kV	20 MW

Note: Maximum Demand Loss and Annual Energy Loss both must be less than 3% for the express feeder

5. Telemetry requirements

On radial circuits that have or can incorporate Distribution Automation, telemetry is required on all systems 250kW and greater.

6. Distribution Power Transformer Limit

The aggregate of “large” DER will be limited to 50% of the substation transformer normal rating. In the case of transformers paralleled on the low side, the limit is 50% of the sum of the transformer normal ratings. This usually ensures that the LTC does not operate excessively. Note that small systems (less than the large system size for the circuits’ voltage class), may continue to be interconnected when these distribution transformer limits are reached.

The absolute net reverse power limit is 40% of the transformer normal rating. This ensures that locations with transfer capability can operate safely where one transformer load automatically transfers to the remaining transformer upon outage of one transformer.

7. Express Circuit Length Limit

The maximum circuit length is limited to 5 miles for 12/13 kV, 7 miles for 25 kV, and 10 miles for 34 kV.

Note: For ACE and Pepco, no 34 kV Express Circuits will be built as that voltage level is being retired. 4 kV Express Circuits will not be built in any PHI jurisdiction.

If there is no more injection capacity or space for an additional transformer at the closest substation, the next closest substation will be considered.

8. 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. In NJ, it is the developer's responsibility to verify eligibility of this configuration for solar renewable energy certificates with New Jersey's Clean Energy Program if desired.

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

Transmission Owner (T.O.) Scope of Direct Connection Work

Transmission Owner scope of work required to accommodate 3 MW of generation via NJ1606 from Tabernacle Substation T1:

1. Reconductor approximately 1.1 miles of feeder NJ1606.
2. Install a utility operated recloser equipped with the proper relaying and communications.
3. Install utility grade primary metering.
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. Direct transfer trip will be required. Approximately 7.6 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Tabernacle Substation to the PV site at Pole H42910 (note: *this may require secondary zone tree trimming*). 12 kV potential transformers will need to be installed if none already in-service.

Tabernacle Substation T1			
Feeder Reconductoring	1.1	mi.	\$632,500
Fiber Installation	7.6	mi.	\$707,612
Substation Relaying & 69 kV PT's			\$230,000
Telecommunications Equipment			\$154,100
Recloser & Metering			\$92,000
SCADA Integration into EMS			\$11,500
Miscellaneous Engineering Costs			\$69,000
Approximate Total Cost			\$1,896,712

Transmission Owner scope of work required to accommodate 8 MW of generation via Express Feeder from Tabernacle Substation T2:

1. Design and construct one new 12 kV feeder with 477 AAC from Tabernacle Substation to the generation site at Pole H42910 – approximately 6.0 miles.
2. One new 12 kV feeder terminal position will be constructed.
3. Install a utility operated recloser equipped with the proper relaying and communications.
4. Install utility grade primary metering.
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. Direct transfer trip will be required. Approximately 7.6 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Tabernacle Substation to the PV site at Pole H42910 (note: *this may require secondary zone tree trimming*). 12 kV potential transformers will need to be installed if none already in-service.

Tabernacle Substation T2			
Transmission	3	Pole	\$82,800
477 AAC Express Feeder	6	mi.	\$3,450,000
Fiber Installation	7.6	mi.	\$707,612
Feeder Terminal			\$722,965
Substation Relaying & 69 kV PT's			\$230,000
Telecommunications Equipment			\$154,100
Recloser & Metering			\$92,000
SCADA Integration into EMS			\$11,500
Miscellaneous Engineering Costs			\$69,000
Approximate Total Cost			\$5,519,977

7 Schedule

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

8 Transmission Owner Analysis

None

9 Interconnection Customer Requirements

Additional Operating Requirements:

1. ACE 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 IC's responsibility to send the data that PJM and ACE requires directly to PJM (or in some cases to ACE directly). The IC will grant permission for PJM to send ACE the following telemetry that the IC sends to PJM: real time MW, MVAR, volts, amperes, generator/status, and interval MWH and MVARH.
3. The IC will be required to make provisions for a voice quality phone ("plain old telephone", or "POT") line within approximately 3 feet of each ACE 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 ACE Distribution Engineering.
5. ACE reserves the right to charge the IC operation and maintenance expenses to maintain the IC attachment facilities, including metering and telecommunications facilities, owned by ACE.

Interconnection Customer Scope of Work

The 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 ACE'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 ACE's specifications. The secondary wiring connections at the instrument transformers will be completed by the IC's contractors and inspected by ACE, while the secondary wiring work at the metering enclosure will be completed by ACE's Meter technicians. The metering control cable and meter cabinets will be supplied by ACE and installed by the IC's contractors. ACE'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.

Power Factor Requirement

The generators used for this project shall be capable of operating at a power factor (or schedule) specified by ACE in the range of 0.95 leading to 0.95 lagging. It is the responsibility of the developer/customer to obtain equipment 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.

For this project, operate inverters at a unity power factor of (**1.0**) not impacting volt-ampere reactive ("VAR") continuously.

Inverter Requirements (if applicable):

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
- Disturbance Ride through for both Voltage and Frequency
- 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
- Ability to operate on a Volt/VAR schedule
- Ability to maintain a voltage schedule

The inverter(s) shall operate in accordance with both the IEEE 1547 and UL 1741 series of standards that have been approved and use default settings except when specified otherwise by ACE. While inverters should be capable of voltage stabilization through dynamic VAR response and capable of low voltage and system disturbance ride through, neither of these capabilities will 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 generation owner/operator shall cooperate with ACE to implement these capabilities with settings acceptable to ACE. Until such time, the inverters shall operate with a fixed power factor value between 0.95 lead and 0.95 lag as specified by ACE.

Security Requirements

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

10 Revenue Metering and SCADA Requirements

10.1 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.

10.2 Meteorological Data Reporting Requirements

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

10.3 Interconnected Transmission Owner Requirements

The IC will be required to comply with all Interconnected Transmission Owner's revenue metering requirements for generation interconnection customers located at the following link:

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

11 Summer Peak Analysis

The Queue Project AF2-174 was evaluated as a 11.0 MW (Capacity 4.6 MW) injection at the Tabernacle 12 kV substation in the AEC area. Project AF2-174 was evaluated for compliance with applicable reliability planning

criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF2-174 was studied with a commercial probability of 100.0 %. Potential network impacts were as follows:

11.1 Generation Deliverability

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

None

11.2 Multiple Facility Contingency

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

None

11.3 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

11.4 Steady-State Voltage Requirements

To be determined

11.5 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

11.6 System Reinforcements

ID	Idx	Facility	Upgrade Description	Cost	Cost Allocated to AF2-174	Upgrade Number
			TOTAL COST	\$0		

Note : For customers with System Reinforcements listed: If your present cost allocation to a System Reinforcement indicates \$0, then please be aware that as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, the cost responsibilities can change and a cost allocation may be assigned to your project. In addition, although your present cost allocation to a System Reinforcement is presently \$0, your project may need this system reinforcement completed to be deliverable to the PJM system. If your project comes into service prior to completion of the system reinforcement, an interim deliverability study for your project will be required.

11.7 Flow Gate Details

The following indices contain additional information about each facility presented in the body of the report. For each index, a description of the flowgate and its contingency was included for convenience. The intent of the indices is to provide more details on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the indices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the indices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators. It should be noted the project/generator MW contributions presented in the body of the report are Full MW Impact contributions which are also noted in the indices column named "Full MW Impact", whereas the loading percentages reported in the body of the report, take into consideration the PJM Generator Deliverability Test rules such as commercial probability of each project as well as the ramping impact of "Adder" contributions. The MW Impact found and used in the analysis is shown in the indices column named "Gendeliv MW Impact".

11.8 Queue Dependencies

The Queue Projects below are listed in one or more indices for the overloads identified in your report. These projects contribute to the loading of the overloaded facilities identified in your report. The percent overload of a facility and cost allocation you may have towards a particular reinforcement could vary depending on the action of these earlier projects. The status of each project at the time of the analysis is presented in the table. This list may change as earlier projects withdraw or modify their requests.

None

11.9 Contingency Descriptions

None

12 Light Load Analysis

The Queue Project AF2-174 was evaluated as a 11.0 MW injection at the Tabernacle 12 kV substation in the AEC area. Project AF2-174 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF2-174 was studied with a commercial probability of 100.0 %. Potential network impacts were as follows:

12.1 Light Load Deliverability

(Single or N-1 contingencies)

12.2 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies)

12.3 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)

12.4 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.

12.5 System Reinforcements

ID	Idx	Facility	Upgrade Description	Cost	Cost Allocated to AF2-174	Upgrade Number

Note : For customers with System Reinforcements listed: If your present cost allocation to a System Reinforcement indicates \$0, then please be aware that as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, the cost responsibilities can change and a cost allocation may be assigned to your project. In addition, although your present cost allocation to a System Reinforcement is presently \$0, your project may need this system reinforcement

completed to be deliverable to the PJM system. If your project comes into service prior to completion of the system reinforcement, an interim deliverability study for your project will be required.

12.6 Flow Gate Details

The following indices contain additional information about each facility presented in the body of the report. For each index, a description of the flowgate and its contingency was included for convenience. The intent of the indices is to provide more details on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the indices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the indices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators. It should be noted the project/generator MW contributions presented in the body of the report are Full MW Impact contributions which are also noted in the indices column named "Full MW Impact", whereas the loading percentages reported in the body of the report, take into consideration the PJM Generator Deliverability Test rules such as commercial probability of each project as well as the ramping impact of "Adder" contributions. The MW Impact found and used in the analysis is shown in the indices column named "Gendeliv MW Impact".

12.7 Contingency Descriptions

13 Short Circuit Analysis

The following Breakers are overdutied

None

14 Stability and Reactive Power

To be determined in the Facilities Study Phase.

15 Affected Systems

None

16 Attachment 1: One Line Diagram