Generation Interconnection

Impact Study Report

for

Queue Project AE1-106

LAKE LYNN-HAZELTON 138 KV

59 MW Capacity / 99.6 MW Energy

January, 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 the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Monongahela Power Company (APS 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 Preston County, West Virginia. The installed facilities will have a total capability of 99.6 MW with 59 MW of this output being recognized by PJM as Capacity.

Queue Number	**AE1-106**
Project Name	LAKE LYNN-HAZELTON 138 KV
Interconnection Customer	Brandonville Solar I, LLC
State	West Virginia
County	Preston
Transmission Owner	APS
MFO	99.6
MWE	99.6
MWC	59
Fuel	Solar
Basecase Study Year	2022

Any new service customers who can feasibly be commercially operable prior to June 1st of the basecase study year are required to request interim deliverability analysis.

4 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 Lake Lynn-106 Junction 138 kV line into the new station. The new substation will be located approximately 11.3 miles from Lake Lynn 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 Albright, Hazelton, and Lake Lynn substations.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE1-106 generation project to connect to the FirstEnergy ("FE") transmission system. 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.

5 Cost Summary

The AE1-106 project will be responsible for the following costs:

Description	Total Cost
Total Physical Interconnection Costs	$ 8,644,800[1]
Allocation towards System Network Upgrade Costs (PJM Identified - Summer Peak)*	$ 0
Allocation towards System Network Upgrade Costs (TO Identified)*	$ 0
Total Costs	$ 8,644,800

*As your project progresses through the study process and other projects modify their request or withdraw, then your cost allocation could change.

This cost excludes a Federal Income Tax Gross Up charges. This tax may or may not be charged based on whether this project meets the eligibility requirements of IRS Notice 88-129. If at a future date it is determined that the Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

[1] No mitigations were found to be required due to instability; however, based on the Impact Study Data provided, it was observed that the AE1-106 plant is deficient in lagging power factor requirement by 3.25 MVAR. This may need to be addressed through reactive compensation.

Note 1: 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.

Note 2: For customers with System Reinforcements listed: If your present cost allocation to a System Reinforcement indicates $0, then please be aware that as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, the cost responsibilities can change and a cost allocation may be assigned to your project. In addition, although your present cost allocation to a System Reinforcement is presently $0, your project may need this system reinforcement completed to be deliverable to the PJM system. If your project comes into service prior to completion of the system reinforcement, an interim deliverability study for your project will be required.

6 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 Lake Lynn-106 Junction 138 kV line into the new station. The new substation will be located approximately 11.3 miles from Lake Lynn 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 Albright, Hazelton, and Lake Lynn substations.

The total physical interconnection costs is given in the table below.

Description	**Total Cost**
New three breaker 138 kV ring bus for AE1-106 interconnection at Bruceton Mills (AE1-106) substation	$ 7,025,100
Loop the Albright-Hazelton-Lake Lynn 138 kV line in and out of the new Bruceton Mills (AE1-106) substation.	$ 905,000
Add anti-islanding transmitters at Hazelton substation	$ 173,300
Add anti-islanding transmitters at Albright substation	$ 173,300
Replace line relaying and add anti-islanding transmitters at Lake Lynn substation	$ 368,100
Total Physical Interconnection Costs	$ 8,644,800

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 **18 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 interconnection substation. 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.

8 Transmission Owner Analysis

8.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE1-106 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: https://www.pjm.com/-/media/planning/plan-standards/private-fe/fcr-facilities-connection-requirements.ashx. 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.

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: https://www.pjm.com/-/media/planning/plan-standards/private-fe/fcr-facilities-connection-requirements.ashx. 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 AE1-106 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 AE1-106 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 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.

10.2 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: https://www.pjm.com/-/media/planning/plan-standards/private-fe/fcr-facilities-connection-requirements.ashx

11 Summer Peak Analysis

The Queue Project AE1-106 was evaluated as a 99.6 MW (Capacity 59.0 MW) injection on the Lake Lynn-106 Junction 138 kV line in the APS area. Project AE1-106 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-106 was studied with a commercial probability of 1.00. Potential network impacts were as follows:

11.1 Generation Deliverability

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

None

11.2 Multiple Facility Contingency

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

None

11.3 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

11.4 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

11.5 System Reinforcements

None

11.6 Flow Gate Details

None

12 Light Load Analysis

Not required for solar projects.

13 Short Circuit

The following Breakers are overduty:

None

14 Stability Analysis and Reactive Power Assessment

Generator Interconnection Request AE1-106 is for a 99.6 MW Maximum Facility Output (MFO) solar generation plant. AE1-106 consists of 31 x 3.2516 MW TMEIC PVH-L3360GR solar inverters with a total capacity of 100.8 MW. The Point of Interconnection POI is at a tap on the Lake Lynn – Hazelton 138 kV transmission line in the Allegheny Power (APS) transmission system, Preston County, West Virginia.

This report describes a dynamic simulation analysis of AE1-106 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. AE1-106 has been dispatched online at maximum power output, with 1.0 p.u. voltage at the generator bus.

AE1-106 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 79 contingencies were studied, each with a 20 second simulation time period. Studied faults included:

a) Steady state operation (20 second);
b) Three phase faults with normal clearing time;
c) Single-phase bus faults with normal clearing time;
d) Single-phase faults with stuck breaker;
e) 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;
f) Three-phase faults with loss of multiple-circuit tower line.

No relevant high-speed reclosing (HSR) contingencies were identified for this study.

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

For all of the fault contingencies tested on the 2022 peak load case:

a) AE1-106 was able to ride through the faults (except for faults where protective action trips a generator(s)),
b) The system with AE1-106 included is transiently stable and post-contingency oscillations were positively damped with a damping margin of at least 3%.
c) Following fault clearing, all bus voltages recovered to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).
d) No transmission element tripped, other than those either directly connected or designed to trip as a consequence of that fault.

Based on the Impact Study Data provided, the reactive power capability of AE1-106 meets the 0.95 leading PF requirement at the high side of the main transformer; however, it does NOT meet the 0.95 lagging PF requirement at the high side of the main transformer.

Non-convergences were observed at the AD1-068 generator bus[2] for several timesteps after fault clearing in several contingencies. This did not result in any network stability issues and AD1-068 generator performed normally in these contingences.

AD1-068 exhibited slow reactive power recovery for several contingencies. This issue did not cause instability in the system and the model can be tuned to have faster reactive power output settlement upon request.

No mitigations were found to be required due to instability; however, based on the Impact Study Data provided, it was observed that the AE1-106 plant is deficient in lagging power factor requirement by 3.25 MVAR. This may need to be addressed through reactive compensation.

[2] *Note: AD1-068 has withdrawn from the queue since this stability analysis was performed.*

15 Affected Systems

None

16 Attachment 1 – One Line