Generation Interconnection

Feasibility Study Report

for

Queue Project AF2-058

FAIRTON 12 KV

0 MW Capacity / 5 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, 36.2, 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 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.

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.

3 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Cumberland County, New Jersey. The installed facilities will have a total capability of 5 MW with 0 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is March 31, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AF2-058
Project Name	FAIRTON 12 KV

Queue Number	AF2-058
State	New Jersey
County	Cumberland
Transmission Owner	AEC
MFO	5
MWE	5
MWC	0
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

AF2-058 will interconnect with the AEC transmission system at the Fairton 12 kV substation.

5 Cost Summary

The AF2-058 project will be responsible for the following costs:

Description	Total Cost
Total Physical Interconnection Costs	$6,505,496
Total System Network Upgrade Costs	$20,000
Total Costs	$6,525,496

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.

Cost allocations for any System Upgrades will be provided in the System Impact Study Report.

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.

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

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

Note: The energy loss on the express feeder needs to be less than 3%.

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.

Transmission Owner (T.O.) Scope of Direct Connection Work
Transmission Owner scope of work required to accommodate 5 MW of generation via Express Feeder from Fairton T1 Substation:

1. Underground feeder getaway from substation.
2. Install approximately 0.08mile of parallel three phase 1000Al cable in cable in concrete encased duct bank from Fairton Substation.
3. Build approximately 0.57mile of three phase distribution primary.
4. Build approximately 1 mile of three phase distribution pole line to include a deck of three phase distribution primary.
5. Rebuild approximately 0.42mile existing two/single phase pole line to include a top deck of three phase distribution primary.
6. Install a utility operated recloser equipped with the proper relaying and communications.
7. Install utility grade primary metering.
8. Generation telemetry and remote trip capability will be provided to the control center.
9. A detailed, time-based study may be performed during later study phases.
10. Direct transfer trip will be required. Approximately 2.1 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Fairton Substation to the PV site.
11. New 12kV feeder bay. Addition of Control Enclosure to accommodate relay protection and communication equipment.
12. Cabling from yard equipment to new Control Enclosure and from this new Enclosure to the existing Enclosure with new cable duct work installation.
13. Testing of all new equipment and its coordination with existing equipment.
14. The substation needs to expand on the northeastern side of the substation by about 50ft. Developer will be responsible for land purchase for the expansion of substation, price is not included.
15. Moving the existing Mobil Unit connection to the end of the new 12kV bay.
16. Site remediation where yard expansion will take place.
17. New grounding encompassing the new yard expansion.

Assumptions
1. Secondary zone tree trimming may be required.
2. 12kV potential transformer will need to be installed if none already in service.
3. The ability to acquire property towards the northeast of the substation.
4. Environment and site expansion permitting requirements will be required.
5. Verification that new expansion is outside railway easement.

The total physical interconnection costs is given in the table below:

High Level Estimates			
Fairton T1			
Express Feeder	2.1	mi.	$2,000,000
Substation Feeder Terminal & Relay			$4,025,000
Telecommunication			$307,996
Recloser & Metering			$92,000
SCADA Integration into EMS			$11,500
Miscellaneous Engineering Costs			$69,000
Approximate Total Cost			$6,505,496

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

High Voltage Warning

Typically, voltage received at the meter from the utility can be up to 105% of nominal (without generation on). 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. It is recommended that transformers with no load taps should be used to adjust secondary voltage to avoid the possibility of inverter trips. Failure to account for this may result in lost energy production.

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. ACE will supply a wireless modem for remote meter interrogation. In the event that a wireless modem is unable to reliably communicate, the IC will be required to make provisions for a POTS (Plain Old Telephone Service) line or equivalent technology approved by ACE within approximately three feet of the ACE metering position to facilitate remote interrogation and data collection. 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.

4. 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.

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 unity power factor of (**1**) 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/

The net interchange of electrical energy will be measured by the new revenue meter, owned by ACE, located at the Point of Interconnection. This will be the official measurement of megawatt hours (“MWH”) and megavar hours (“MVARH”) received into and delivered by ACE’s Electric System by the net generation and load behind the meter. These revenue meters will be the source for reporting generation output to PJM.

ACE will purchase all metering instrument transformers and related surge arresters and switches and will install them on an ACE-supplied wood pole at the POI location. All secondary metering wiring will be completed by ACE. The metering control cable and meter cabinets will be supplied and installed by ACE. ACE meter technicians will program and install two solid state multi-function meters (Primary & Backup) for the new metering position.

ACE will supply a wireless modem for MV90 interrogation. In the event that a wireless modem is unable to reliably communicate, the Interconnection Customer will be required to make provisions for a POTS (Plain Old Telephone Service) line or equivalent technology approved by ACE within approximately three feet of the ACE metering position to facilitate remote interrogation and data collection.

11 Summer Peak - Load Flow Analysis

The Queue Project AF2-058 was evaluated as a 5.0 MW (Capacity 2.5 MW) injection at the Fairton 69 kV substation in the AEC area. Project AF2-058 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF2-058 was studied with a commercial probability of 53.0 %. 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)

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
101570265	940000	AE1-240 TAP	69.0	AE	228226	SHRMAN#2	69.0	AE	1	AE_P4-2 AE46	breaker	93.0	155.04	156.44	DC	1.3

11.4 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.

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
10157084 6	228252	CRLS CR2	69.0	AE	940000	AE1-240 TAP	69.0	AE	1	AE_P1-2 ORCH-CUMB	operation	93.0	115.26	116.56	DC	1.21
10157084 9	939500	AE1-179 TAP	69.0	AE	228228	SO MVLLE	69.0	AE	1	228226 SHRMAN# 2 69.0 940000 AE1-240 TAP 69.0 1	operation	89.0	108.71	111.0	DC	2.04
10157072 2	940000	AE1-240 TAP	69.0	AE	228226	SHRMAN# 2	69.0	AE	1	AE_P1-2 ORCH-CUMB	operation	93.0	152.35	153.65	DC	1.21
10157072 6	940000	AE1-240 TAP	69.0	AE	228226	SHRMAN# 2	69.0	AE	1	Base Case	operation	82.0	117.45	119.11	DC	1.36

11.5 System Reinforcements - Summer Peak Load Flow - Primary POI

ID	Idx	Facility	Upgrade Description	Cost
101570265	1	AE1-240 TAP 69.0 kV - SHRMAN#2 69.0 kV Ckt 1	ACECCShermr01 : To mitigate the AE1-240 tap to Sherman 69 kV line section oveload a 600 amp disc switch must be upgraded at Sherman. Project Type : FAC Cost : $20,000 Time Estimate : 6 to 14 Months	$20,000
			TOTAL COST	$20,000

11.6 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".

11.6.1 Index 1

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
101570265	940000	AE1-240 TAP	AE	228226	SHRMAN#2	AE	1	AE_P4-2 AE46	breaker	93.0	155.04	156.44	DC	1.3

Bus #	Bus	Gendeliv MW Impact	Type	Full MW Impact
228200	CARL#1CT	2.0154	50/50	2.0154
228201	CARL#2CT	2.1333	50/50	2.1333
228251	CARLLS#4	0.2308	50/50	0.2308
228260	V4-054C	0.3406	50/50	0.3406
228261	V4-054E	1.6109	50/50	1.6109
228334	MANNMILG	0.6930	Adder	0.82
228343	**QUINTN#1 (Deactivation : 26/04/2020)**	**0.3260**	**50/50**	**0.3260**
228351	V2-046C	0.1285	50/50	0.1285
228357	V2-046E	1.3727	50/50	1.3727
938871	AE1-115 C	0.5038	Adder	0.59
938872	AE1-115 E	0.5038	Adder	0.59
940001	AE1-240 C O1	20.6996	50/50	20.6996
940002	AE1-240 E O1	14.7752	50/50	14.7752
942571	AE2-272	0.0147	50/50	0.0147
945431	AF1-208 C O1	8.1116	50/50	8.1116
945432	AF1-208 E O1	5.4077	50/50	5.4077
945733	AF1-238 BAT	17.1921	50/50	17.1921
945743	AF1-239 BAT	4.0452	50/50	4.0452
957223	AF2-016 BAT	5.4696	Merchant Transmission	5.4696
957253	AF2-019 BAT	1.4149	Merchant Transmission	1.4149
957261	AF2-020 C	3.4272	50/50	3.4272
957262	AF2-020 E	5.1408	50/50	5.1408
957283	AF2-022 BAT	2.4595	Merchant Transmission	2.4595
957291	AF2-023 C O1	0.5365	Adder	1.19
957292	AF2-023 E O1	0.8048	Adder	1.79
957323	AF2-026 BAT	3.4767	50/50	3.4767
957641	AF2-058 C	0.6496	50/50	0.6496
957642	AF2-058 E	0.6496	50/50	0.6496
958811	AF2-172 C	0.4088	50/50	0.4088
958812	AF2-172 E	0.6669	50/50	0.6669
959111	AF2-202 C	0.4920	50/50	0.4920
959112	AF2-202 E	0.6733	50/50	0.6733
NEWTON	NEWTON	0.0054	Confirmed LTF	0.0054
FARMERCITY	FARMERCITY	0.0003	Confirmed LTF	0.0003
CALDERWOOD	CALDERWOOD	0.0025	Confirmed LTF	0.0025
NY	NY	0.0310	Confirmed LTF	0.0310
PRAIRIE	PRAIRIE	0.0129	Confirmed LTF	0.0129
O-066	O-066	0.5510	Confirmed LTF	0.5510
CHEOAH	CHEOAH	0.0025	Confirmed LTF	0.0025
EDWARDS	EDWARDS	0.0017	Confirmed LTF	0.0017
TILTON	TILTON	0.0031	Confirmed LTF	0.0031

Bus #	Bus	Gendeliv MW Impact	Type	Full MW Impact
G-007	G-007	0.2049	Confirmed LTF	0.2049
GIBSON	GIBSON	0.0027	Confirmed LTF	0.0027
BLUEG	BLUEG	0.0087	Confirmed LTF	0.0087
TRIMBLE	TRIMBLE	0.0028	Confirmed LTF	0.0028
CATAWBA	CATAWBA	0.0017	Confirmed LTF	0.0017

11.7 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.

Queue Number	Project Name	Status
AE1-115	Churchtown 69 kV	Active
AE1-240	Carlls Corner-Sherman Avenue 69 kV	Active
AE2-272	Woodstown 12 kV	In Service
AF1-208	Quinton-Roadstown 69 kV	Active
AF1-238	Sherman Ave. 69 kV	Active
AF1-239	Sherman Ave-Vineland 69 kV	Active
AF2-016	Lewis 138 kV	Active
AF2-019	Middle 69 kV	Active
AF2-020	Carll's Corner 69 kV	Active
AF2-022	Cumberland 138 kV	Active
AF2-023	Churchtown 69 kV	Active
AF2-026	Sherman Ave 138 kV	Active
AF2-058	Fairton 12 kV	Active
AF2-172	Newport 12 kV	Active
AF2-202	Landis 12 V	Active
V2-046	Pilesgrove Township 12kV	In Service
V4-054	Fairfield Township 12kV	In Service

11.8 Contingency Descriptions

Contingency Name	Contingency Definition
AE_P4-2 AE46	CONTINGENCY 'AE_P4-2 AE46' /*ORCHARD 230 BUS BREAKER D DISCONNECT BRANCH FROM BUS 228002 TO BUS 228310 CKT 1 /* ORCHARD TO CHURCHTOWN 230 230 DISCONNECT BRANCH FROM BUS 200063 TO BUS 228002 CKT 1 /*ORCHARD ORCHARD 500 230 T1 END
Base Case	
228226 SHRMAN#2 69.0 940000 AE1-240 TAP 69.0 1	CONTINGENCY '228226 SHRMAN#2 69.0 940000 AE1-240 TAP 69.0 1' OPEN BRANCH FROM BUS 228226 TO BUS 940000 CKT 1 END
AE_P1-2 ORCH-CUMB	CONTINGENCY 'AE_P1-2 ORCH-CUMB' OPEN LINE FROM BUS 228002 TO BUS 228207 CIRCUIT 1 / END

12 Short Circuit Analysis

The following Breakers are overdutied

None

13 Affected Systems

None

14 Attachment 1: One Line Diagram