Generation Interconnection

System Impact Study Report

for

Queue Project AE1-185

HOKES-JACKSON 69 KV

12.6 MW Capacity / 20 MW Energy

August, 2019

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 Feasibility Study Agreement between Belltown Power PA Projects, LLC, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Metropolitan Edison Company (ME).

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 York County, Pennsylvania. The installed facilities will have a total capability of 20 MW with 12.6 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is April 1, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AE1-185
Project Name	HOKES-JACKSON 69 KV
Interconnection Customer	Belltown Power PA Projects, LLC
State	Pennsylvania
County	York
Transmission Owner	ME
MFO	20
MWE	20
MWC	12.6
Fuel	Solar
Basecase Study Year	2022

3.1 Point of Interconnection

The interconnection of the project at the Primary POI will be accomplished by tapping the Hokes - Jackson 69 kV line and constructing a one span tap. The transmission line tap will be located approximately 3.5 miles from Jackson substation. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection line tap and the associated Attachment Facilities. The project will also require Non-Direct Connection upgrades at Jackson and Hokes substations.

Attachment 1 shows a one-line diagram of the proposed Direct Connection facilities for the AE1-185 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.

3.2 Cost Summary

The AE1-185 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$249,770
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$499,530
New System Upgrades	$0
Contribution to Previously Identified Upgrades	$0
Total Costs	$749,300[1]

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 AE1-185 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.

[1] The customer will be required to address a reactive power deficiency described in the "Stability and Reactive Power Assessment" section of this report. The installation and cost for that upgrade is the responsibility of the customer and is not reflected in this total cost.

4 Transmission Owner Scope of Work

The interconnection of the project at the Primary POI will be accomplished by tapping the Hokes - Jackson 69 kV line and constructing a one span tap. The transmission line tap will be located approximately 3.5 miles from Jackson substation. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection line tap and the associated Attachment Facilities. The project will also require Non-Direct Connection upgrades at Jackson and Hokes substations.

Attachment 1 shows a one-line diagram of the proposed Direct Connection facilities for the AE1-185 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.

4.1 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
Tap the Hokes - Jackson 69 kV line at or near structure 79-64 and construct 1 span of 69 kV line towards the developer	$249,770
Total Attachment Facility Costs	$249,770

4.2 Direct Connection Cost Estimate

There is no Direct Connection scope of work required.

4.3 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 disconnect switches with SCADA control	$499,530
Total Non-Direct Connection Facility Costs	$499,530

5 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 9 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 construction of 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.

6 Transmission Owner Analysis

6.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE1-185 project did not contribute to any overloads on the FE transmission <100 kV system.

7 Interconnection Customer Requirements

7.1 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.

7.2 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 69 kV circuit breaker to protect the AE1-185 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 AE1-185 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.

7.3 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.

8 Revenue Metering and SCADA Requirements

8.1 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.

8.1.1 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

8.2 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

9 Network Impacts

The Queue Project AE1-185 was evaluated as a 20.0 MW (Capacity 12.6 MW) injection at Hokes-Jackson 69kV in the ME area. Project AE1-185 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-185 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

10 Generation Deliverability

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

None

11 Multiple Facility Contingency

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

None

12 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

13 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

14 System Reinforcements

See the Reactive Power Deficiency identified in the Stability and Reactive Power Assessment section of this report. To fulfill the power factor requirement, the estimated additional capacitive (lagging) reactive power is 0.28 MVAR. The customer must indicate how they will address the power factor requirement and the reinforcement will be tested in the Facilities Study phase of this project.

Affected Systems

15 Affected Systems

15.1 NYISO

None

Short Circuit

16 Short Circuit

The following Breakers are overduty:

None

Stability and Reactive Power Assessment

17 Stability Analysis

17.1 Executive Summary

Generator Interconnection Request AE1-185 is for a 20 MW Maximum Facility Output (MFO) solar generating facility, which consists of 9 SMA Sunny Central 2500-US inverters. Project AE1-185 located in York County, Pennsylvania will interconnect with the Mid-Atlantic Interstate Transmission, LLC (MAIT) transmission system by tapping the Hokes – Jackson 69 kV line at a point located approximately 3.8 miles from Hokes substation and approximately 3.5 miles from Jackson substation in the Metropolitan Edison (METED) transmission system.

This report describes a dynamic simulation analysis of AE1-185 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. AE1-185 has been dispatched online at maximum power output, with approximately unity power factor and 1.01 pu voltage at the generator terminals.

AE1-185 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 57 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 57 fault contingencies tested on the 2022 peak load case:

a) AE1-185 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.

It is worth mentioning that the reactive power response of AE1-185 may not return to the pre-fault value for some of the events. This is because the voltage control (RefFlag=1) is used in the REPCAU1 model and the model is trying to control the bus voltage at the POI. Q control (RefFlag=0) can be used if maintaining the reactive power output of the generating facility is desired.

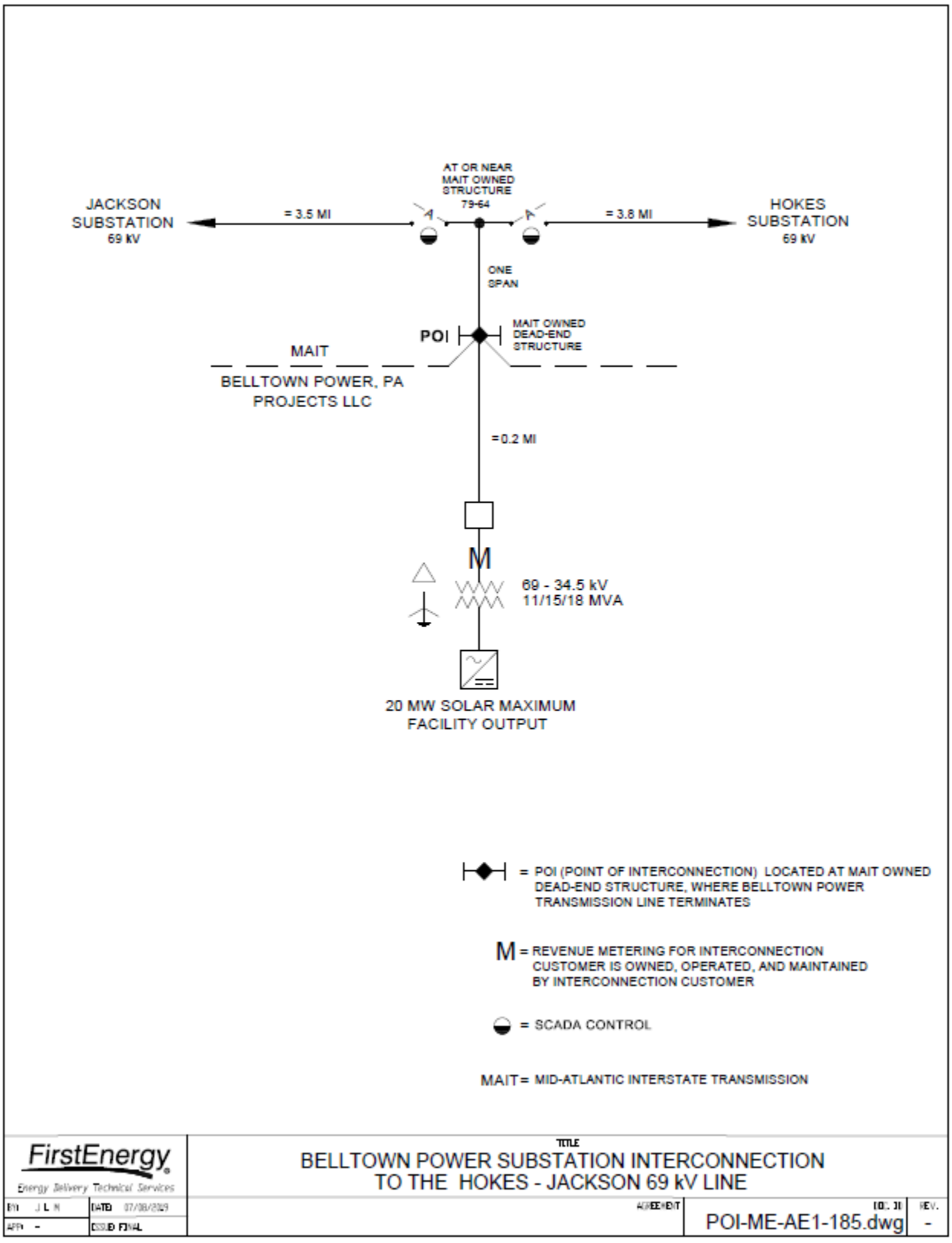
Please also note that the solar generating facility AE1-185 does not meet the reactive power requirement at the POI. To fulfill the power factor requirement, the estimated additional capacitive (lagging) reactive power is 0.28 MVAR.

Light Load

18 Light Load Analysis

Not applicable for solar projects.

19 Attachment 1- One Line



20 Attachment 2 – Project Location