Revised

Generation Interconnection

System Impact Study Report

for

Queue Project AE2-030

FROSTBURG 138KV

7.56 MW Capacity / 18 MW Energy

August 2021

Revision 1

Table of Contents

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 **Dan's Mountain Solar, LLC**, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is APS (Appalachian Power Systems – Potomac Edison 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 Revisions since February 2020 System Impact Study

The AE2-030 System Impact Study has been revised to reflect the results from a recent retool analysis as well as to incorporate the final stability analysis results. No other changes were made. Updates to the physical interconnection scope and cost will be reflected in the Facilities Study Report.

- Retooled analysis results show that the AE2-030 customer no longer has a contribution to the need for n6170 (Rockwood-Somerset 115 kV line rebuild). (See Network Impacts Section of the report.)
- Stability analysis results show no issues and the project meets the power factor requirements. (See Stability and Reactive Assessment Section 22 of the report.)

4 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Frostburg, Allegany County, Maryland. The installed facilities will have a total capability of 18 MW with 7.56 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is June 30, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AE2-030
Project Name	FROSTBURG 138KV
Interconnection Customer	Dan's Mountain Solar, LLC
State	Maryland
County	Allegany
Transmission Owner	APS
MFO	18
MWE	18
MWC	7.56
Fuel	Solar
Basecase Study Year	2022

5 Point of Interconnection

The interconnection of the project at the Primary POI will be accomplished by constructing a new 138 kV three (3) breaker ring bus substation and looping the Frostburg-Ridgeley 138 kV line into the new station. The new substation will be located approximately four miles from Frostburg 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 Finzel and Ridgeley substations.

Attachment 1 shows a one-line diagram of the proposed primary Direct Connection facilities for the AE2-030 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 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.

6 Cost Summary

The AE2-030 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$307,500
Direct Connection Network Upgrade	$8,761,900
Non Direct Connection Network Upgrades	$1,420,900
Allocation for New System Upgrades	$0
Contribution to Previously Identified Overloads	$0
Total Costs	**$10,490,300**

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 Up 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 AE2-030 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.

7 Transmission Owner Scope of Work

The interconnection of the project at the Primary POI will be accomplished by constructing a new 138 kV three (3) breaker ring bus substation and looping the Frostburg-Ridgeley 138 kV line into the new station. The new substation will be located approximately four miles from Frostburg 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 Finzel and Ridgeley substations.

7.1 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 Attachment Facilities associated with new 138 kV terminal at new 138 kV ring bus substation for new POI for AE2-030	$247,000
Engineering oversight of IC specification and installation of revenue metering equipment at generation facility. Support set up of Power Producer-owned metering in FE's MV90 and other systems.	$3,700
Customer nameplates and drawing review at AE2-030 substation	$56,800
Total Attachment Facility Costs	**$307,500**

7.2 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 three breaker ring bus (Old McDonald Substation) for the connection of AE2-030 to the Frostburg-Ridgeley 138 kV line	$6,389,800
Install microwave tower at AE2-030 to support SCADA communications to Dans Rock.	$821,800
Install microwave radio at Dans Rock to support SCADA transport to AE2-030 (Old McDonald substation)	$814,000

Description	Total Cost
Estimated in-sub fiber run to customer-built fiber run outside AE2-030 substation. Estimated SCADA work at Ridgeley substation to support relay installation. Estimated SCADA work at Finzel & Frostburg substations to support updated relay settings.	$107,700
Project Management, Environmental, Forestry, Real Estate.	$628,600
Total Direct Connection Facility Costs	**$8,761,900**

7.3 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 two new structures between existing structures 321 and 322 on the existing Finzel-Ridgeley 138 kV transmission line to loop the transmission line in/out of the new Old McDonald substation at AE2-030 Interconnect - Finzel-Ridgeley 138 kV line loop	$855,700
Line Name Change and Relay Settings at Frostburg	$144,300
Line Name Change & UPLC Replacement at Ridgeley	$268,200
Update NPs & Dwgs at Finzel	$152,700
Total Non-Direct Connection Facility Costs	**$1,420,900**

8 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 **24 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 and Direct Connection work. Full initial deposit is required for all Non-Direct Connection worl. 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 all transmission system outages will be allowed when requested.

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimate elapsed time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

9 Transmission Owner Analysis

9.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE2-030 project did not contribute to any overloads on the FE <100 kV transmission system.

10 Interconnection Customer Requirements

10.1 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.

10.2 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 138 kV circuit breaker to protect the AE2-030 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 AE2-030 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.

10.3 Power Factor Requirements

The IC shall design its 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.

11 Revenue Metering and SCADA Requirements

11.1 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.

11.1.1 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

11.2 APS 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.

12 Network Impacts

The Queue Project AE2-030 was evaluated as a 18.0 MW (Capacity 7.6 MW) injection at the tap of the Frostburg to Ridgeley 138 kV line in the APS area. Project AE2-030 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-030 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

13 Generation Deliverability

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

None

14 Multiple Facility Contingency

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

None

15 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

16 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

17 System Reinforcements

None

18 Flow Gate Details

The following indices 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

19 Affected Systems

19.1 NYISO

None

20 Contingency Descriptions

None

Short Circuit

21 Short Circuit

The following Breakers are overduty:

None

Stability

22 Stability Analysis and Reactive Power Assessment

22.1 Executive Summary

Generator Interconnection Request AE2-030 is for an 18 MW Maximum Facility Output (MFO) solar plant. AE2-030 consists of 5 x 3.7 MW SMA SC 4000 UP solar inverters with a Point of Interconnection (POI) tapping the 138 kV transmission connecting the Frostburg and Ridgeley substations in Allegany County, Maryland, in the First Energy (FE) transmission system.

The power flow scenario for the analysis was based on the RTEP 2022 summer peak case, modified to include applicable queue projects. AE2-030 has been dispatched online at maximum facility output, with approximately unity power factor at the high side of the station transformer.

AE2-030 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 53 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 with delayed clearing time
- Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at remote line end because of primary communications/relaying failure
- Single-phase faults with loss of multiple circuit towers

The 53 fault contingencies tested on the 2022 summer peak case met the recovery criteria:

- The AE2-030 generator was 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 voltages are within the steady-state voltage ranges below per FE's transmission planning criteria.
    - 500 kV Facilities: 0.97 to 1.1 p.u.
    - 345, 230, 138, and 69 kV Facilities: 0.92 to 1.05 p.u.
- No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

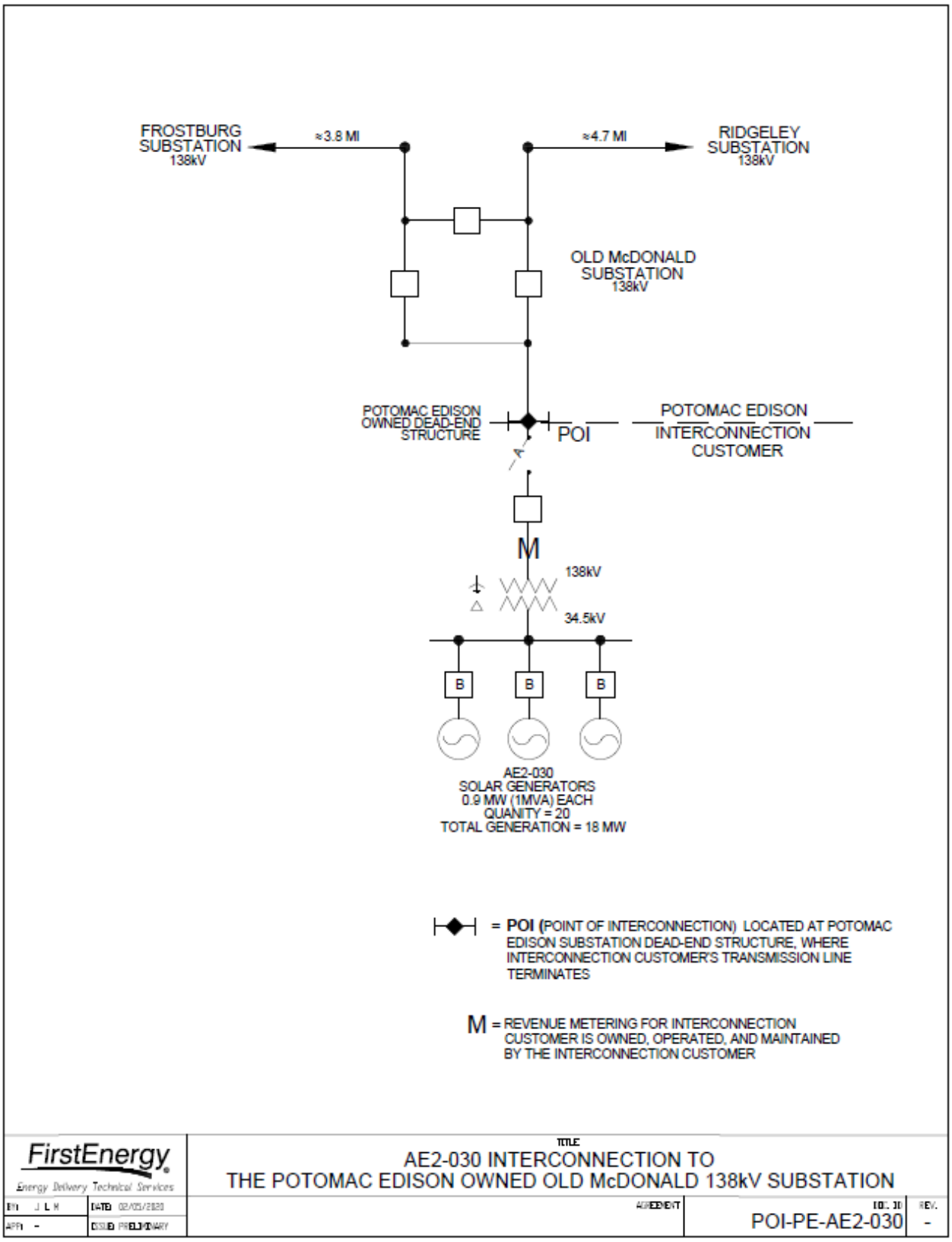
Based on the Impact Study Data provided, the AE2-030 queue project met both the 0.95 lagging power factor requirement and the 0.95 leading power factor requirement.

Light Load

23 Light Load Analysis

Not applicable to solar projects.

24 Attachment One: One Line Diagram



25 Attachment Two: Project Location