Revised

Generation Interconnection

System Impact Study Report

for

Queue Project AE1-071

SHADE GAP-ROXBURY 115 KV

62.1 MW Capacity / 100.1 MW Energy

June, 2021

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1 Introduction

This System Impact Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the System Impact Study Agreement between **Aspen Road Solar I, LLC**, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Pennsylvania Electric Company (Penelec).

2 Preface

The intent of the System Impact 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.

An Interconnection Customer with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

3 Revisions since August 2019 System Impact Study Report

The AE1-071 System Impact Study has been revised from August 2019 to include the Stability Analysis and Reactive Power Assessment results.

The reactive power assessment for this project reveals that the project does not meet the lagging power factor requirement at the high side of the main transformer. This project needs to have additional reactive power capabilities to fulfill the power factor requirement. An additional 25.77 MVar would be required for the plant to meet the 0.95 lagging power factor requirement. The customer is responsible for this reactive power compensation. PJM will test the customer's proposed reactive solution in the Facilities Study phase to ensure the required power factor can be achieved.

4 General

Aspen Road Solar I, LLC, the Interconnection Customer (IC), has proposed a solar generating facility located in Franklin County, PA. The installed facilities will have a total capability of 100.1 MW with 62.1 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 1, 2021. **This study does not imply a Penelec commitment to this in-service date.**

Queue Number	**AE1-071**
Project Name	SHADE GAP-ROXBURY 115 KV
Interconnection Customer	Aspen Road Solar I, LLC
State	PA
County	Franklin
Transmission Owner	PENELEC
MFO	100.1
MWE	100.1
MWC	62.1
Fuel	Solar
Basecase Study Year	2022

4.1 Point of Interconnection

The interconnection of the project at the Primary POI will be accomplished by constructing a new 115 kV three (3) breaker ring bus substation and looping the Roxbury – Shade Gap 115 kV line into the new station. The new substation will be located approximately 6.4 miles from Roxbury substation. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection switching station and the associated facilities. The IC will also be responsible for the rough grade of the property and an access road to the proposed three breaker ring bus site. The project will also require Non-Direct connection upgrades at Lewistown, Shade Gap, and Roxbury substations.

Attachment 1 shows a one-line diagram of the Direct Connection facilities for the AE1-071 generation project to connect to the FirstEnergy ("FE") transmission system. Attachment 2 provides the proposed location. The IC will be responsible for constructing the facilities on its side of the POI.

4.2 Cost Summary

The AE1-071 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 325,000
Direct Connection Network Upgrade	$5,181,600
Non Direct Connection Network Upgrades	$ 876,800
New System Upgrades	$0
Contribution to Previously Identified Upgrades	$0
Total Costs	$6,383,400

The costs provided above exclude the Contribution in Aid of Construction ("CIAC") Federal Income Tax Gross Up charge. If, at a future date, it is determined that the CIAC Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

The required Attachment Facilities and Direct and Non-Direct Connection work for the interconnection of the AE1-071 generation project to the FE Transmission System is detailed in the following sections. The associated one-line with the generation project Attachment Facilities and the Primary Direct and Non-Direct Connection facilities are shown in Attachment 1.

5 Transmission Owner Scope of Work

The interconnection of the project will be accomplished by constructing a new 115 kV three (3) breaker ring bus and looping the Roxbury – Shade Gap 115 kV line into the new station. The new substation will be located approximately 6.4 miles from Roxbury substation. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection switching station and the associated attachment facilities. The IC will also be responsible for the rough grade of the property and an access road to the proposed three breaker ring bus site. The project will also require non-direct connection upgrades at Lewistown, Roxbury, and Shade Gap substations.

5.1 Attachment Facilities

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Install line exist take-off structure, foundations, disconnect switch, and associated equipment including revenue metering at interconnection substation.	$325,000
Total Attachment Facility Costs	$325,000

5.2 Direct Connection Cost Estimate

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Build new (3) breaker 115kV ring bus for generation interconnection queue AE1-071	$5,181,600
Total Direct Connection Facility Costs	$5,181,600

5.3 Non-Direct Connection Cost Estimate

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Loop the Roxbury-Shade Gap 115kV line into the new AE1-071 substation.	$498,500
Install anti-islanding relaying, change nameplates and drawings for line name change @ Shade Gap SS	$126,100
Install anti-islanding relaying, change nameplates and drawings for line name change @ Roxbury SS	$126,100
Install anti-islanding relaying @ Lewistown SS	$126,100
Total Non-Direct Connection Facility Costs	$876,800

6 Schedule

Based on this scope of work, it is expected to take a minimum of **14 months** after the signing of an Interconnection Construction Service Agreement and construction kickoff call. This includes preliminary payment that compensates FE for the first three months of the engineering design work that is related to the construction of the AE1-071 interconnection substation (Attachment Facilities and Direct Connection work). Full initial deposit is required for the Non-Direct Connection work. This assumes that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined interconnection work, and that PJM will allow all transmission system outages when requested.

7 Transmission Owner Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE1-071 project did not contribute to any overloads on the FE transmission <100 kV system.

8 Interconnection Customer Requirements

8.1 System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx.

Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

8.2 Compliance Issues and Interconnection Customer Requirements

1. The proposed Customer Facilities must be designed in accordance with FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. In particular, the IC is responsible for the following:

2. The purchase and installation of a fully rated 115 kV circuit breaker to protect the AE1-071 generator lead line. A single circuit breaker must be used to protect this line; if the project has several GSU transformers, the individual GSU transformer breakers cannot be used to protect this line.

3. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

4. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the FE Transmission System Control Center.

5. Compliance with the FE and PJM generator power factor and voltage control requirements.

6. The execution of a back-up service agreement to serve the customer load supplied from the AE1-071 generation project metering point when the units are out-of-service. This assumes the intent of the IC is to net the generation with the load.

7. The IC will also be required to meet all PJM, ReliabilityFirst, and NERC reliability criteria and operating procedures for standards compliance. For example, the IC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

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8.3 Power Factor Requirements

The IC shall design its facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the FE transmission system.

9 Revenue Metering and SCADA Requirements

9.1 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.

9.1.1 Meteorological Data Reporting Requirement

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

9.2 PENELEC Requirements

The IC will be required to comply with all FE revenue metering requirements for generation interconnection customers which can be found in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx.

10 Network Impacts

The Queue Project AE1-071 was evaluated as a 100.1 MW (Capacity 62.1 MW) injection at a new interconnection switchyard along the Shade Gap-Roxbury 115kV in the PENELEC area. Project AE1-071 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-071 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

11 Generation Deliverability

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

None

12 Multiple Facility Contingency

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

None

13 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

14 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

15 System Reinforcements

None

Affected Systems

16 Affected Systems

16.1 NYISO

None

Short Circuit

17 Short Circuit

The following Breakers are overduty:

None

Stability

18 Stability Analysis

18.1 Executive Summary

Generator Interconnection Request AE1-071 is for a 100.1 MW Maximum Facility Output (MFO) solar generating facility. AE1-071 consists of 39 x 2.625 MW TMEIC PVH-L2700 GR solar inverters with a Point of Interconnection (POI) tapping the 115 kV line from the Shade Gap to the Roxbury substation in Franklin County, Pennsylvania, in the First Energy transmission system.

The power flow scenario for the analysis was based on the RTEP 2022 summer peak case, modified to include applicable queue projects. AE1-071 has been dispatched online at maximum facility output, with approximately unity power factor at the high-side of the station transformer.

AE1-071 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 42 contingencies were simulated, each with a 20 second simulation time period. Studied faults included:

- Steady-state operation (20 second simulation)
- Three-phase faults with normal clearing time
- Single-phase bus faults with normal clearing time
- Single-phase faults with a stuck breaker

The 42 fault contingencies tested on the 2022 summer peak case met the recovery criteria:

- The AE1-071 generators were able to ride through the faults except for faults where protective actions trip one or more generator(s).
- All generators maintained synchronism and any post-contingency oscillations are positively damped with a damping margin of at least 3%.
- All bus voltages recover to 0.7 p.u. within 2.5 seconds and the final voltage is within the range of 0.92 p.u. to 1.05 p.u. for buses other than 500 kV. The final voltages for 500 kV buses should be within 1.02 p.u. to 1.08 p.u.
- No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

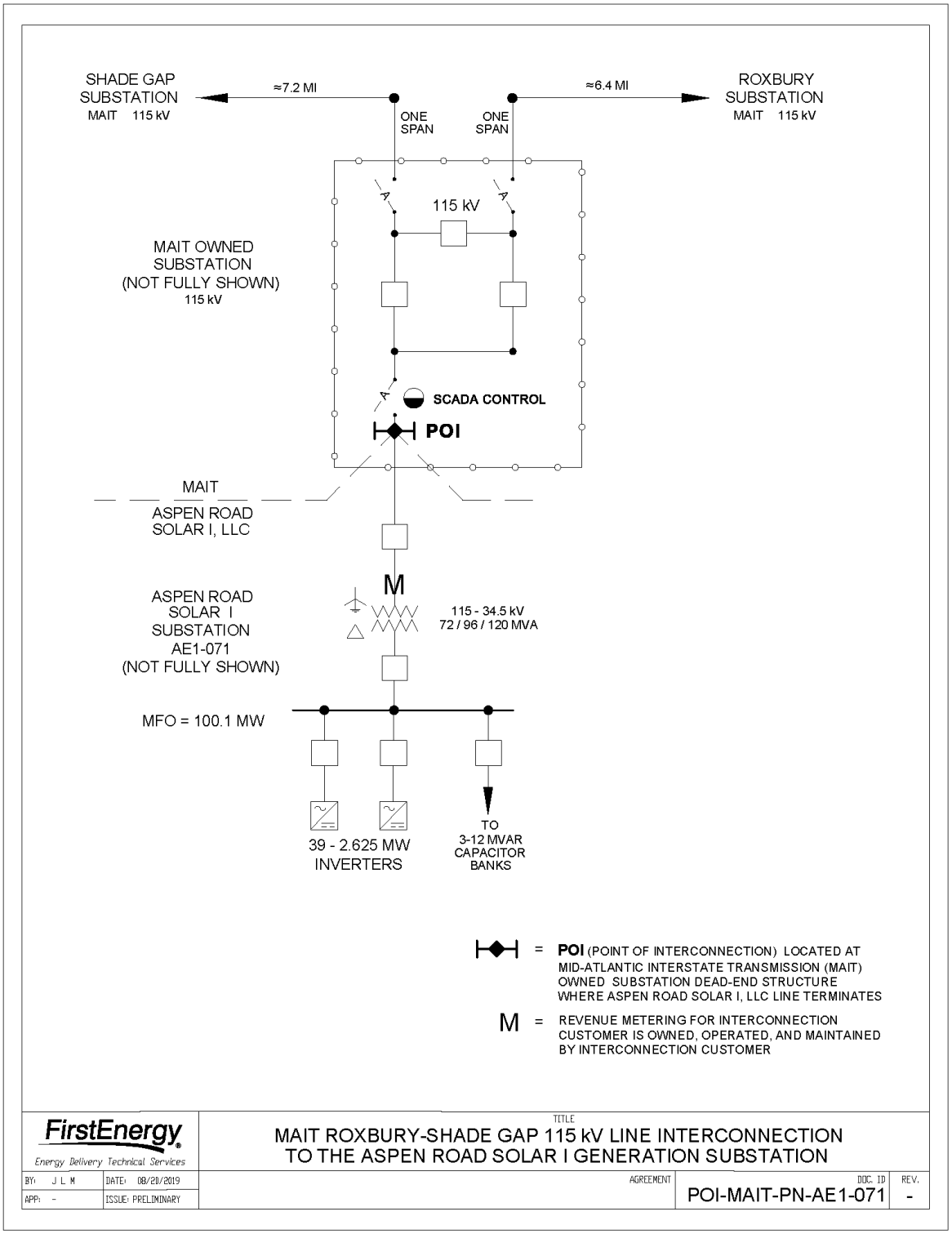
The queue project, AE1-071, does not meet the 0.95 lagging power factor requirement. An additional 25.77 Mvar would be required for the plant to meet the 0.95 lagging power factor requirement. The plant did meet the 0.95 leading power factor requirement.

Light Load

19 Light Load Analysis

Not required for solar projects.

20 Attachment 1: One Line Diagram



21 Attachment 2: Site Plan