Generation Interconnection

REVISED System Impact Study Report

for

Queue Project AE2-345

HUNTERSTOWN-TEXAS EASTERN TAP 115 KV

42 MW Capacity / 70 MW Energy

March 2022

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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 Granite Hill Solar LLC, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Mid-Atlantic Interstate Transmission ("MAIT" in the Metropolitan 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 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 70 MW with 42 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is October 1, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AE2-345
Project Name	HUNTERSTOWN-TEXAS EASTERN TAP 115 KV
Interconnection Customer	Granite Hill Solar LLC
State	PA
County	Adams
Transmission Owner	MAIT (ME)
MFO	70
MWE	70
MWC	42
Fuel	Solar
Basecase Study Year	2022

4 Point of Interconnection

The interconnection of the project to the MAIT system will be accomplished by constructing a new 115 kV three (3) breaker ring bus substation and looping the Hunterstown – Texas Eastern Tap 115 kV line into the new station. The new substation would be located approximately four miles from Hunterstown substation.

Attachment 1 shows a one-line diagram of the proposed primary Direct Connection facilities for the AE2-345 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 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 AE2-345 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$296,200
Direct Connection Network Upgrade	$6,894,900
Non Direct Connection Network Upgrades	$757,100
System Upgrades	$0
Total Costs	**$7,948,200**

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 AE2-345 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 system will be accomplished by constructing a new 115 kV three (3) breaker ring bus substation and looping the Hunterstown – Texas Eastern Tap 115 kV line into the new station. The new substation would be located approximately four miles from Hunterstown substation.

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 ring bus substation	$242,700
Customer nameplate & drawing review at AE2-345 customer substation	$53,500
Total Attachment Facility Costs	**$296,200**

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
Construct a new three-breaker 115 kV ring bus	$5,751,100
Design, install, and test/commission MPLS equipment for SCADA transport.	$208,400
Install fiber from AE2-345 to Hunterstown for relaying communication & MPLS transport.	$521,500
Estimated in-sub fiber run to customer-built fiber run outside AE2-345 substation. Estimated SCADA work at Hunterstown & Gardners substation to support updated relay settings.	$75,100
Project Management, Environmental, and Real Estate.	$338,800
Total Direct Connection Facility Costs	**$6,894,900**

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
Loop the Gardners - Hunterstown 115 kV line into the new three-breaker ring bus, approximately four miles from the Hunterstown substation.	$484,900
Line name change drawings & nameplates at Hunterstown	$136,100
Line name change drawings & nameplates at Gardners	$136,100
Total Non-Direct Connection Facility Costs	**$757,100**

7 Schedule

Based on the scope of work for the Attachment Facilities and the Direct and Non-Direct Connection facilities, it is expected to take a minimum of **20 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 will be required for 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 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 estimated time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

8 Transmission Owner Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE2-345 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 AE2-345 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 AE2-345 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 FirstEnergy 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 AE2-345 was evaluated as a 97.5 MW (Capacity 58.5 MW) injection at the tap of the Hunterstown to Texas Eastern TP 115 kV line in the ME area. Project AE2-345 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-345 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)

None.

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.

Overload	Contingency		Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution
Number	Type	Name			From	To			Initial	Final	Type	MVA	
1	N-1	ME-P1-2-ME-115-022-A	METED - METED	27HUNTRSTN-AD1-020 TAP 115 kV line	204539	933970	1	AC	101.5	122	ER	160	8.35
2	N-1	ME-P1-2-ME-115-016-A	METED - METED	27LINC TAP-27LINCOLN 115 kV line	204543	204544	1	AC	107	112	ER	152	8.1
3	N-1	ME-P1-2-ME-115-022-A	METED - METED	AD1-020 TAP-27LINCOLN 115 kV line	933970	204544	1	AC	100.6	106	ER	160	8.35

16 System Reinforcements

None.

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.

None.

Affected Systems

18 Affected Systems

No Impacts.

19 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
ME-P1-2-ME-115-022-A	CONTINGENCY 'ME-P1-2-ME-115-022-A' /* LINCOLN JUNCTION 115 KV LINES DISCONNECT BRANCH FROM BUS 204543 TO BUS 204539 CKT 1 /* 27LINC TAP 115 27HUNTRSTN 115 DISCONNECT BRANCH FROM BUS 204543 TO BUS 204544 CKT 1 /* 27LINC TAP 115 27LINCOLN 115 DISCONNECT BRANCH FROM BUS 204543 TO BUS 939100 CKT 1 /* 27LINC TAP 115 AE1-139 TAP 115 DISCONNECT BUS 204543 /* 27LINC TAP 115 END

Short Circuit

20 Short Circuit

The following Breakers are overduty:

None.

Stability

21 Stability Analysis and Reactive Power Assessment

Generator Interconnection Request AE2-345 is for a 70 MW Maximum Facility Output (MFO) solar generating facility, which consists of 23 Power Electronics PE FS3430 inverters. The AE2-345 solar generating facility will be located in Adams County, Pennsylvania.

Project AE2-345 will be accomplished by constructing a new 115 kV three breaker ring bus substation and looping the Hunterstown – Texas Eastern Tap 115 kV line into the new station via approximately 3 miles 115 kV transmission line. The new substation will be located approximately 4.2 miles from Hunterstown substation in the Metropolitan Edison (Met Ed) zone of Mid-Atlantic Interstate Transmission, LLC (MAIT), FirstEnergy (FE) Transmission System. The Point of Interconnection (POI) will be where the Interconnection Customer transmission line attaches to the line terminal dead-end structure.

This report describes a dynamic simulation analysis of AE2-345 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. AE2-345 has been dispatched online at maximum power output, with approximately unity power factor at the high side of GSU, 1.02 pu voltage at the generator terminal and 1.02 pu voltage at the POI bus.

AE2-345 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 77 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 77 fault contingencies tested on the 2022 peak load case:

a) AE2-345 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.

AE2-345 was tripped during the three-phase fault application at the POI as a result of fictitious frequency spikes at the frequency relay monitored bus. Therefore, the frequency relay was disabled during the model development tests and the issues were resolved.

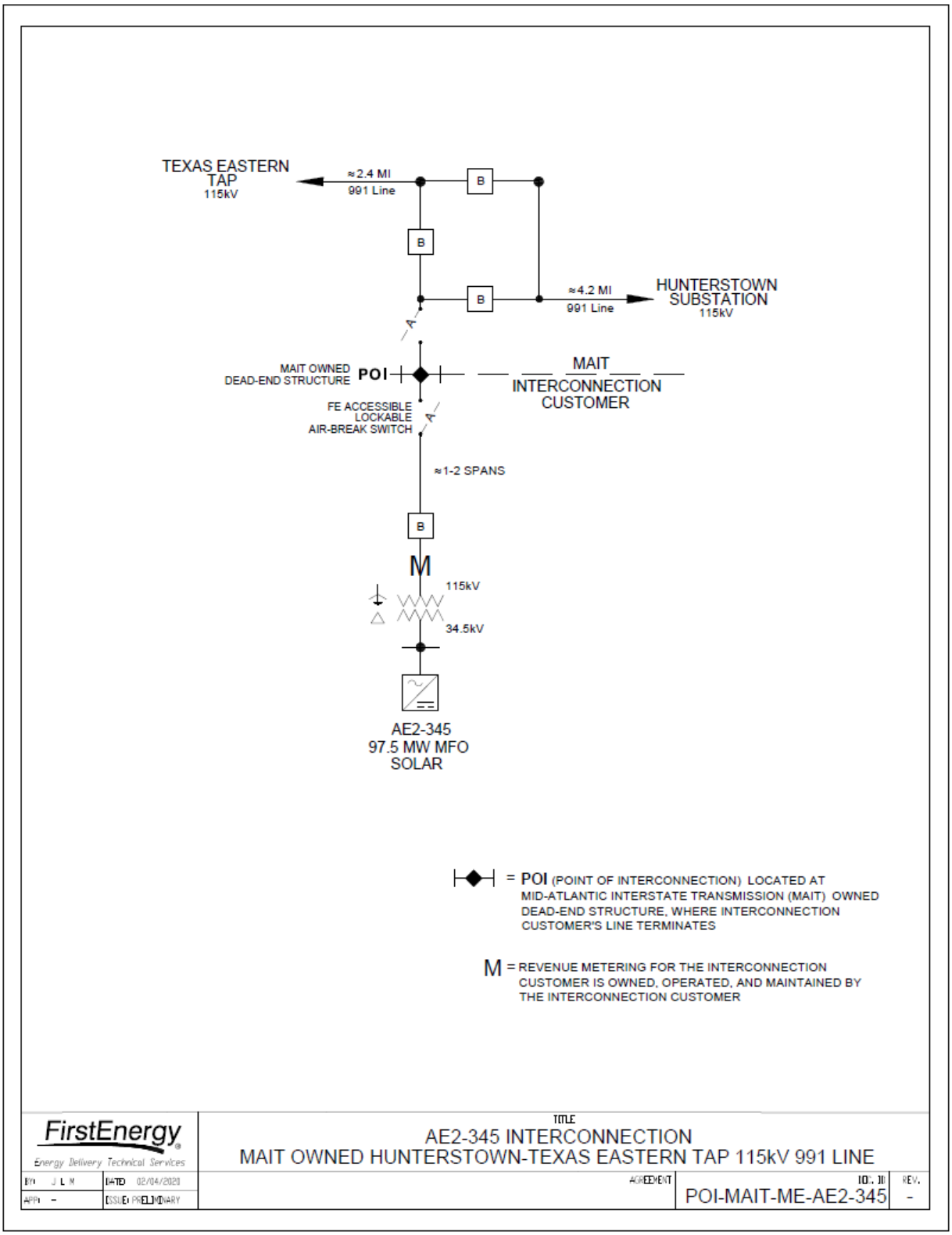
AE2-345 meets the 0.95 leading and lagging reactive power requirement at the high side of the facility main power transformer.

Light Load

22 Light Load Analysis

Not applicable to solar projects.

23 Attachment One: One Line Diagram



24 Attachment Two: Project Location