Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AE1-029

Wheatland 12 kV

May 2019

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. 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.

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. 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 Feasibility 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

The Interconnection Customer (IC), has proposed a Storage generating facility located in Mercer County, PA. The installed facilities will have a total capability of 8.8 MW with 0 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is March 1, 2019. **This study does not imply a ATSI commitment to this in-service date.**

Point of Interconnection

AE1-029 will interconnect with the ATSI (Penn Power) distribution system along the 12 kV circuit which is fed from the Wheatland substation.

Cost Summary

The AE1-029 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 550,000
Direct Connection Network Upgrades	$ 400,000
Non Direct Connection Network Upgrades	$ 2,700,000
Total Costs	**$ 3,650,000***

*Cost to accommodate the proposed 8.8 MW fed from new express feed from new transformer at Wheatland substation

The following Attachment, Direct Connection, and Non Direct Connection estimates are provided for the proposed 8.8 MW storage generating facility (total $3,650,000).

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
795 AAC Express feed 1.8 miles & Recloser Installation	$ 550,000
Total Attachment Facility Costs	**$ 550,000**

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
Engineering review and commissioning	$ 400,000
Total Direct Connection Facility Costs	**$ 400,000**

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
Substation transformer and breaker with exit	$ 2,500,000
Scada Installation and commissioning	$ 200,000
Total Non-Direct Connection Facility Costs	**$ 2,700,000**

Transmission Owner Scope of Work (8.8 MW)

For 8.8 MW connection via new express feed and new transformer at Wheatland substation:

Transmission Department will need to complete a DLS to verify there are no issues adding the 8.8 MW to the transmission system.

Install a new 69/13.02 10 MVA transformer at Wheatland substation along with all switches and breaker needed to provide a distribution exit out of Wheatland substation.

Design and construct a new 1.8 mile 12.47 kV wye 795 AAC express feed from Wheatland substation to the customers site.

Install a new distribution pole with electronic recloser at customers site to facilitate a transfer trip scheme

Install and commission new Scada to new substation equipment.

The new express feed will connect to the new customer owned primary metered service for the battery storage facility. The POI for the AE1-029 project will be at the high side of the new Primary meter point. The IC will be responsible for acquiring all easements, properties and permits that may be required to construct both the associated attachment facilities. The one-line for the POI is shown in Attachment 3.

Transmission Owner Scope of Work (1.5 MW)

As a courtesy, First Energy provided the following information for a reduced project size to 1.5MW.

The AE1-029 project will be responsible for the following costs: Penn Power calculates for an unconstrained system, the maximum allowable system size at this location is 1.5 MW. Cost to feed 1.5 MW from the W-149 circuit: **$238,288 (**direct connection network upgrade)

For 1.5 MW connection:

The proposed POI for the project is located 1.8 miles from the Penn Power Wheatland Substation and will be connected to W-149 at 12.47 kV wye through IC owned 12.47kV / 480V – 277V pad mount transformer(s). FE will place a new distribution pole on Wheatland 12.47 kV to feed a new customer owned primary metered service for the battery storage facility. The POI for the AE1-029 project will be at the high side of the new Primary meter point. The IC will be responsible for acquiring all easements, properties and permits that may be required to construct both the associated attachment facilities. The one-line for the POI is shown in Attachment 2.

Scope

The Study scope is to identify any facility modifications needed to accommodate the installation of 8,800 KW of BESS frequency regulated generation at the POI described above.

General Requirements

Penn Power calculates for an unconstrained system, the maximum allowable system size at this location is 1.5 MW. See voltage analysis portion of study.

To accommodate the requested 8.8 MW. A new transformer and breaker would be needed at Wheatland substation along with 1.8 mile express feed to the customers primary meter pole will need to be constructed.

The requirements for an interconnected distributed energy resource on FirstEnergy's distribution system are contained in Refer to EP#02-280 Part C. Distributed generation must not interfere with the proper operation of the distribution system, including causing power quality problems, the detection and clearing of faults on the First Energy system.

Control Systems

The proposed generator interconnection must not island with any Penn Power native load should the portion of the system with the interconnection become disconnected from its source. The submitted information does not specify if the inverters used are UL1741 certified therefore the proposed generator interconnection will require a direct transfer trip (DTT) scheme from Penn Power's Wheatland substation breaker(s) to directly trip the generator breaker(s) via a dedicated communication channel DTT scheme.

Refer to EP#02-280 Part C section 4.4.8 for all the requirements of the DTT scheme. The generator owner will be responsible for all the costs associated with the DTT scheme including modifications to Penn Power facilities. If the inverters are UL1741 certified, then the DTT scheme will not be needed.

Short Circuit

The available fault current at the Wheatland W-149 circuit at the 12.47 kV distribution system point of connection, without the proposed generation, is 2131 amperes – (3) phase and 1,881 amperes line to ground.

Express feed fed by new transformer short circuit to be determined.

Voltage Analysis

Penn Power calculates for an unconstrained system, the maximum allowable system size at this location is 1.5 MW.

Distribution circuit analysis confirms potential dynamic voltage changes exceeding 4% as well as voltage output above the ANSI allowable 5% on the existing 12.47 kV primary system. This level of voltage swing and voltage level is unacceptable and will require mitigation.

During the Impact Study phase for this project, the Developer will need to provide documentation acceptable to Penn Power/FirstEnergy that dynamic voltage swings will be mitigated to below 4% and the maximum voltage above the ANSI 5% level on the primary 12.47 kV system. Such mechanisms may include, but not be limited to curtailing ramp in / out rates for charging and discharging, dynamic inverter power factor modulation, or reducing system size.

Work Requirements

Either Option below will take 24 to 36 months for completion.

Work needed to feed 1.5 MW installation

Main Line: None required

At Substation: Install SCADA and controls upgrade for demarcation equipment for DTT scheme to communicate with customers new breaker installation at customer facility.

At Battery Storage Facility:Customer breaker must have a communications upgrade to provide Scada with Penn Power EMS and DTT with substation breaker if inverters are not UL1741 certified. Customer must have the battery metering separated from all other ancillary loads (Lighting, AC, Controls etc.)

Work needed to feed 8.8 MW installation

Main Line: Construct new 1.8 mile 795 AAC express feed from Wheatland substation to customer's facility.

At Substation. Install New 10 MW transformer, Breaker and Exit along with Scada and controls for demarcation equipment for DTT scheme to communicate with customers new breaker installation at customer facility

At Battery Storage Facility:Customer breaker must have a communications upgrade to provide Scada with Penn Power EMS and DTT with substation breaker if inverters are not UL1741 certified. Customer must have the battery metering separated from all other ancillary loads (Lighting, AC, Controls etc.)

Power Quality

The connected facility shall comply with harmonic voltage and current limits specified in IEEE Standards as they now exist. These IEEE standards include, but not limited to:141-1992, 519-2014 2, 1453-20153 and IEEE 1547-20034

To provide continuous monitoring of Power Quality performance, Penn Power will require the installation of a Power Quality Meter (SEL- 735 with intermediate PQ option) to monitor and capture power quality information and the provision of a communications circuit to monitor compliance. This unit will be installed at the circuit breaker dedicated to the Battery Energy Storage System.

[1] IEEE Standard 141-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants, The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, NY 10017-2394, USA

[2] IEEE Standard 519-2014, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, NY 10017-2394, USA

[3] IEEE Standard 1453-2015, IEEE Recommended Practices for Measurement and Limits of Voltage Fluctuations Associated with Light Flicker on AC Power Systems, The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, NY 10017-2394, USA

[4] UL1741 Standard 2003, UL Standard for inverters, Underwriter Laboratories. 1900 Indian Wood Cir., #200 Maumee, OH 43537. U.S.A.

Anti-Island Protection

The proposed generation facility must be equipped with adequate protection to detect an island condition and disconnect from the FirstEnergy distribution system within two seconds of the formation of an island (per IEEE 1547). The proposed generator interconnection inverters if not UL1741 certified, will require a direct transfer trip (DTT) scheme from Penn Power's Wheatland substation breaker to directly trip the generator breaker via a dedicated communication channel DTT scheme. Refer to EP@02-280 Part C section 4.48 for all requirements of the DTT scheme. The generator owner will be responsible for all the costs associated with the DTT scheme.

Metering and Communications

The Battery Storage Facility has to be metered separately from ancillary loads such as lighting, AC, controls and the IC shall provide the communication link required for the revenue meter data directly to PJM and Penn Power. All costs associated with the meter upgrades shall be the responsibility of the IC. The IC must meet the requirements of PJM and Penn Power. Please see Attachment 5 for meter requirements. Additionally, a SCADA interface of the Battery Storage System to Penn Power EMS will be required.

Interconnection Customer Requirements

- IC must meet all PJM, Reliability First and NERC reliability criteria and operating procedures required 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 Reliability First 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

- IC must meet all applicable /FirstEnergy standards and requirements which are included in the current Tariff for Electric Service.

- IC's main breaker shall have a utility grade SEL 351 Multi-function relay (or equivalent) which is required for interconnection protection. This relay must have the capability to measure reverse power.
- All breakers and electrical equipment shall meet FirstEnergy's minimum BIL Ratings.
- The Battery Storage System must not interfere with operation of FE voltage line regulating equipment including voltage regulators, line capacitors and substation load tap changer.
- IC must meet applicable FE Technical Standards and Requirements for Distribution Connected Facilities which can be found under:
- http://www.pjm.com/~/rnedia/planning/plan-standards/private-fe/generation-interconnection-technical-requirements-for-distribution-connected-facilitie.asshx
- Frequency response systems participating in the PJM Ancillary Services Market respond to an automatic signal from PJM to correct for short-term changes in electricity use that might affect the stability of the power system by matching generation and load to maintain system frequency. Consequently, because of the magnitude and frequency of load changes, additional analysis is required during the review process.
- Presence of frequency response may significantly increase costs to reconfigure system to accommodate future load growth or inhibit / prevent system reconfiguration. Additional costs to reconfigure system because of frequency response may be passed on to IC or Frequency Response may be required to cease interconnection operations.
- Customer generation shall be capable of maintaining Power Factor between .95 leading to .95 lagging measured at the Point of Interconnection. Penn Power may require customer generation to absorb vars after the generation is operational.
- Distributed generation must not interfere or degrade the quality of service to any other FirstEnergy Corp. customers (service voltage, voltage flicker, harmonics, service reliability etc.)
- Revenue metering will be owned, operated and maintained by the FirstEnergy.
- The IC shall provide the revenue metering data to PJM as required.
- 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.

The above requirements are in addition to any metering required by PJM.

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.

Metering

The IC will be require 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.

Behind-The-Meter Generation Facilities Participating in the PJM or Wholesale Energy Markets

The revenue metering requirements will be reviewed by FirstEnergy (FE) on a case-by-case basis.

In general, the FE Operating Company (FEOC) shall continue to own, operate, test, and maintain the existing revenue metering equipment per the applicable retail tariff or interconnection service agreement.

The Interconnection Customer (IC) must provide FE with a facility one line and the estimated bi-directional power flow at the existing FEOC metering point.

The existing FEOC billing meter at these locations will be replaced with a bi-directional revenue meter and the FEOC metering current transformers will be replaced with higher capacity units if required. This work will generally be completed at the IC's expense.

The bi-directional revenue meter provided and installed by the FEOC will record billing data in intervals of typically fifteen or thirty minutes. If applicable, the IC shall continue to provide, at its sole cost and expense, communication link required by the FE billing data collection system for access to the meter.

The IC shall, at its expense, install, own, operate, test, and maintain any metering and telemetry equipment that may be required to provide rea*time meter data to FE or PJM.

The FEOC will provide the IC access to bi-directional KWh and KVARh from FEOC meter at the IC's expense if requested.

The IC shall provide FE with prior notification of any modifications at the facility that could affect the FEOC revenue meter measurements (substation reconfigurations, generator additions, etc.)

Network Impacts

The Queue Project AE1-029 was evaluated as a 8.8 MW (Capacity 0 MW) injection at NMLK-CROSSLAND 13.2 KV substation in the ATSI area. Project AE1-029 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-029 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis – 2022

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.

Short Circuit

(Summary of impacted circuit breakers)

None.

Steady-State Voltage Requirements

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

Steady State Voltage Studies to be conducted during later study phases

Stability and Reactive Power Requirement for Low Voltage Ride Through

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

Stability Studies to be conducted during later study phases

Affected System Analysis & Mitigation

MISO Impacts:

MISO Impacts to be determined during later study phases (as applicable)

Winter Analysis - 2021

Winter Studies to be conducted during later study phases

Light Load Analysis - 2021

Light Load Studies to be conducted during later study phases

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.

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)

None.