Revised

Generation Interconnection

System Impact Study Report

for

Queue Project AE1-138

Hamilton 115 kV substation

13.2 MW Capacity / 22 MW Energy

December 2021

Table of Contents

1 Introduction

This System Impact Study (SIS) 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 Metropolitan Edison Company (ME).

2 Revisions since August 2019 System Impact Study Report

The Stability Analysis section of this report has been updated to include the Executive Summary from the completed stability analysis.

3 Revisions since Revised December 2020 System Impact Study Report

Updated the Summer Peak Load Flow results from the retool of the AE1 queue.

4 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.

5 General

Interconnection Customer has proposed a new solar generating facility located in Adams County, Pennsylvania. The installed facilities will have a total capability of 22 WM with 13.2 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 31, 2021. **This study does not imply a Mid-Atlantic Interstate Transmission, LLC (Transmission Owner or MAIT) commitment to this in-service date.**

Queue Number	**AE1-138**
Project Name	Hamilton 115 kV substation
Interconnection Customer	Keystone State Renewables, LLC
State	Pennsylvania
County	Adams
Transmission Owner	ME
MFO	22
MWE	22
MWC	13.2
Fuel	Solar
Basecase Study Year	2022

5.1 Point of Interconnection

The interconnection of the project at the will be accomplished by constructing a new 115 kV line terminal and dead-end structure at the existing Hamilton 115 kV substation.

Attachment 1 shows a one-line diagram of the proposed Direct Connection facilities for the AE1-138 generation project to connect to the FirstEnergy ("FE") transmission system. Attachment 2 provides the proposed location. The IC will be responsible for constructing all of the facilities on its side of the POI.

5.2 Cost Summary

The AE1-138 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$2,700
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$1,134,900
New System Upgrades	$0
Contribution to Previously Identified Upgrades	$0
Total Costs	$1,137,600

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/or Non-Direct Connection work for the interconnection of the AE1-138 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 Direct Connection facilities are shown in Attachment 1.

6 Transmission Owner Scope of Work

The interconnection of the project at the will be accomplished by constructing a new 115 kV line terminal and dead-end structure at the existing Hamilton 115 kV substation.

Attachment 1 shows a one-line diagram of the proposed Direct Connection facilities for the AE1-138 generation project to connect to the FirstEnergy ("FE") transmission system. Attachment 2 provides the proposed location. The IC will be responsible for constructing all of the facilities on its side of the POI.

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
Revenue metering - engineering oversight of specification and design of new revenue metering that will be installed by power producer (interconnection customer - Keystone State Renewables) at their location (AE1-138) and connected to a new line terminal at the Hamilton Substation	$2,700
Total Attachment Facility Costs	$2,700

6.2 Direct Connection Cost Estimate

There is no Direct Connection scope of work required.

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
Install new 115 kV terminal for AE1-138 interconnection at Hamilton substation.	$451,700
Install line exit take-off structure, foundations, disconnect switch and associated equipment at Hamilton substation.	$316,100
Estimated SCADA work at Hamilton substation to support updated relay settings, relay replacements, and breaker installation. Estimated in-sub fiber run from Hamilton control house to developer ran fiber outside Hamilton control house.	$50,000
Project Management and Commissioning.	$317,100
Total Non-Direct Connection Facility Costs	$1,134,900

7 Schedule

Based on the scope of work for the Attachment Facilities and the Direct and/or Non-Direct Connection facilities, it is expected to take a minimum of **11 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 will be 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

8.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE1-138 project did not contribute to any overloads on the FE transmission <100 kV 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.

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 AE1-138 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 AE1-138 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 Attachment O, Appendix 2, Section 8.

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 AE1-138 was evaluated as a 22.0 MW (Capacity 13.2 MW) injection at Hamilton 115 kV substation in the ME area. Project AE1-138 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-138 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

12 Generation Deliverability

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

None

12.1 Multiple Facility Contingency

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

None

12.2 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

12.3 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

12.4 System Reinforcements

None

12.5 Flow Gate Details

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

None

Affected Systems

12.6 Affected Systems

None

12.7 Contingency Descriptions

None

Short Circuit

13 Short Circuit

The following Breakers are overduty:

None

Stability

14 Stability Analysis and Reactive Power Assessment

14.1 Executive Summary

Generator Interconnection Request AE1-138 is for a 22 MW Maximum Facility Output (MFO) solar generating facility, which consists of 8 PE FS3150MU inverters. The AE1-138 solar generating facility will be located in Adams County, Pennsylvania.

Project AE1-138 will directly connect into the existing Hamilton 115 kV substation in the Metropolitan Edison (MetEd) zone of Mid-Atlantic Interstate Transmission, LLC (MAIT) transmission system via approximately 2.0 miles 115 kV transmission line. The Point of Interconnection (POI) will be where the Interconnection Customer gen-tie line attaches to the line terminal dead-end structure.

This report describes a dynamic simulation analysis of AE1-138 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. AE1-138 has been dispatched online at maximum power output, with 0.83 power factor and approximately 1.0174 pu voltage at the generator terminals.

AE1-138 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. 117 contingencies were studied, each with a 20 second simulation time period (with 1.0 second initial run prior to any events). Studied faults included:

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 117 fault contingencies tested on the 2022 peak load case:

a) AE1-138 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.

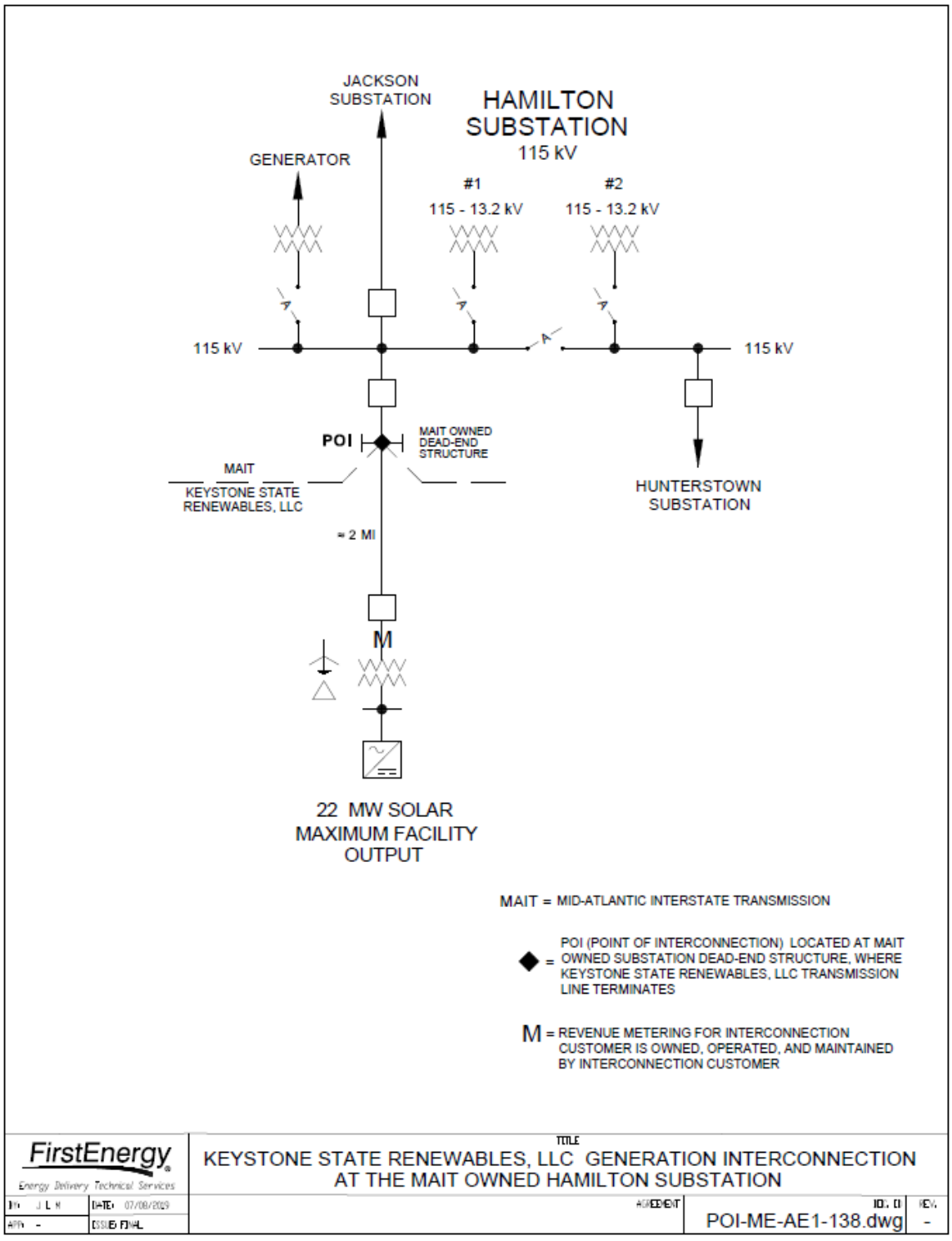
The solar generating facility AE1-138 **meets** the reactive power requirement at the high side of facility transformer.

Light Load

15 Light Load Analysis

Not required for solar projects.

16 Attachment 1 – One Line



17 Attachment 2 – Project Location