Generation Interconnection

System Impact Study Report

for

Queue Project AF1-057

JACKSON-THREE MILE ISLAND 230 KV II

8.4 MW Capacity / 20 MW Energy

August 2020

Table of Contents

1 Introduction 4
2 Preface 4
3 General 5
4 Point of Interconnection 6
5 Cost Summary 6
6 Transmission Owner Scope of Work 8
7 Schedule 8
8 Transmission Owner Analysis 8
8.1 Power Flow Analysis 8
9 Interconnection Customer Requirements 8
9.1 System Protection 8
9.2 Compliance Issues and Interconnection Customer Requirements 8
9.3 Power Factor Requirements 9
10 Revenue Metering and SCADA Requirements 10
10.1 PJM Requirements 10
10.2 Meteorological Data Reporting Requirements 10
10.3 Interconnected Transmission Owner Requirements 10
11 Summer Peak Analysis 11
11.1 Generation Deliverability 11
11.2 Multiple Facility Contingency 11
11.3 Contribution to Previously Identified Overloads 11
11.4 Steady-State Voltage Requirements 11
11.5 Potential Congestion due to Local Energy Deliverability 11
11.6 System Reinforcements 12
11.7 Flow Gate Details 13
11.8 Queue Dependencies 14
11.9 Contingency Descriptions 15
12 Light Load Analysis 16
13 Short Circuit Analysis 16
14 Stability and Reactive Power 17
14.1 Executive Summary 17

15 Affected Systems 19
16 Attachment 1: One Line Diagram 20

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 Mid-Atlantic Interstate Transmission, LLC (MAIT) (Meted 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 an uprate to a planned/existing Solar generating facility located in York, Pennsylvania. This project is an increase to the Interconnection Customer's AE2-211 project, which will share the same point of interconnection. The AF1-057 queue position is a 20 MW uprate (8.4 MW Capacity uprate) to the previous project. The total installed facilities will have a capability of 75 MW with 31.5 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this uprate project is June 30, 2022. This study does not imply a TO commitment to this in-service date.

Queue Number	AF1-057
Project Name	JACKSON-THREE MILE ISLAND 230 KV II
State	Pennsylvania
County	York
Transmission Owner	ME
MFO	75
MWE	20
MWC	8.4
Fuel	Solar
Basecase Study Year	2023

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

AF1-057 will interconnect with the ME on transmission system as an uprate to AE2-211 tapping the Jackson to TMI 230 kV line.

The interconnection of the project will be accomplished by constructing a new 230 kV three breaker ring bus substation and looping the Jackson - TMI 230 kV line into the new station. This direct connection point will be established by the preceding AE2-211 project. It is anticipated that there will be no new direct connect costs associated with the AF1-057 project.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AF1-057 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 AF1-057 project will be responsible for the following costs:

Description	Total Cost
Total Physical Interconnection Costs	$0 (See Note 3)
Allocation towards System Network Upgrade Costs*	$0
Total Costs	$0

*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.

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.

Note 3: The solar generating facility AF1-057 (combined with AE2-211) does not meet the reactive power requirement. The estimated required additional capacitive reactive power is 15.198 Mvar. The customer is required to compensate for this deficiency. (See "Stability and Reactive Power" Executive Summary in Section 14 below).

6 Transmission Owner Scope of Work

The interconnection of the project will be accomplished by constructing a new 230 kV three breaker ring bus substation and looping the Jackson - TMI 230 kV line into the new station. This direct connection point will be established by the preceding AE2-211 project. It is anticipated that there will be no new direct connect costs associated with the AF1-057 project.

No additional interconnection work is required as AF1-057 is an uprate to AE2-211.

NOTE: If AE2-211 withdraws from the interconnection queue, then this project will be responsible for the interconnection work identified in the AE2-211 System Impact Study Report and the analysis results will need to be retooled for any required system reinforcements.

7 Schedule

AF1-057 is an increase to the AE2-211 project. Therefore, there no additional facilities work is required to be completed outside of the scope of the AE2-211 project.

8 Transmission Owner Analysis

8.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AF1-057 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.

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 230 kV circuit breaker to protect the AF1-057 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 AF1-057 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.

10.2 Meteorological Data Reporting Requirements

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Back Panel temperature (Fahrenheit)
- Irradiance (Watts/meter^2)
- Ambient air temperature (Fahrenheit) – (Accepted, not required)
- Wind speed (meters/second) – (Accepted, not required)
- Wind direction (decimal degrees from true north) – (Accepted, not required)

10.3 Interconnected Transmission Owner 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 Summer Peak Analysis

The Queue Project AF1-057 was evaluated as a 20 MW (Capacity 8.4 MW) injection as an uprate to AE2-211 tapping the Jackson to TMI 230 kV line in the ME area. Project AF1-057 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-057 was studied with a commercial probability of 100.0 %. 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 Steady-State Voltage Requirements

See Stability and Reactive Power Executive Summary in Section 14 below.

11.5 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

11.6 System Reinforcements

None

11.7 Flow Gate Details

The following indices contain additional information about each facility presented in the body of the report. For each index, a description of the flowgate and its contingency was included for convenience. The intent of the indices is to provide more details on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the indices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the indices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators. It should be noted the project/generator MW contributions presented in the body of the report are Full MW Impact contributions which are also noted in the indices column named "Full MW Impact", whereas the loading percentages reported in the body of the report, take into consideration the PJM Generator Deliverability Test rules such as commercial probability of each project as well as the ramping impact of "Adder" contributions. The MW Impact found and used in the analysis is shown in the indices column named "Gendeliv MW Impact".

None

11.8 Queue Dependencies

The Queue Projects below are listed in one or more indices for the overloads identified in your report. These projects contribute to the loading of the overloaded facilities identified in your report. The percent overload of a facility and cost allocation you may have towards a particular reinforcement could vary depending on the action of these earlier projects. The status of each project at the time of the analysis is presented in the table. This list may change as earlier projects withdraw or modify their requests.

None

11.9 Contingency Descriptions

None

12 Light Load Analysis

Not required for solar projects.

13 Short Circuit Analysis

The following Breakers are overdutied:

None

14 Stability and Reactive Power

(Summary of the VAR requirements based upon the results of the dynamic studies)

14.1 Executive Summary

Generator Interconnection Request AF1-057 is for a 20 MW Maximum Facility Output (MFO) uprate to a planned solar generating facility AE2-211 located in York County, Pennsylvania. The incremental solar project AF1-057 as separate new queue application consists of 8 additional SMA Sunny Central SC 2.75 MVA inverters. The uprated project will be a total of 29 inverters (21 from original project AE2-211 + 8 additional from AF1-057) with total 75 MW MFO (55 MW from AE2-211 and 20 MW from AF1-057) connecting to the Metropolitan Edison (Met-Ed/ME) transmission system.

AF1-057 will share the same property and point of interconnection with AE2-211. The interconnection of the project at the Point of Interconnection (POI) will be accomplished by constructing a new 230 kV three breaker ring bus substation and looping the Jackson – Three Mile Island (TMI) 230 kV line into the new interconnection yard. The new substation will be located approximately 5.92 miles from Jackson substation and 11.6 miles from TMI substation. The project will interconnect via an approximate 0.15 miles gen tie attaching to the line terminal dead-end structure to the POI.

This report describes a dynamic simulation analysis of AF1-057 as part of the overall system impact study. The load flow scenario for the analysis was based on the RTEP 2023 peak load case, modified to include applicable queue projects. AF1-057 has been dispatched online at maximum power output, with unity power factor and approximately 1.01 pu voltage at the generator terminals.

AF1-057/AE2-211 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 78 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);

For all 78 fault contingencies tested on the 2023 peak load case:

a) AF1-057/AE2-211 was able to ride through the faults.

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 other transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

Solar generating facility AF1-057 (combined with AE2-211) does not meet the reactive power requirement. The estimated required additional capacitive reactive power is 15.198 Mvar. The customer is required to compensate for this deficiency.

15 Affected Systems

None

16 Attachment 1: One Line Diagram