Generation Interconnection

System Impact Study Report

for

Queue Project AE2-192

ORRTANNA 115 KV

39 MW Capacity / 65 MW Energy

February 2020

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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 **Keystone State Renewables, LLC**, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Mid-Atlantic Interstate Transmission ("MAIT" – Meted zone).

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.

3 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Adams County, Pennsylvania. The installed facilities will have a total capability of 65 MW with 39 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 31, 2022. This study does not imply a TO commitment to this in-service date.

Queue Number	**AE2-192**
Project Name	ORRTANNA 115 KV
Interconnection Customer	Keystone State Renewables, LLC
State	PA
County	Adams
Transmission Owner	ME
MFO	65
MWE	65
MWC	39
Fuel	Solar
Basecase Study Year	2022

4 Point of Interconnection

The interconnection of the project to the MAIT transmission system will be accomplished by constructing a new 115 kV line terminal and dead-end structure at the existing Orrtanna 115 kV substation. The project will not require any remote terminal upgrades.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-192 generation project to connect to the FirstEnergy ("FE") transmission system. **Attachment 2** provides the proposed location for the point of interconnection. IC will be responsible for constructing all of the facilities on its side of the POI, including the attachment facilities which connect the generator to the FE transmission system's direct connection facilities.

5 Cost Summary

The AE2-192 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$242,700
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$843,700
System Upgrades	$0
Total Costs	**$1,086,400**

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 AE2-192 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.

Note: 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.

6 Transmission Owner Scope of Work

The interconnection of the project to the MAIT transmission system will be accomplished by constructing a new 115 kV line terminal and dead-end structure at the existing Orrtanna 115 kV substation. The project will not require any remote terminal upgrades.

6.1 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 exit take-off structure, foundations, disconnect switch and associated equipment at new ring bus substation.	$242,700
Total Attachment Facility Costs	**$242,700**

6.2 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
	$0
Total Direct Connection Facility Costs	**$0**

6.3 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
Add a new 115 kV breaker to the Orrtanna Ring bus creating a new line terminal at Orrtanna	$660,500
Estimated SCADA work at Orrtanna substation to support breaker installation, relay installation, and updated relay settings. Estimated (1) in-sub fiber run to represent ADSS tail extension from Orrtanna substation control house to last T-Line structure for communications for AE2-192.	$50,000
Project Management	$133,200
Total Non-Direct Connection Facility Costs	**$843,700**

7 Schedule

Based on the scope of work for the Attachment Facilities and the Direct Connection facilities, it is expected to take a minimum of **13 months** after the signing of an Interconnection Construction Service Agreement to complete the installation. This includes the requirement for the IC to make a preliminary payment that compensates FE for the first three months of the engineering design work that is related to the Attachment Facilities. 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 direct connection and network upgrades, and that all transmission system outages will be allowed when requested.

8 Transmission Owner Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE2-192 project did not contribute to any overloads on the FE transmission system.

9 Interconnection Customer Requirements

9.1 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.

The IC has requested a non-standard GSU transformer winding configuration. This transformer is in violation of section 14.2.6 of FE's "Requirements for Transmission Connected Facilities" document and will not be accepted. The GSU transformer must have a grounded wye connection on the high (utility) side and a delta connection on the low (generator) side.

9.2 Compliance Issues and Interconnection Customer Requirements

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:

1. The purchase and installation of a fully rated 115 kV circuit breaker to protect the AE2-192 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.

2. 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.

3. 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.

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

5. The execution of a back-up service agreement to serve the customer load supplied from the AE2-192 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.

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.

9.3 Power Factor Requirements

The IC shall design its solar-powered non-synchronous Customer 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.

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.

10.1.1 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

10.2 FE 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

11 Network Impacts

The Queue Project AE2-192 was evaluated as a 65.0 MW (Capacity 39.0 MW) injection at the Orrtanna 115 kV substation in the ME area. Project AE2-192 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-192 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

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 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
7156743	204543	27LINC TAP	115.0	METED	204544	27LINCOLN	115.0	METED	1	ME-P1-2-ME-115-016-A	operation	152.0	101.38	108.58	AC	11.34

11.5 System Reinforcements:

None

Affected Systems

11.6 Affected Systems

None

11.7 Contingency Descriptions

Contingency Name	Contingency Definition
ME-P1-2-ME-115-016-A	CONTINGENCY 'ME-P1-2-ME-115-016-A' /* HUNTERSTOWN - LINCOLN 115 KV DISCONNECT BRANCH FROM BUS 204539 TO BUS 933970 CKT 1 /* 27HUNTRSTN 115 AD1-020 TAP 115 END

Short Circuit

12 Short Circuit

The following Breakers are overduty:

None

Stability

13 Stability Analysis and Reactive Power Assessment

13.1 Executive Summary

Generator Interconnection Request AE2-192 is for a 65 MW Maximum Facility Output (MFO) solar facility consisting of 23 3.339 MVA Power Electronics HEM FS3150MU inverters connecting to the Metropolitan Edison (Met-Ed/ME) transmission system. The AE2-192 will be located in Adams County, Pennsylvania. The interconnection of the project at the Point of Interconnection (POI) will be accomplished by constructing a new 115 kV line terminal and dead-end structure at the existing Orrtanna 115 kV substation. The project will interconnect via an approximate 1 mile gen tie to the POI.

This report describes a dynamic simulation analysis of AE2-192 as part of the overall system impact study. The load flow scenario for the analysis was based on the RTEP 2022 peak load case, modified to include applicable queue projects. AE2-192 has been dispatched online at maximum power output, with approximately 1.01 pu voltage at the generator terminals.

AE2-192 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 68 contingencies were studied, each with a 20 second simulation time period (with 1.0 second initial run prior to any events). The studied faults include:

a) Steady state operation (Category P0);

b) Three phase faults with normal clearing time on the intact network (Category P1);

c) Single phase to ground faults with delayed clearing due to a stuck breaker (Category P4);

d) Single phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from the fault due to primary communications/relay failure (Category P5);

e) Single phase to ground faults with normal clearing for common structure (Category P7).

For all 68 fault contingencies tested on the 2022 peak load case:

a) AE2-192 was able to ride through the faults (except for faults where protective action trips a generator(s)).

b) Post-contingency oscillations were positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

No mitigation was found to be required.

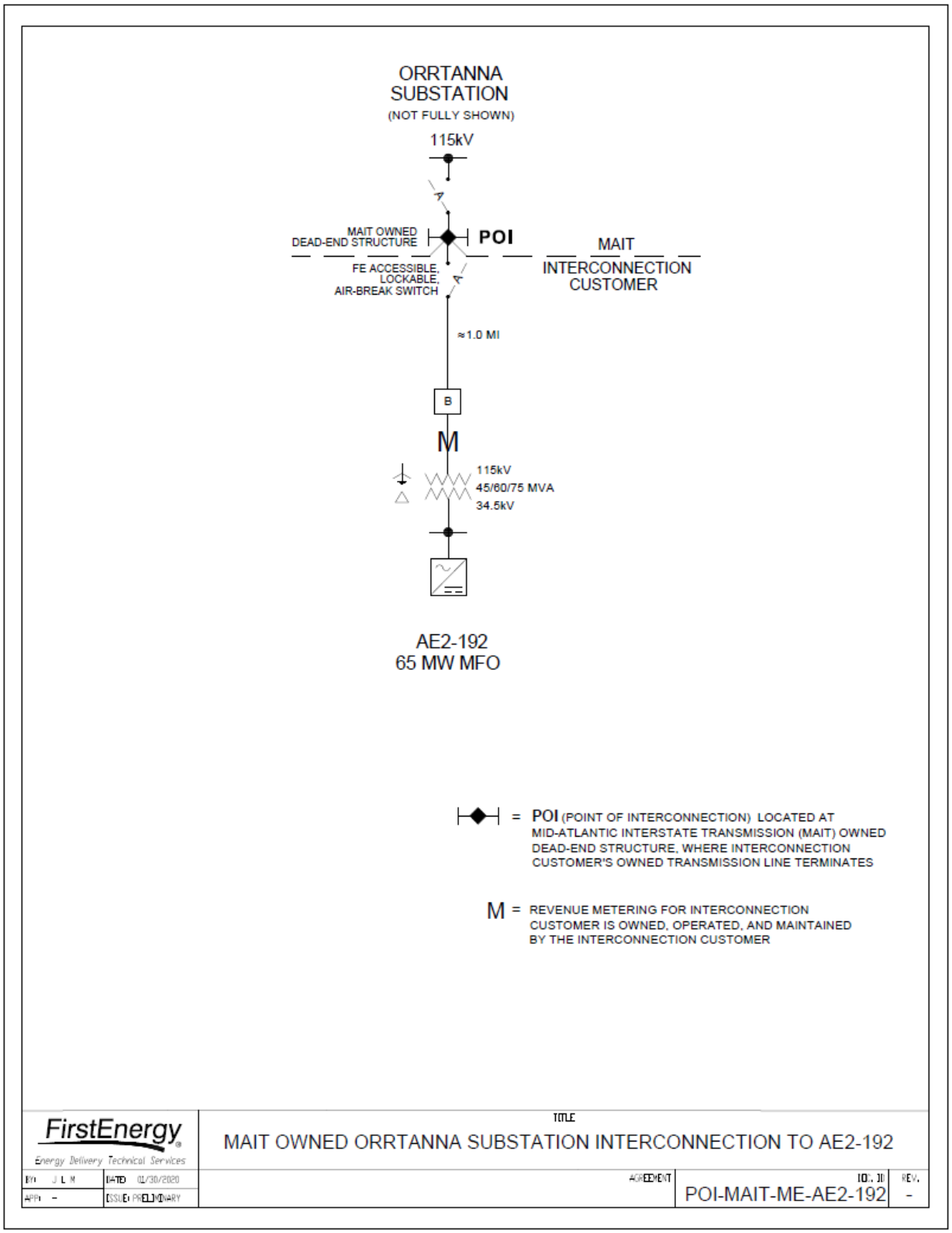
Please also note that the project AE2-192 meets the 0.95 leading and lagging reactive power requirement at the high side of facility transformer.

Light Load

14 Light Load Analysis

Not required for solar projects.

15 Attachment One: One Line Diagram



16 Attachment Two: Project Location