Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AD2-014

Steubenville 69kV

January 2020

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: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) 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 or merchant transmission upgrade, may also contribute to the need for the same network reinforcement.

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.

General

BQ Energy LLC proposes to install PJM Project #AD2-014, a 53.3 MW (22.4 MW Capacity) solar facility in Jefferson County, Ohio (see Figure 2). The point of interconnection will be a direct connection to AEP's Steubenville 69 kV substation (see Figure 1).

The requested in service date is January 1, 2021

Attachment Facilities

Point of Interconnection (Steubenville 69kV substation)

To accommodate the interconnection at the Steubenville 69 kV substation, the substation will have to be expanded requiring the installation of one (1) 69 kV circuit breaker (see Figure 1). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 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.

Direct Connection at the Steubenville 69 kV Substation Work and Cost:

- Expand the substation requiring the installation of one (1) new 69 kV circuit breaker (see Figure 1). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 kV revenue metering will also be required.
- **Estimated Station Cost: $1,000,000**
- **Note:** The Interconnection Customer may be required to go offline for routine circuit breaker maintenance.

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following table below:

For AEP building Non-Direct Connection cost estimates:

Description	Total Cost
69 kV Revenue Metering	$200,000
Upgrade line protection and controls at the Steubenville 69 kV substation	$200,000
Total	**$400,000**

Table 1

Interconnection Customer Requirements

It is understood that BQ Energy is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of BQ Energy's generating plant and the costs for the line connecting the generating plant to the Steubenville 69 kV substation are not included in this report; these are assumed to be BQ Energy'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.

Revenue Metering and SCADA Requirements

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 Sections 24.1 and 24.2.

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

Network Impacts

The Queue Project AD2-014 was evaluated as a 53.3 MW (Capacity 22.4 MW) injection into the Stuebenville 69 kV substation in the AEP area. Project AD2-014 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-014 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2021

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

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

PJM analysis has found **no new breakers** to be over-duty.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

Generator Interconnection Request AD2-014 is for a 53.325 MW Maximum Facility Output (MFO) solar generation plant. AD2-014 consists of 18 Power Electronics 3.0 MW HEM – FS3000MU15 Solar inverters. The Point of Interconnection (POI) is at Steubenville 69 kV substation in the American Electric Power (AEP) region, Jefferson County, Ohio.

This report describes a dynamic simulation analysis of AD2-014 as part of the overall system impact study.

The loadflow scenario for the analysis was based on the RTEP 2021 peak load case, modified to include applicable queue projects. AD2-014 has been dispatched online at maximum power output, with 1.0 p.u. voltage at the generator bus.

AD2-014 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 74 contingencies were studied, each with at least a 10 second simulation time period. Studied faults included:

a) Steady state operation (20 second);

b) Three phase faults with normal clearing time and high-speed reclosing (HSR);

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.

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 2021 peak load case:

a) AD2-014 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% 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.

In the initial run, in several contingencies (P1.02, P4.06, P4.09), numerical oscillations were observed in the response of AD2-014 during the fault application under Q control mode. The contingencies were re-ran with V control and the oscillations during the fault were not observed.

Under V control mode QELEC response did not settle within 20 sec. Integral gain Ti_v, CON(J+2) for POI V control was increased from 0.3 to 10 in order to improve QELEC recovery. The updated value for Ti_v falls within the range specified for Ti_v (0.1~100). The parameter Vth_lvrt was set to 0.85 as default value.

The outputs PELEC, QELEC and ETERM of AD2-014 did not reached zero in several contingencies where AD2-014 is tripped in the IDEV which is a known issue for PE user defined model. Since there is no flow to the network during the simulation, it did not cause any issue.

The reactive power capability of AD2-014 does NOT meet the 0.95 lagging PF requirement whereas 0.95 leading PF requirement was met at the high side of the main transformer.

No mitigations were found to be required due to instability. However, it was observed that plant is deficient in lagging power factor requirement by 2.4 MVAr. This may need to be addressed through reactive compensation.

Affected System Analysis & Mitigation

LGEE Impacts:

None

MISO Impacts:

None

Duke, Progress & TVA Impacts:

None

OVEC Impacts:

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.

1. (AEP - AEP) The 05G WASH-05KAMMR1 138 kV line (from bus 243012 to bus 243026 ckt 1) loads from 99.56% to 100.24% (AC power flow) of its emergency rating (409 MVA) for the single line contingency outage of '247131 05HOLLOW 247849 05HOLLOW_XFL 1 138/138'. This project contributes approximately 3.23 MW to the thermal violation.

CONTINGENCY '247131 05HOLLOW 247849 05HOLLOW_XFL 1 138/138'
OPEN BRANCH FROM BUS 247131 TO BUS 247849 CKT 1
END

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

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 be between 24 to 36 months after signing an interconnection agreement.

Note: The time provided between anticipated normal completion of System Impact, Facilities Studies, subsequent execution of ISA and ICSA documents, and the proposed Backfeed Date is shorter than usual and may be difficult to achieve.

Conclusion

Based upon the results of this System Impact Study, the construction of the 53.3 MW (22.4 MW Capacity) solar generating facility of BQ Energy (PJM Project #AD2-014) will require the following additional interconnection charges. This plan of service will interconnect the proposed solar generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the BQ Energy generating facility.

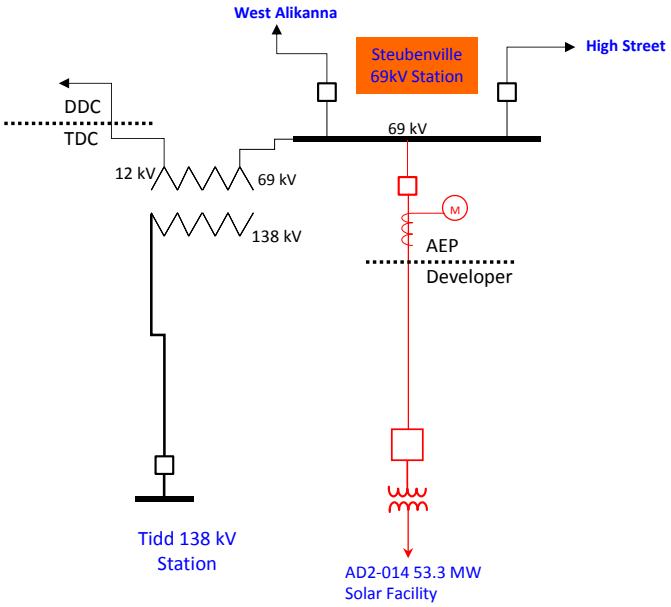
Cost Breakdown for Point of Interconnection (Steubenville 69 kV Substation)		
Attachment Cost	Expand Steubenville 69 kV substation	**$1,000,000**
Non-Direct Connection Cost Estimate	69 kV Revenue Metering	**$200,000**
	Upgrade line protection and controls at the Steubenville 69 kV substation.	**$200,000**
	BQ Energy will be responsible for addressing the deficiency in lagging power factor requirements.	**BQ Energy Responsibility**
	Total Estimated Cost for Project AD2-014	**$1,400,000**

Table 3

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.

Figure 3: Point of Interconnection (Steubenville 69kV Substation)

Single-Line Diagram



Legend

Existing

To be constructed for AD2-014

Figure 2: Point of Interconnection (Steubenville 69 kV Substation)