Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA1-122

Antietam 34.5 kV Generation Project

September, 2015

System Impact Study Report

Antietam 34.5 kV Generation Project

Introduction

This System Impact Study report provides the documentation of an assessment that has been performed by PJM Interconnection, LLC and FirstEnergy (FE) in response to a request made by Hecate Energy, LLC for the connection of a 10.0 MW (3.8 MW Capacity) PV generation project to the Antietam 34.5 kV substation, PJM queue number (AA1-122), on the Potomac Edison transmission system

Connection Facilities

In compliance with the RTEP protocol, Hecate Energy, LLC has submitted a "Form of System Impact Study Agreement" to PJM that identifies its plan to construct the Antietam 34.5 kV (AA1-122) Generation Project, with PV cells. The installed facilities will have a total generating capability of 10.0 MW, of which, 3.8 MW will be recognized by PJM as a capacity resource.

As defined by Hecate Energy, LLC and shown on Attachment 1, the proposed Hecate Energy, LLC site will be located at a point approximately 2.8 miles from Antietam substation. The direct connection of this project will be accomplished by extending the existing 34.5 kV bus at Antietam substation. Attachment 2 shows a conceptual one-line diagram of the proposed direct connection of (AA1-122) to the Potomac Edison transmission system. The Hecate Energy, LLC will be responsible for constructing all of the facilities on its side of the Point of Interconnection (POI) including the attachment line. Hecate Energy, LLC may not install above ground equipment within any Potomac Edison right-of-way unless permission to do so is expressly granted by Potomac Edison. The Potomac Edison facilities required to be upgraded for the Direct Connection of the generation project and the associated cost estimate are shown in Attachment 3.

PJM Interconnection Study Results

The following is the report describing the results of the analysis performed by PJM engineers with respect to the transmission system impacts

Network Impacts

The Queue Project AA1-122 was studied as a 10.0 MW (Capacity 3.8 MW) injection at the Antietam 34.5 kV substation in the APS area. Project AA1-122 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA1-122 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2018

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

None

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

None

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

Steady-State Voltage Requirements
(Results of the steady-state voltage studies should be inserted here)

None

Delivery of Energy Portion of Interconnection Request

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.
Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

None

Light Load Analysis - 2018

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

System Reinforcements

New System Reinforcements
(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Short Circuit
(Summary form of Cost allocation for breakers will be inserted here if any)

None

Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

Not required

Appendices

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

Interconnected Transmission Owner's Analysis Results

The following was prepared by FirstEnergy the Interconnected Transmission Owner, based upon its analysis, as well as that of PJM, for mitigation of the project's impacts on the transmission and lower voltage system as applicable. It includes the costs and schedules for any system upgrades.

Power Flow Analysis

A power flow study was conducted to determine the reliability impact of the proposed (AA1-122) generation project on the Potomac Edison transmission system. This study was completed using a 2018 and 2015 summer peak power flow model that contain a detailed representation of the Potomac Edison transmission networks in the area of the proposed (AA1-122) generation project. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the ReliabilityFirst, PJM, or FE Planning Criteria and are attributable to this project. Note that in accordance with PJM RTEP study procedures, the (AA1-122) generation project under study and earlier active queue projects are considered to be in-service. All active queue projects after the (AA1-122) project are considered not in-service.

For the POI (see Attachment 2), the (AA1-122) generation project connected to the 34.5 kV bus at Antietam substation. The results of the FE analysis show that there are no transmission network upgrades required for the deliverability of the (AA1-122) generation project to the Potomac Edison transmission systems (see Attachment 4).

Note that a further conclusion of this study is that it will be mandatory for the (AA1-122) generation project to have a range of dynamic reactive capability that supports its operation from a 0.95 leading to 0.95 lagging power factor at the POI. The FE studies show that the addition of solar projects can cause voltage swings as their output oscillates with moving clouds without continuous regulation, and system voltages can exceed the established limits. Should Hecate Energy, LLC fail to provide dynamic reactive capability from the (AA1-122) generation project for any reason once interconnected, the FE and/or PJM Dispatchers may need to take action to curtail both the energy and capacity portion of its output to prevent non-compliance with voltage criteria.

Short Circuit and Dynamics Analysis

In accordance with the RTEP process, a short circuit analysis was not conducted by PJM since the (AA1-122) generation project connection is to the Potomac Edison transmission system less than 100 kV. Therefore, the FE Protection staff conducted a short circuit review of the project connection. An assumption of this study was that solar generation projects will contribute no appreciable fault current to the breakers on the Potomac Edison transmission system. As stated by EPRI: "Inverters are generally designed to limit fault currents to 130% or less of rated

current. Thus they can usually be disregarded when conducting fault studies."[1] Based on this statement, the results of the FE analysis showed that no Potomac Edison circuit breaker will exceed its interrupting capability with the implementation of the (AA1-122) generation project. Therefore no circuit breaker reinforcements will be required.

A dynamics study wasn't performed for the (AA1-122) generation project since it is an inverter based PV project less than 70 MW.

System Protection Analysis

An analysis was conducted to assess the impact of the (AA1-122) generation project on the system protection requirements in the area. The results of this review have identified the following:

The inverters associated with the Antietam 34.5 kV (AA1-122) generation project shall comply with IEEE 1547 and UL 1741. In addition, the GSU connecting to the Potomac Edison system shall be delta-wye, with the delta on the Potomac Edison side. This is to provide isolation for ground faults and to prevent the solar installation from becoming a ground source. The GSU transformers and all 34.5 kV facilities at the customer substation shall have redundant high speed protection.

Metering

Hecate Energy, LLC will be required to comply with all FE revenue metering requirements for generation interconnection customers. The FE revenue metering requirements may be found in the FE "Requirements for Transmission Connected Facilities" document located at the following links:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

Compliance Issues

The proposed interconnection facilities must be designed in accordance with the FE "Requirements for Transmission Connected Facilities" document located at:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

Hecate Energy, LLC will also be responsible for following the requirements of the FE "Approved Vendors and Contractors" document which is also located at the above link.

Hecate Energy, LLC will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, Hecate Energy, LLC

[1] EPRI Document TR-111490 "Integration of Distributed Resources in Electric Utility Distribution Systems: Distribution System Behavior Analysis for Suburban Feeder", published November 1998, page 62

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 Potomac Edison system.

PE Facility Upgrades and Costs

The results of the FE power flow analysis for the Antietam 34.5 kV (AA1-122) generation project show that there are no FE criteria violations directly attributable to the capacity of the (AA1-122) generation project. Therefore in accordance with the RTEP procedures defined in the PJM Open Access Transmission Tariff and PJM Manuals, the (AA1-122) generation project is not responsible for network upgrades.

The Direct Connection requirements for the (AA1-122) generation project to the Potomac Edison transmission system are detailed in Attachment 3. The associated one-line with the generation project primary Direct Connection is shown in Attachment 2. Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to change. More accurate estimates will be determined as a part of the Facilities Study. Hecate Energy, LLC will be responsible for the actual cost of the direct connection that is implemented. In addition, Hecate Energy, LLC is responsible to provide metering, disconnect switches and high-side breakers for each unit, as Hecate Energy, LLC will own this equipment. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission system.

Hecate Energy, LLC Requirements

In addition to the Potomac Edison facilities, Hecate Energy, LLC will also be responsible for meeting all criteria as specified in the applicable sections of the FE "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 34.5 kV circuit breaker on the high side of the (AA1-122) step-up transformer.

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. The establishment of dedicated communication circuits for SCADA to the FE Transmission System Control Center.

5. A compliance with the FE and PJM generator power factor and voltage control requirements.

6. The execution of a back-up service agreement to serve the customer load supplied from the (AA1-122) generation project interconnection point when the units are out-of-service. This assumes the intent of Hecate Energy, LLC is to net the generation with the load.

The above requirements are in addition to any metering or other requirements imposed by PJM.

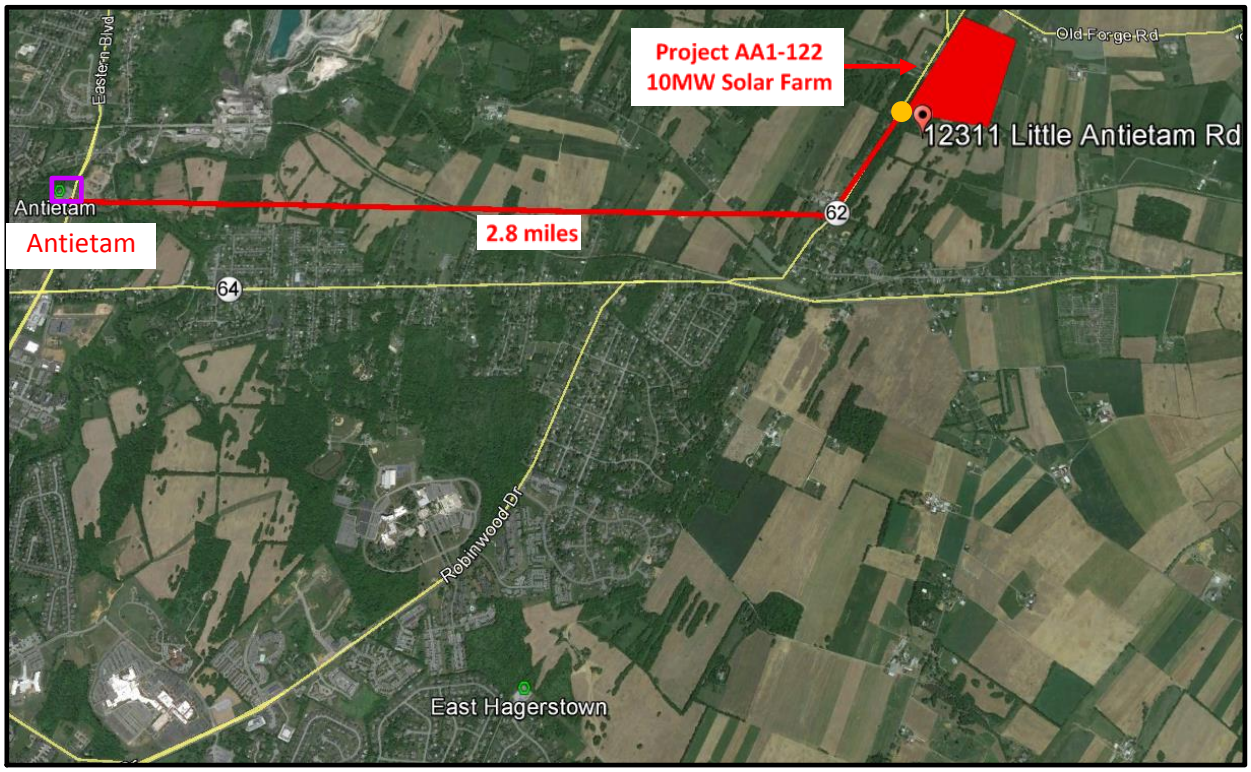
Summary

The Hecate Energy, LLC Antietam 34.5 kV (AA1-122) Generation Project primary Direct Connection will require the facility upgrades defined in Attachment 3. As shown in Attachment 3, the estimated cost of the new (AA1-122) primary Direct Connection facilities is $505,700. This cost includes a Federal Income Tax Gross Up charge of $120,700. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129. Power flow results for the (AA1-122) generation project show that no facility upgrades in the Potomac Edison service territory are required.

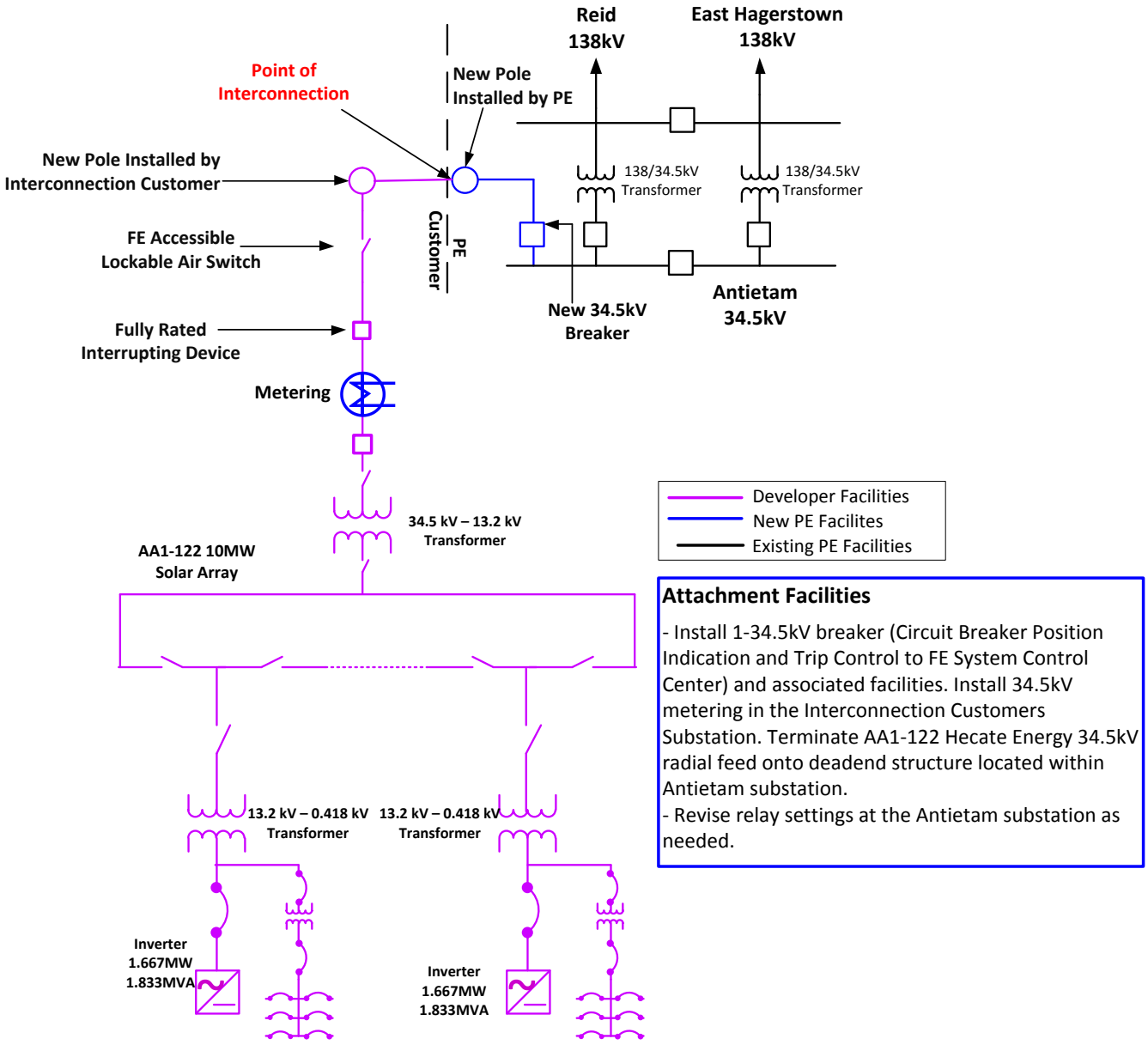
Based on the extent of the Potomac Edison primary Direct Connection required to support the (AA1-122) generation project, it is expected to take a minimum of fifteen (15) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes the requirement for Hecate Energy, LLC to make a preliminary payment to FE which funds the first three months of engineering design that is related to the construction of the Direct Connection facilities. It further assumes that Hecate Energy, LLC will provide all rights-of-way, permits, easements, etc. that will be needed. A further assumption is 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 system outages will be allowed when requested.

Note that the FE findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in the Facilities Study. Further note that the cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

Attachment 1
Project Location



Attachment 2
POI Proposed Interconnection Single Line Diagram



Attachment Facilities

- Install 1-34.5kV breaker (Circuit Breaker Position Indication and Trip Control to FE System Control Center) and associated facilities. Install 34.5kV metering in the Interconnection Customers Substation. Terminate AA1-122 Hecate Energy 34.5kV radial feed onto deadend structure located within Antietam substation.
- Revise relay settings at the Antietam substation as needed.

Attachment 3
Direct Connection Requirements

Number of Months to Complete --- 15 Months.

SS/LN	Estimate No.	Description	Total with Tax	Tax	Total Cost
		DC Sub-Total.	-	-	-
SS	PE-S-227A	**Antietam Substation:** Install a 34.5kV breaker and associated facilities for line to AA1-122 generator. This includes relocating the No. 2 bus PTs.	$453,000	$106,600	$346,400
0	Metering	34.5 kV Metering package in the Customer's substation.	$52,700	$14,100	$38,600
		NDC Sub-Total.	$505,700	$120,700	$385,000
		Totals	**$505,700**	**$120,700**	**$385,000**

Attachment 4
PJM Contingency Analysis Results

Table 1: Overloads Identified by PJM Energy Deliverability Study

Outage Description	Overloaded Element	Rating (MVA)	CTG Flow (MVA)	% 4-Hr Rating
None				