Generation Interconnection

Revised System Impact Study Report

for

Queue Project AE2-290

NOTTINGHAM 138 KV

60 MW Capacity / 100 MW Energy

August 2022

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1 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, a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. 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 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.

An Interconnection Customer with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2 General

BQ Energy Development, LLC has proposed to install PJM project # AE2-290, a Solar generating facility located in Harrison County, Ohio (See Figure 2). The installed facilities will have a total capability of 100 MW with 60 MW of this output being recognized by PJM as Capacity. The Point of Interconnection will be to AEP's Nottingham 138 kV substation (See Figure 1).

The proposed in-service date for this project is September 30, 2021. This study does not imply AEP's commitment to this in-service date.

The objective of this System Impact Study is to determine budgetary cost estimates and approximate construction timelines for identified transmission facilities required to connect the proposed generating facilities to the AEP transmission system. These reinforcements include the Attachment Facilities, Local Upgrades, and Network Upgrades required for maintaining the reliability of the AEP transmission system.

Queue Number	**AE2-290**
Project Name	NOTTINGHAM 138 KV
Interconnection Customer	BQ Energy Development, LLC.
State	Ohio
County	Harrison
Transmission Owner	AEP
MFO	100
MWE	100
MWC	60
Fuel	Solar
Base case Study Year	2022

2.1 Primary Point of Interconnection

AE2-290 will interconnect with the AEP transmission system at the Nottingham 138 kV substation.

To accommodate the interconnection at the Nottingham 138 kV substation, the substation will have to be expanded requiring building of a new string and installation of two (2) 138 kV circuit breakers (see Figure 1). Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

2.2 Cost Summary

The AE2-290 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$750,000
Direct Connection Network Upgrade	$4,000,000
Non Direct Connection Network Upgrades	$0
Allocation for New System Upgrades	$0
Contribution for Previously Identified Upgrades	$5,441,200
Total Costs	$10,191,200

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

3 Transmission Owner Scope of Work

4 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
138 kV Revenue Metering	$250,000
Generator lead first span exiting the POI station, including the first structure outside the fence	$500,000
Total Attachment Facility Costs	$750,000

5 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
Total Direct Connection Facility Costs	$0

6 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
Build a new string and Install two (2) additional 138 kV circuit breakers. Installation of associated protection and control equipment, 138 kV line risers and SCADA will also be required.	$4,000,000
Total Non-Direct Connection Facility Costs	$4,000,000

7 Incremental Capacity Transfer Rights (ICTRs)

None

8 Schedule

It is anticipated that the time between receipt of executed Agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would generally be between 24 to 36 months after signing Agreement execution.

9 Interconnection Customer Requirements

It is understood that BQ Energy Development is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of BQ Energy Development's generating plant and the costs for the line connecting the generating plant to the Nottingham 138 kV substation are not included in this report; these are assumed to be BQ Energy Development's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.
2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

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 AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

11 Network Impacts

The Queue Project AE2-290 was evaluated as a 100.0 MW (Capacity 60.0 MW) injection into the Nottingham 138 kV substation in the AEP area. Project AE2-290 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-290 was studied with a commercial probability of 1.00. 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.

None

16 Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

None

17 Stability and Reactive Power Requirements for Low Voltage Ride Through

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

Executive Summary

Generator Interconnection Request AE2-290 is for a 100.0 MW Maximum Facility Output (MFO) solar generation plant. AE2-290 consists of 32 x 3.16625 MW HEM FS3510M solar inverters with a total capacity of 101.32 MW. AE2-290 has a Point of Interconnection (POI) at the existing Nottingham 138 kV station, in the American Electric Power (AEP) transmission system, Harrison County, Ohio.

This report describes a dynamic simulation analysis of AE2-290 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. AE2-290 has been dispatched online at maximum power output, with 1.0 p.u. voltage at the generator bus.

AE2-290 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 58 contingencies were studied, each with a 20 second simulation time period. Studied faults included:

a) Steady-state operation (20 second run);
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) schemes 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.

P6 contingencies will be tested during the facility study phase if required.

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

a) AE2-290 was able to ride through the faults (except for faults where protective action trips a generator(s)),
b) The system with AE2-290 included is transiently stable and post-contingency oscillations were positively damped with a damping margin of at least 3% for interarea and local modes.
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.

The reactive power capability of AE2-290 meets the 0.95 lagging and leading PF requirement at the high side of the main transformer.

The initial results showed that AE2-290 exhibited slow reactive power recovery within the 20 second simulation window under plant level V control for contingencies P1.02 ~ P1.07, P1.15, P1.17, P4.02 ~ P4.04, P4.06 ~ P4.09, P4.23 ~ P4.28, P5.03 ~ P5.10, P7.01 and P7.02. This issue did not cause system instability. The model can be tuned to achieve faster reactive power recovery upon request.

No mitigations were found to be required.

18 Light Load Analysis

Light Load Studies (applicable to wind, coal, nuclear, and pumped storage projects).

Not required

19 Short Circuit

The following Breakers are over-duty

None

20 System Reinforcements

None

Affected Systems

21 Affected Systems

21.1 LG&E

None

21.2 MISO

None

21.3 TVA

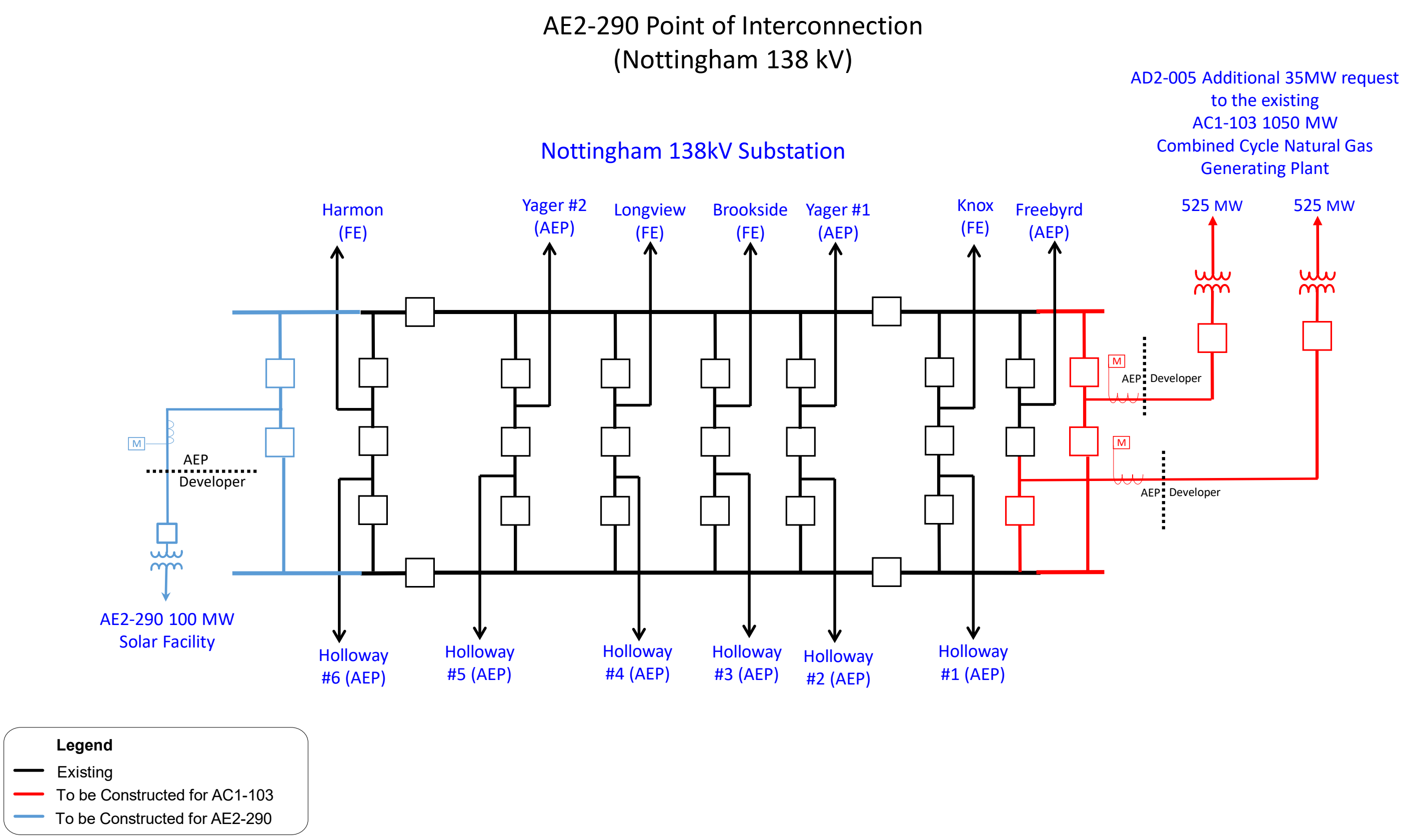
None

21.4 Duke Energy Progress

None

22 Figure 1: AE2-290 Point of Interconnection (Nottingham 138 kV Substation)

Single-Line Diagram



23 Figure 1: AE2-290 Point of Interconnection (Nottingham 138 kV Substation)