Revised

Generation Interconnection

System Impact Study Report

for

Queue Project AE1-139

Hunterstown 115 kV

39 MW Capacity / 65 MW Energy

December, 2021

Revision 1

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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 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 Revision Since August 2019 System Impact Study Report

The system impact study report has been revised to reflect retooled study results. The only remaining upgrade required is N6166 for reconductoring AD1-020 Tap-Lincoln 115 kV line for 1.5 mile. AE1-139 is the driver for this upgrade. No other information has been revised. Updated scope, cost and schedule will be provided in the facility study report.

4 General

Keystone State Renewables, LLC (Interconnection Customer) has proposed a new 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, 2021. **This study does not imply a Mid-Atlantic Interstate Transmission, LLC (Transmission Owner or MAIT) commitment to this in-service date.**

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Queue Number	AE1-139
Project Name	Hunterstown 115 kV substation
Interconnection Customer	Keystone State Renewables, LLC
State	Pennsylvania
County	Adams
Transmission Owner	ME
MFO	65
MWE	65
MWC	39
Fuel	Solar
Basecase Study Year	2022

4.1 Point of Interconnection

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

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE1-139 generation project to connect to the FirstEnergy ("FE") transmission system. Attachment 2 provides the proposed location for the point of interconnection. The IC will be responsible for constructing all of the facilities on its side of the POI.

4.2 Cost Summary

The AE1-139 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$2,700
Direct Connection Network Upgrade	$187,300
Non-Direct Connection Network Upgrade	$1,122,600
New System Upgrades	$3,900,000
Contribution to Previously Identified Upgrades	$0
Total Costs	$5,212,600

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 Non-Direct Connection work for the interconnection of the AE1-139 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 line terminal and dead-end structure at the existing Hunterstown 115 kV substation.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE1-139 generation project to connect to the FirstEnergy ("FE") transmission system. Attachment 2 provides the proposed location for the point of interconnection. The IC will be responsible for constructing all of the facilities on its side of the POI.

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
Revenue metering	$2,700
Total Attachment Facility Costs	$2,700

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
Project Management and Commissioning	$187,300
Total Direct Connection Facility Costs	$187,300

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
Add new 115 kV line terminal to the Hunterstown 115 kV Substation.	$793,200
Add new disconnect switch and dead-end structure at Hunterstown substation	$279,400
SCADA at Hunterstown substation to support relay installation.	$50,000
Total Non-Direct Connection Facility Costs	$1,122,600

6 New System Upgrades

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

Description	Total Cost
AD1-020 Tap –Lincoln 115 kV Line (962)- reconductor 1.5 miles to achieve higher conductor rating. 18 months to complete. PJM Network Upgrade n6166	$3,900,000
Total System Upgrade Facility Costs	$3,900,000

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 **12 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 payment 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.

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.

8 Transmission Owner Analysis

8.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The [QUEUE] 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.

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 AE1-139 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 AE1-139 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 AE1-139 was evaluated as a 65.0 MW (Capacity 39.0 MW) injection at Hunterstown 115 kV substation in the ME area. Project AE1-139 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-139 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

13 Multiple Facility Contingency

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

Overload	Contingency				Bus			Power	Loading %		Rating		MW	Flowgate
Number	Type	Name	Affected Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Appendix
1	BUS	ME-P2-2-ME-115-007B	METED - METED	AD1-020 TAP-27LINCOLN 115 kV line	933970	204544	None	N/A	N/A	102.91	ER	160	12.81	1

14 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

15 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

16 System Reinforcements

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	Cost Allocated to AE1-139
1	AD1-020 TAP-27LINCOLN 115 kV line	***Project Description:*** Reconductor line with larger conductor (1.5 miles). Cost ($) : 3,900,000 New Rating: Rate A: 136 MVA Rate B : 185 MVA Rate C : 185 MVA **Note: AE1-139 is the Driver for this overload.**	N6166	$3,900,000	$3,900,000

17 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.

17.1 Index 1

(METED - METED) The AD1-020 TAP-27LINCOLN 115 kV line (from bus 933970 to bus 204544 ckt 1) loads from 95.61% to 102.91% (AC power flow) of its emergency rating (160 MVA) for the bus fault outage of 'ME-P2-2-ME-115-007B'. This project contributes approximately 12.81 MW to the thermal violation.

CONTINGENCY 'ME-P2-2-ME-115-007B' /* HUNTERSTOWN 115 KV BUS 8 FAULT
DISCONNECT BRANCH FROM BUS 204575 TO BUS 204539 CKT 5 /* 27HUNTRST1 230 27HUNTRSTN 115
DISCONNECT BRANCH FROM BUS 204539 TO BUS 204668 CKT 1 /* 27HUNTRSTN 115 27TEX E TP 115
DISCONNECT BRANCH FROM BUS 204539 TO BUS 204543 CKT 1 /* 27HUNTRSTN 115 27LINC TAP 115
DISCONNECT BRANCH FROM BUS 204539 TO BUS 204551 CKT 1 /* 27HUNTRSTN 115 27OXFORD 115
END

Bus Number	*Bus Name*	*Full Contribution*
204646	*27HAM CT*	*0.43*
204647	*27HUNTR CT*	*2.08*
933973	*AD1-020 BAT*	*0.02*
933971	*AD1-020 C*	*12.3*
933972	*AD1-020 E*	*10.65*
939091	*AE1-138 C O1*	*1.65*
939092	*AE1-138 E O1*	*1.1*
939101	*AE1-139 C O1*	*7.69*
939102	*AE1-139 E O1*	*5.12*
LTF	*BLUEG*	*2.6*
LTF	*CALDERWOOD*	*0.33*
LTF	*CANNELTON*	*0.16*
LTF	*CATAWBA*	*0.23*
LTF	*CBM-N*	*0.78*
LTF	*CHEOAH*	*0.3*
LTF	*COFFEEN*	*0.28*
LTF	*COTTONWOOD*	*1.2*
LTF	*DUCKCREEK*	*0.59*
LTF	*EDWARDS*	*0.27*
LTF	*FARMERCITY*	*0.19*
LTF	*G-007A*	*3.04*
LTF	*GIBSON*	*0.11*
LTF	*HAMLET*	*0.4*
LTF	*NEWTON*	*0.72*

LTF	*NYISO*	*3.37*
LTF	*PRAIRIE*	*1.38*
LTF	*SMITHLAND*	*0.11*
LTF	*TATANKA*	*0.33*
LTF	*TILTON*	*0.32*
LTF	*TRIMBLE*	*0.29*
LTF	*TVA*	*1.01*
LTF	*UNIONPOWER*	*0.46*
LTF	*VFT*	*8.25*
930521	*AB1-096 C*	*-0.57*
930791	*AB1-124 C O1*	*-0.86*
930801	*AB1-125 C O1*	*-0.44*

Affected Systems

18 Affected Systems

None.

19 Contingency Descriptions

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CONTINGENCY 'ME-P2-2-ME-115-007B'                    /* HUNTERSTOWN 115 KV BUS 8 FAULT
 DISCONNECT BRANCH FROM BUS 204575 TO BUS 204539 CKT 5      /* 27HUNTRST1 230 27HUNTRSTN 115
 DISCONNECT BRANCH FROM BUS 204539 TO BUS 204668 CKT 1      /* 27HUNTRSTN 115 27TEX E TP 115
 DISCONNECT BRANCH FROM BUS 204539 TO BUS 204543 CKT 1      /* 27HUNTRSTN 115 27LINC TAP 115
 DISCONNECT BRANCH FROM BUS 204539 TO BUS 204551 CKT 1      /* 27HUNTRSTN 115 27OXFORD 115
 END
```

Short Circuit

20 Short Circuit

The following Breakers are overduty:

None

Stability

21 Stability Analysis and Reactive Power Assessment

21.1 Executive Summary

Generator Interconnection Request AE1-139 is for a 65 MW Maximum Facility Output (MFO) solar generating facility, which consists of 23 PE FS3150MU inverters. The AE1-139 solar generating facility will be located in Adams County, Pennsylvania.

Project AE1-139 will directly connect into the existing Hunterstown II 115 kV substation in the Metropolitan Edison (Met Ed) 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 AE1-139 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. AE1-139 has been dispatched online at maximum power output, with 0.83 power factor and approximately 1.01 pu voltage at the generator terminals.

AE1-139 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 116 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 116 fault contingencies tested on the 2022 peak load case:

a) AE1-139 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).

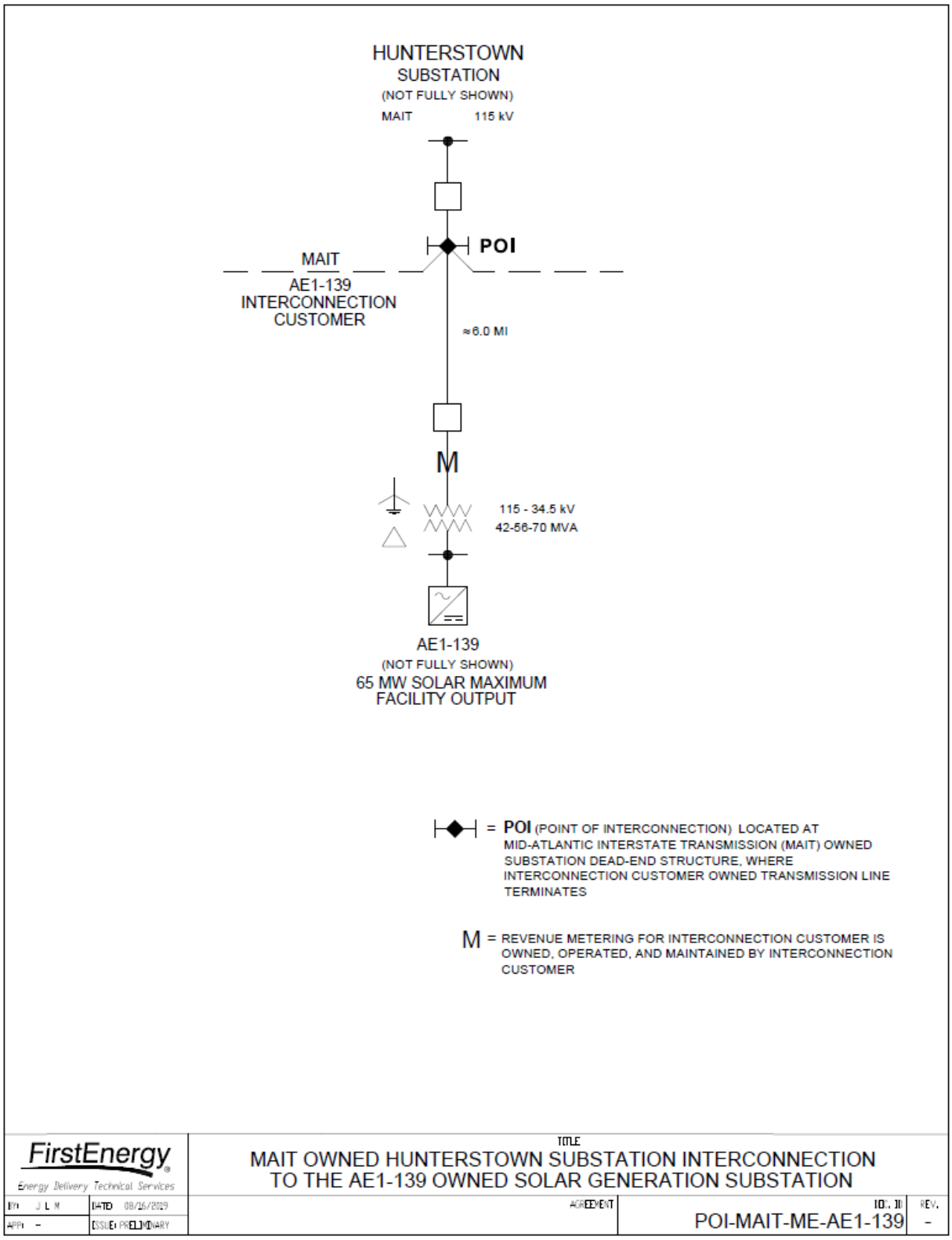
d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

Light Load

22 Light Load Analysis

Not required for solar projects.

23 Attachment 1 – One Line



24 Attachment 2 – Project Location