# *Generation Interconnection Facilities Study Report*

# *For*

# *PJM Transmission Interconnection Request Queue Position AE1-132*

# *"McConnellsburg 138 kV"*

***December 2021***

## Table of Contents

# Contents

## *Preface*

The intent of the Facility 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 Facility Study estimates attempt to identify the estimated 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.

## A. Transmission Owner Facilities Study Summary

### *1. Description of Project*

Keystone State Renewables, LLC, (hereinafter referred to as "IC") has proposed a new solar generating facility to be located in McConnellsburg, Fulton County, Pennsylvania. The installed facilities for AE1-132 will have a total Maximum Facility Output (MFO) of 85 MW with 51 MW of this output being recognized by PJM as Capacity. The generation facility will interconnect with Allegheny Power Systems (APS), a FirstEnergy Company (FE), hereinafter referred to as "Transmission Owner" (TO), by installing a new 138 kV breaker at McConnellsburg Substation.

The following table provides a breakdown of MW contributions to the Maximum Facility Output (MFO) and Capacity Interconnection Rights (CIR) by fuel type:

| **Fuel Type** | **Energy** | **Capacity** |
|---|---|---|
| Solar | 85 | 51 |
| Battery Storage | 25 | 0.0 |
| | MFO = 85 | CIR = 51 |

### *2. Amendments to the System Impact Study or System Impact Study Results*

There were no notable amendments since the May 2021 revised System Impact Study.

### *3. Interconnection Customer's Milestone Schedule*

The Commercial Operation Date (COD) for the transmission interconnection facility is **December 17, 2023**.

**Milestone Schedule:**

| | |
|---|---|
| 10/1/2023 | Initial Back-feed Date |
| 12/17/2023 | Project Commercial Operation Date |

### *4. Customer's Scope of Work*

IC is responsible for all design and construction related to activities on their side of the Point of Interconnection (POI). This includes, but is not limited to, the generation step-up (GSU) transformer, 138 kV (AE1-132) generator lead line and connection to the tap point on the new 138 kV line terminal at the existing McConnellsburg 138 kV Substation.

**Point of Interconnection** (POI): The interconnection of the project will be accomplished by installing a new 138 kV breaker at McConnellsburg 138 kV Substation.

IC is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of the GSU transformer, as well as the necessary revenue metering equipment. The revenue metering current and voltage transformers shall be installed on the high voltage side of the GSU, on the generation side of the fault-interrupting device, and within the local zone of fault protection for the facility. The protective relaying and metering design must comply with FirstEnergy's applicable standards as well as with PJM requirements.

The easements and associated rights of way for the TO owned substation along with the 138 kV line taps to the substation will be acquired by the IC and transferred to the TO at no cost. Site preparation for the TO owned substation, including clearing, grading and an access road, as necessary, is assumed to be by the IC. The access road design must be approved by FirstEnergy to ensure it provides adequate access to the substation to support construction and maintenance activities. Route selection, line design, and right-of-way acquisition for the IC's facilities are not included in this report and are the responsibility of the IC.

**Assumptions / Notes:**

- IC will coordinate design and alignment of proposed 138 kV generator lead line with the Transmission Owner for review of any clearance, right-of-way or right-of-way encroachment issues with TO owned facilities.
- IC will coordinate design and construction of proposed 138 kV lead line. For these areas, the IC shall provide TO with proposed drawings prior to construction and as-built drawings, confirmed by as-built survey data post-construction.
- Transmission Owner's preference would be to limit interference and avoid transmission line crossings with new 138 kV terminal positions. As a minimum, IC facilities should not encroach within 100 feet of TO centerline at blowout conditions. If IC's line design does not comply with this requirement TO would need to review this area as a special exception.
- Additional costs will be incurred by the IC, if final alignment of the 138 kV generator lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities.
- IC is responsible to make all arrangements for electric distribution service (if required) for its generation station. No costs or schedule are included herein.
- All new generator only and new generator plus load facilities must be isolated from the FE Transmission System by a Power Transformer. The winding configurations of the transformer connecting to a non-effectively grounded portion of the FE Transmission system shall be determined by FE on a case-by-case basis.
- The IC has requested a non-standard GSU transformer winding configuration. This transformer is in violation of section 14.2.6 of FE's "Requirements for Transmission Connected Facilities" document and will not be accepted. The GSU transformer must have a grounded wye connected on the high (utility) side and a delta connection on the low (generator) side.

## *5. Description of Facilities Included in the Facilities Study*

**Attachment Facilities**

- AE1-132 Generator Lead Termination (New connection to line terminal at McConnellsburg 138 kV)
    - Construction of a new 138 kV line terminal for connection to Keystone State Renewables, LLC (AE1-132 Customer Substation) will be performed by the Transmission Owner.
- AE1-132 Customer Substation (Keystone State Renewables, LLC)
    - Review of nameplates, drawings, and relay settings will be performed by the Transmission Owner.

**Direct Connection**

- SCADA/ Fiber Communication
    - One (1) in-sub fiber run from McConnellsburg Substation control house to developer-built fiber run to support communications and control to generator site will be required. Additionally, SCADA work at McConnellsburg Substation to support breaker installation, new motor-operated switch (MOAB) installations, wave trap installations, and relay installations as well as SCADA work at Guilford and Cherry Run substations to support wave trap and relay installations, will be required.

- Project Management
    - Project Management, Commissioning, Environmental, Forestry, Real Estate, and Right of Way.

**Non-Direct Connection**

None

**Other Facilities**

- AE1-132 Metering
    - Engineering oversight of Power Producer's specification and installation of revenue metering equipment at generation facility will be performed. Support will be required for set up of Power Producer-owned metering in FE's MV90 and other systems.

**New System Upgrades**

None.

Notes:

- Existing PJM Supplemental Upgrade S1643
    - To relieve the Roxbury 138/115 kV transformer overload (ckt 2)
    - Replace the existing Roxbury 100 MVA 138/115 kV transformer with a 224 MVA unit. Convert Roxbury 115 kV Substation into a four (4) breaker ring bus.
    - Projected In-service date: 7/15/2021
    - AE1-132 does not have cost responsibility for this upgrade. AE1-132 will need this upgrade in-service to be deliverable to the PJM system. IF AE1-132 intends to come into service prior to completion of this upgrade, they will need an interim study.

### *6. Total Cost of Transmission Owner Facilities Included in the Facilities Study*

| Description | Total (w/o Tax) | Tax (if applicable) | Total Cost (w/Tax) |
|---|---|---|---|
| **Attachment Facilities:** | **$ 1,449,700** | **$ 243,600** | **$ 1,693,300** |
| **Total Direct Connection (DC) Costs:** | **$ 155,500** | **$ 26,200** | **$ 181,700** |
| **Total Non-Direct Connection (NDC) Costs:** | **$ 0** | **$ 0** | **$ 0** |
| **Total Other Costs** | **$ 4,600** | **$ 800** | **$ 5,400** |
| **New System Upgrades** | **$ 0** | **$ 0** | **$ 0** |

| | | | |
|---|---|---|---|
| **TOTAL Costs (ALL Categories)** | **$ 1,609,800** | **$ 270,600** | **$ 1,880,400** |

### *7. Summary of the Schedule for Completion of Work for the Facilities Study*

| *Attachment Facility* | *Duration* |
|---|---|
| AE1-132: Engineering, Procurement, and Construction | 18 months |

## B. Transmission Owner Facilities Study Results

This section describes facilities identified to be installed (attachment facilities), replaced, and/or upgraded (upgrade facilities) by FirstEnergy to accommodate the project. During detailed design and analysis other components may be identified for installation or replacement due to this interconnection.

### *1. Transmission Lines –New*

None.

### *2. Transmission Lines – Upgrade*

None.

### *3. New Substation/Switchyard Facilities*

AE1-132 Customer Substation (Keystone State Renewables)

- Below Grade
  - None
- Above Grade
  - Review nameplates, one-lines, and relay settings.
  - Add to HV circuit diagram
- R&C (Relaying & Communications)
  - None
- Additional Equipment to be Removed
  - None

Revenue Metering

- Revenue metering located at Customer substation.

SCADA Communication

- Keystone State Renewables Substation
  - Modify EMS Screen.

### *4. Substation/Switchyard Facility Upgrades*

McConnellsburg Substation

- Below Grade
  - Install Foundations, Conduit, and Grounding for a New Line Terminal Breaker, Disconnect Switches, Surge Arresters, and Transmission Line Exit.
- Above Grade
  - Install one (1) 138 kV Breaker.
  - Install two (2) 138 kV Breaker Disconnect Switches.
  - Install three (3) 108 kV, 84 kV MCOV, Surge Arresters.

- Install three (3) 138 kV CVTs
- Expand Fence for New Line Terminal.

- R&C (Relaying & Communications)
  - Install one (1) FE Standard Transmission Panel with Dual SEL411L with SEL501 for BFT Relaying & DCB over Fiber.
  - Install one (1) fiber patch panel.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Revenue Metering will be at the Keystone State Renewables Substation.
  - Existing AC and DC systems are adequate

Fiber (Relaying and Communications)

- Install one (1) fiber interface panel at McConnellsburg Substation

Distribution

- None

Real Estate

- Real estate to verify FE owns property in expansion

Environmental

- None

### *5. Telecommunications Facilities – Upgrades*

IC will design, provide, install, own and maintain a fiber-optic communications cable between the McConnellsburg 138 kV substation and IC's **generation** (collector) substation. Two (2) fiber-optic channels are required for each generator protection scheme to obtain high- speed tripping capability for any fault within the zone of protection. Should subsequent/additional PJM studies indicate that stability issues exist, the primary and backup relay fiber-optic communication channels must be in separately-routed cable paths and additional fiber-optic connection costs would apply (not included herein).

The IC will make the fiber-optic cable termination connections for its cable(s) at the Hamilton substation control house.

IC is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber cable.

### *6. Metering & Communications*

IC shall install, own, operate, test and maintain the necessary revenue metering equipment. IC shall provide Transmission Owner with dial-up communication to the revenue meter.

The revenue metering system (particularly the revenue metering current transformers) shall be designed to accurately meter the light loads that will occur when the facility is not generating power and only back-feeding station service from the Transmission Owner. This will require the use of high accuracy extended range current transformers.

Transmission Owner's Revenue Metering Requirements may be found FirstEnergy Corporation Requirements for Transmission Connected Facilities dated October 3, 2016 document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

These requirements are in addition to any metering required by PJM.

Transmission Owner will obtain real-time, site-specific, generation data from PJM, via the required communication link from IC to PJM. Transmission Owner will work with PJM and IC to ensure the generation data provided to PJM meets Transmission Owner's requirements.

## *7. Environmental, Real Estate and Permitting*

The following are possible environmental, real estate and permitting issues:

- Environmental permitting, Real Estate acquisition, and Pennsylvania Public Utility Commission (PaPUC) notifications vary, some up to twelve (12) months after preliminary engineering is completed to secure the required approvals.
- Prior to agreement by Developer to purchase the property, a Phase 1 Environmental Assessment should be conducted for the entire site to avoid assumption of environmental liabilities by Developer or Transmission Owner.
- The Transmission Owner interconnection substation may involve environmental surveys, permits, approvals and plans with federal, state, and/or local agencies.
- Assumed Developer is to provide all access rights, easements, ROW and permits necessary to complete the Project to the satisfaction of Transmission Owner. Environmental permitting shall encompass all federal, state and local requirements, consultations and agency coordination. Confirmation of meeting all permitting requirements shall be provided to Transmission Owner, prior to start of construction. Following construction and energization, confirmation of permit closeout shall be provided to the satisfaction of Transmission Owner, prior to transfer of ownership. If any of these elements are not included in the final agreement between Transmission Owner and Developer, twelve (12)-to-eighteen (18) months should be added to the Project Schedule to secure necessary permits, and additional costs would apply.
- Developer will provide copies of all of the relative environmental permits and other necessary approvals to Transmission Owner before Transmission Owner accepts the interconnection facilities.
- Developer is required to install an access road from the new interconnection substation to the nearest public road (must be approved by Transmission Owner) and obtain access rights for Transmission

Owner. Developer is responsible to maintain access road and ensure unimpeded access for Transmission Owner at all times.

- Developer is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.
- If Developer owns the project property, in fee title, Transmission Owner will require a fee property transfer for the interconnection substation site which may require subdivision approval, together with permanent access rights to and from the substation, as well as a perpetual easement for any transmission lines to the substation. Developer is responsible for all costs, including but not limited to subdivision, associated with the property transfer.
- If Developer leases the project property, the Developer will be required to obtain fee property from the underlying fee property owner, on behalf of Transmission Owner, for the interconnection substation site, together with permanent access rights to and from the substation, as well as a perpetual easement for any transmission lines to the substation.
- All property rights must be surveyed and metes and bounds descriptions prepared for incorporation into Transmission Owner's document forms, for transfer of title.
- The Transmission Owner interconnection substation and transmission line loop will involve Pennsylvania Public Utility Commission (PaPUC) notification/approval.
- All work occurs within an existing transmission line right-of-way or on Developer's property with access to all existing structures possible via that property and the right-of- way following established access routes that do not cross wetlands or streams.
- Developer will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits.
- Developer will obtain all necessary permits.
- Developer will conduct all necessary wetlands and waterways studies and permits.
- Developer will conduct all necessary historical and archaeological studies.
- If the Developer plans to cross the transmission line right of way with facilities or access roads, please refer to the Transmission Rights-of-Way Restrictions information located at:

  https://www.firstenergycorp.com/help/safety/real-estate-power-lines/transmission-right-of-way.html#ROWform

## *8. Summary of Results of Study*

| Description | Total Cost (w/o Tax) | Tax (if applicable) | Total Cost (w/ Tax) |
|---|---|---|---|
| **Attachment Facilities** | | | |
| **AE1-132 Generator Lead Termination (McConnellsburg Substation):** | $ 1,419,400 | $ 238,500 | $ 1,657,900 |

| | | | |
|---|---|---|---|
| Construct a new 138 kV line terminal for connection to Keystone State Renewables, LLC. | | | |
| **AE1-132 Customer Substation (Keystone State Renewables, LLC):**<br>Review nameplates, drawings, and relay settings. | $ 30,300 | $ 5,100 | $ 35,400 |
| ***Total Attachment Facilities (AF) Costs*** | $ 1,449,700 | $ 243,600 | $ 1,693,300 |
| **Direct Connect Facilities** | | | |
| **SCADA/Fiber Communication:**<br>Estimated 1 in-sub fiber run from McConnellsburg substation control house to developer built fiber run to support communications and control to generator site. Estimated SCADA work at McConnellsburg substation to support breaker installation, new Motor-operated switch (MOAB) installations, wavetrap installations, and relay installations. | $ 55,600 | $ 9,400 | $ 65,000 |
| **Project Management:**<br>Project Management, Commissioning, Environmental, Forestry, Real Estate, and Right of Way. | $ 99,900 | $ 16,800 | $ 116,700 |
| ***Total Direct Connect (DC) Costs*** | $ 155,500 | $ 26,200 | $ 181,700 |
| **Non-Direct Connect Facilities** | | | |
| ***Total Non Direct Connect (NDC) Costs*** | $ 0 | $ 0 | $ 0 |
| **Other Facilities** | | | |
| **AE1-132 Metering:**<br>Engineering oversight of Power Producer's specification and installation of revenue metering equipment at generation facility. Support set up of Power Producer-owned metering in FE's MV90 and | $ 4,600 | $ 800 | $ 5,400 |

| | | | |
|---|---|---|---|
| other systems. | | | |
| ***Total Other Facilities Costs*** | $ 4,600 | $ 800 | $ 5,400 |
| | | | |
| **Total AF + DC + NDC + Other Costs** | **$ 1,609,800** | **$ 270,600** | **$ 1,880,400** |

Generation projects meeting IRS "Safe Harbor" provisions generally do not incur "CIAC" (Contribution in Aid to Construction), a tax collected by the utility for the state or federal government. First Energy does not expect to collect CIAC for this project. If for any reason, "CIAC" would be required for this project, it would be the responsibility of the party owning the generator to pay this cost.

First Energy reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering facilities, owned by First Energy.

### *9. Schedules and Assumptions*

A proposed **18 month Direct Connection** schedule is estimated to complete the engineering, construction and the associated activities, from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. This schedule assumes that all issues covered by the "Environmental, Real Estate and Permitting Issues" section of this document are resolved, and outages (typically not granted from June through September) will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

**18 month Schedule (schedule to start after Construction KO call)**

| Activity | Start Month | End Month |
|---|---|---|
| | | |
| Preliminary Engineering | 1 | 3 |
| Siting, Permits & Real Estate | 2 | 12 |
| Detailed Engineering | 2 | 12 |
| Equipment Delivery | 9 | 12 |
| Below Grade Construction – Substation | 10 | 12 |
| Below Grade Construction – T-Lines | 11 | 12 |
| Above Grade Construction – Substation | 11 | 17 |
| Above Grade Construction – T-Lines | 14 | 17 |
| Testing & Commissioning | 18 | 18 |

### *10. Information Required for Interconnection Service Agreement*

| Work Description | Direct | | Indirect | | Total Cost |
|---|---|---|---|---|---|
| | Labor | Material | Labor | Material | |
| | | | | | |
| **AE1-132 Generator Lead Termination (McConnellsburg Substation):** Construct a new 138 kV line terminal for connection to Keystone State Renewables, LLC. | $ 749,700 | $ 404,300 | $ 237,600 | $ 27,800 | $ 1,419,400 |
| **AE1-132 Customer Substation (Keystone State Renewables, LLC):** Review nameplates, drawings, and relay settings. | $ 23,000 | $ 0 | $ 7,300 | $ 0 | $ 30,300 |
| **Total Attachment Facilities Cost** | **$ 772,700** | **$ 404,300** | **$ 244,900** | **$ 27,800** | **$ 1,449,700** |
| | | | | | |
| **SCADA/Fiber Communication:** Estimated 1 in-sub fiber run from McConnellsburg substation control house to developer built fiber run to support communications and control to generator site. Estimated SCADA work at McConnellsburg substation to support breaker installation, new Motor-operated switch (MOAB) installations, wavetrap | $ 38,900 | $ 4,100 | $ 12,300 | $ 300 | $ 55,600 |

| | | | | | |
|---|---|---|---|---|---|
| installations, and relay installations. | | | | | |
| **Project Management:** Project Management, Commissioning, Environmental, Forestry, Real Estate, and Right of Way. | $ 71,800 | $ 5,000 | $ 22,800 | $ 300 | $ 99,900 |
| **Total Direct Connection Cost** | **$ 110,700** | **$ 9,100** | **$ 35,100** | **$ 600** | **$ 155,500** |
| | | | | | |
| **Total Non-Direct Connection Cost** | **$ 0** | **$ 0** | **$ 0** | **$ 0** | **$ 0** |
| | | | | | |
| **AE1-132 Metering:** Engineering oversight of Power Producer's specification and installation of revenue metering equipment at generation facility. Support set up of Power Producer-owned metering in FE's MV90 and other systems. | $ 3,500 | $ 0 | $ 1,100 | $ 0 | $ 4,600 |
| **Total Other Costs** | **$ 3,500** | **$ 0** | **$ 1,100** | **$ 0** | **$ 4,600** |
| **Total Project Costs** | **$ 886,900** | **$ 413,400** | **$ 281,100** | **$ 28,400** | **$ 1,609,800** |

## Attachment #1: Protection Study

**PROTECTION & COMMUNICATION AND EQUIPMENT SCOPE**

The protection requirements listed in this document assume that AD2-009 and all associated upgrades at McConnellsburg, Cherry Run, and Guilford will be complete and in-service prior to AE1-132.

### Non-Direct Connect Protection Requirements

Transmission Owner will perform an area coordination study to determine if relay settings are affected by the change in short circuit current due to the addition of the AE1-132 solar generation.

### Direct Connect Protection Requirements Short Circuit Values (Existing Conditions)

Fault values for the AE1-132 Interconnection Substation location:

Three phase = 5,993 A
Single line to ground = 3,777 A
Zl= 0.00949 + j0.06916 p.u.
Z0= 0.05269 + j0.1855 p.u.

Note: These fault values were obtained using the FirstEnergy short circuit model without AE1-132 or AD2-009 solar generation in the fault case.

Impedances are given on 100 MVA and 138kV bases. The faults provided are bolted, symmetrical values for normal system conditions with a flat 1.0 p.u. voltage profile. Future increases in fault currents are possible and it is Developer's responsibility to upgrade its equipment and/or protective equipment coordination when necessary.

### AE1-132 Interconnection Substation (138kV existing McConnellsburg Substation) Protection Requirements

One new 145kV rated, 3000A continuous, 40kA interrupting, nominal 138kV breaker is required to connect to the McConnellsburg 138kV bus. The 138kV breaker will be equipped with four sets (12 total) 2000:5 A multi- ratio C800 relay accuracy CTs with a thermal rating factor of 2.0, and one set (3 total) 1500:5 A, single-ratio 0.3B1.8 meter accuracy CTs with a thermal factor of 2.0, for direct connect tie line operational metering. One set of (3) CCVTs, one per phase, is required on the 138kV line exit. The CCVTs shall have dual secondary windings with each winding capable of being connected at either a 1200:1 or 700:1 ratio.

**Anti-islanding scheme** - Utilize breaker status at McConnellsburg and from the remote substations as communicated via Frequency Shift Keyed power line carrier, to determine when the local direct connect tie line breaker should be tripped. This is when both 138kV network connections at McConnellsburg are open,

either locally or at the adjacent substations or beyond. Tripping of the local direct connect tie line breaker takes the generation offline.

**AE1-132 Direct Connect Tie Line Protection**

The zone of protection for this scheme consists of the direct connect tie line between the CTs supplying the relays at AE1-132 Interconnection (McConnellsburg) Substation and the CTs on the direct connect tie line circuit breaker at the AE1-132 Generation substation. The line protection system will consist of dual, high speed clearing pilot protection schemes. The AE1-132 direct connect tie line primary protection shall be an SEL-411L current differential scheme communicating over a dedicated fiber-optic channel via a direct, relay to relay fiber cable, with direct tripping, non-pilot step distance and directional ground overcurrent backup elements. The AE1-132 direct connect tie line backup protection shall be an SEL-411L current differential scheme utilizing a second dedicated fiber-optic channel over a direct, relay-to-relay fiber cable, with direct tripping, non-pilot, step distance and directional ground overcurrent backup elements. Direct Transfer Trip (DTT) for breaker failure to trip will also utilize both SEL-411L relays and their respective fiber optic communication channels between the AE1-132 Interconnection Substation and the AE1-132 Generation Substation. Redundancy for primary and backup line protection schemes is required including independent DC supply on separate breakers from a DC panelboard, separate tripping paths energizing separate trip coils in the breakers, independent current transformers, and independent secondary windings of the same voltage transformer for primary and backup relaying. Should additional PJM studies indicate that stability issues exist, therefore requiring dual high-speed tripping schemes, the primary and backup relay fiber optic communication channels must be in separately routed cable paths. No automatic reclosing will be applied at the AE1-132 Interconnection Substation for faults on the 138kV direct connect tie line.

**Breaker Failure Relaying**

A breaker failure relay (SEL-501) shall be utilized on the new 138kV circuit breaker. The source for the breaker failure relay shall be the same CTs as used on the backup relaying. Any protective trip of this breaker shall initiate the breaker failure to trip scheme. The re-trip feature of the SEL-501 breaker failure relay shall be utilized to re-trip the 138kV circuit breaker. DC supplied to power the breaker failure schemes shall be independent DC breakers from either the primary or backup relaying scheme DC.

This 138 kV breaker failure scheme shall trip and block closing of all adjacent breakers at the AE1-132 Interconnection (McConnellsburg) Substation. Tripping shall be done via a hand-reset LOR lockout relay. Breaker failure should key direct transfer trip (DTT) to the AE1-132 Generation Substation main breaker.

**DC Power**

The relaying system shall have a reliable source of DC power independent from the AC system that is immune to AC system disturbance or loss (for example - DC battery and charger) to assure proper operation of the protection scheme. Primary and backup relaying schemes shall be powered from different DC distribution panel circuit breakers.

**Operational Metering Requirements**

Meter accuracy operational metering is required by PJM for the direct connect tie lines and will be provided using a Satec meter, and meter accuracy CTs and CCVTs at the direct connect tie line exits at the AE1-132 Interconnection Substation.

## AE1-132 Generation Substation Protection Requirements

It is the responsibility of the Developer to assure protection, coordination and equipment adequacy within its facility for conditions including but not limited to:

- Single phasing of supply
- System faults
- Equipment failures
- Deviations from nominal voltage or frequency
- Lightning and switching surges
- Harmonic voltages
- Negative sequence voltages
- Separation from FE supply
- Synchronizing generation
- Synchronizing facilities between independent transmission system and FE
- Transmission System

Developer is to design its protective system to clear any faults within their zones of protection with one or more of their local circuit breakers. Each zone of protection covering the 138kV portion of the interconnection system, including the GSU transformer, is to be protected by two independent relay schemes that each provide high speed fault clearing. The terminal breaker at the generation end of the direct connect tie line is to be included in the 138kV over-lapping zones of protection. The CTs used for the zones of protection covering the 138kV portion of the system shall use C800 relay accuracy CTs and the CTs should not saturate for the maximum through-fault current that can be experienced by the relay system for the tap ratio in use. Each 138kV breaker is to have breaker failure to trip protection. The AE1-132 Generation substation will contain at least one 138kV direct connect tie line/high-side GSU circuit breaker. The GSU transformer windings shall be wye ground–delta (HV-LV). The 138kV interconnection line circuit breaker shall be purchased with four sets (12 total) of 2000:5 A MR C800. A 138kV three phase potential source (CCVT or equivalent) is required for line terminal relaying. The AE1-132 Generation Substation shall not close into the direct connect tie line if it is dead, so that all synchronizing is performed at the AE1-132 Generation Substation. All communications between AE1-132 Interconnection Substation and the AE1-132 Generation Substation, including relay trip signals, shall utilize fiber optic communications paths so that no copper cables shall be run between these substations for the purpose of carrying currents, trip signals, or communications of any sort. No automatic reclosing will be applied at the AE1-132 Interconnection Substation for faults on the 138kV direct connect tie line.

**AE1-132 Direct Connect Tie Line Protection**

The zone of protection for this scheme consists of the direct connect tie line between the CTs supplying the relays at AE1-132 Interconnection Substation and the CTs on the direct connect tie line circuit breaker at the AE1-132 Generation Substation. The line protection system will consist of dual, high speed clearing pilot protection schemes. The AE1-132 direct connect tie line primary protection shall be an SEL-411L current differential scheme communicating over a dedicated fiber-optic channel via a direct, relay to relay fiber cable, with direct tripping, non-pilot step distance and directional ground overcurrent backup elements. The AE1-132 direct connect tie line backup protection shall be an SEL-411L current differential scheme utilizing a second dedicated fiber-optic channel over a direct, relay-to-relay fiber cable, with direct tripping, non-pilot, step distance and directional ground overcurrent backup elements. Direct Transfer Trip (DTT) for breaker failure to trip will also utilize both SEL-411L relays and their respective fiber optic communication channels between the AE1-132 Interconnection Substation and the AE1-132 Generation Substation. Redundancy for primary and backup line protection schemes is required including independent DC supply on separate breakers from a DC

panelboard, separate tripping paths energizing separate trip coils in the breakers, independent current transformers, and independent secondary windings of the same voltage transformer for primary and backup relaying. Should additional PJM studies indicate that stability issues exist, therefore requiring dual high-speed tripping schemes, the primary and backup relay fiber optic communication channels must be in separately routed cable paths. Developer may propose additional schemes or relays to protect its facility such as DTT transmitters/receivers, etc. Transmission Owner must review and agree to any additional protection. No automatic reclosing will be applied at the AE1-132 Generation Substation for faults on the 138kV direct connect tie line.

**Breaker Failure Relaying**

Each breaker on the high side portion of the AD AE1-132 Generation Substation is to have breaker failure to trip protection. The breaker failure to trip protection must include current sensing Or'd with the breaker status to identify a closed breaker. The breaker failure to trip protection shall trip all breakers electrically adjacent to the failed breaker at the AE1-132 Generation substation and the breaker failure to trip protection on the direct connect tie line breaker shall send DTT through both fiber channels to the Transmission Owner AE1-132 Interconnection Substation.

**Inter-tie Relaying**

In addition to the two fully independent high-speed relay schemes for the 138 kV portion of the AE1-132 Generation Substation, an inter-tie relay is also required. The inter-tie relay shall be an SEL-351 or equivalent, including 27, 59, 81, 67V and 67N elements. The current source for the intertie relay shall be CTs on the direct connect tie line breaker and the protection elements listed shall trip the 138 kV interconnection line main breaker.

The relaying system shall have a reliable source of DC power independent from the AC system or immune to AC system disturbance or loss (for example - DC battery and charger) to assure proper operation of the protection scheme.

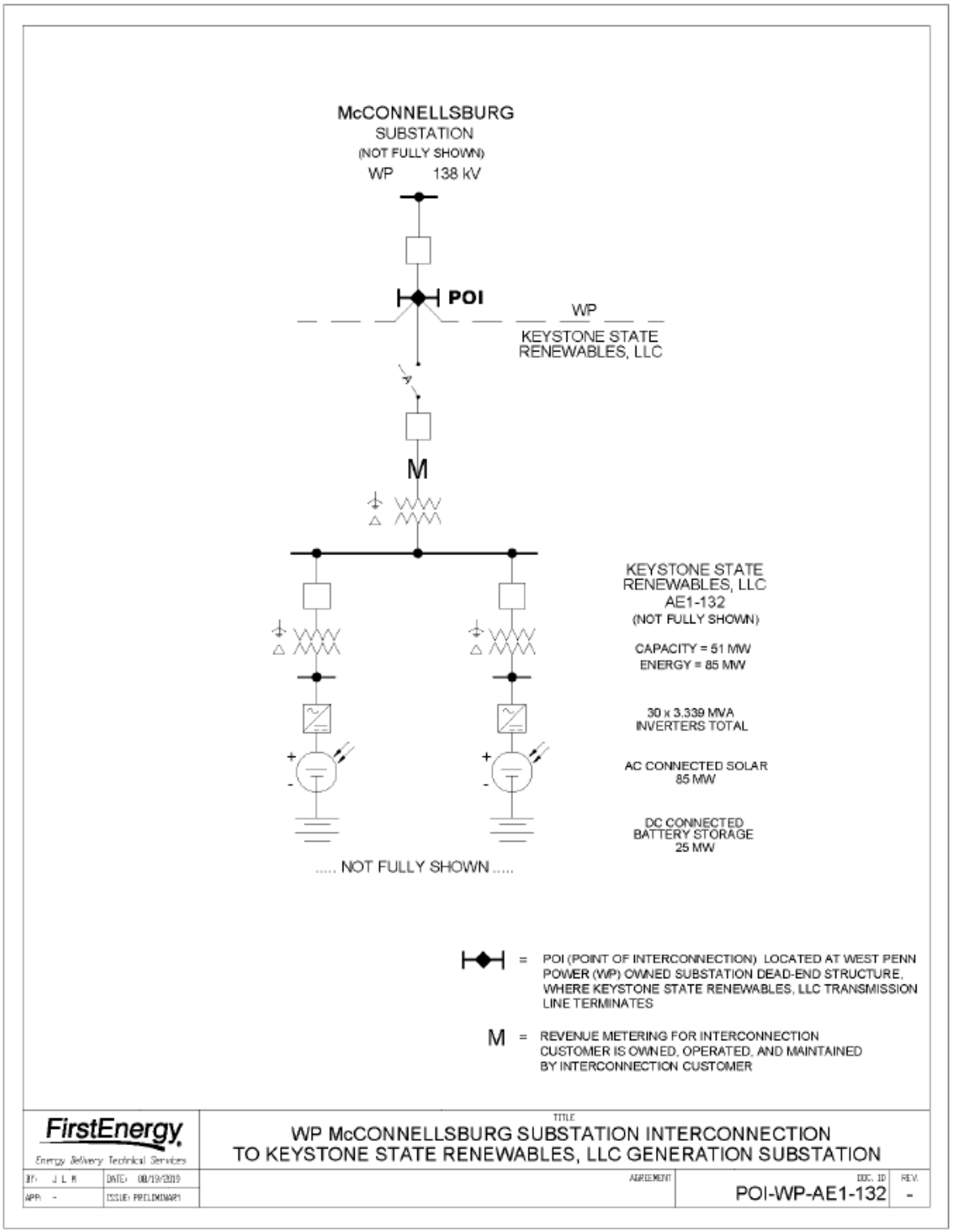
Developer is solely responsible for protecting its own equipment in such a manner that electrical faults or other disturbances on the Transmission Owner system do not damage its equipment.

**Approvals**

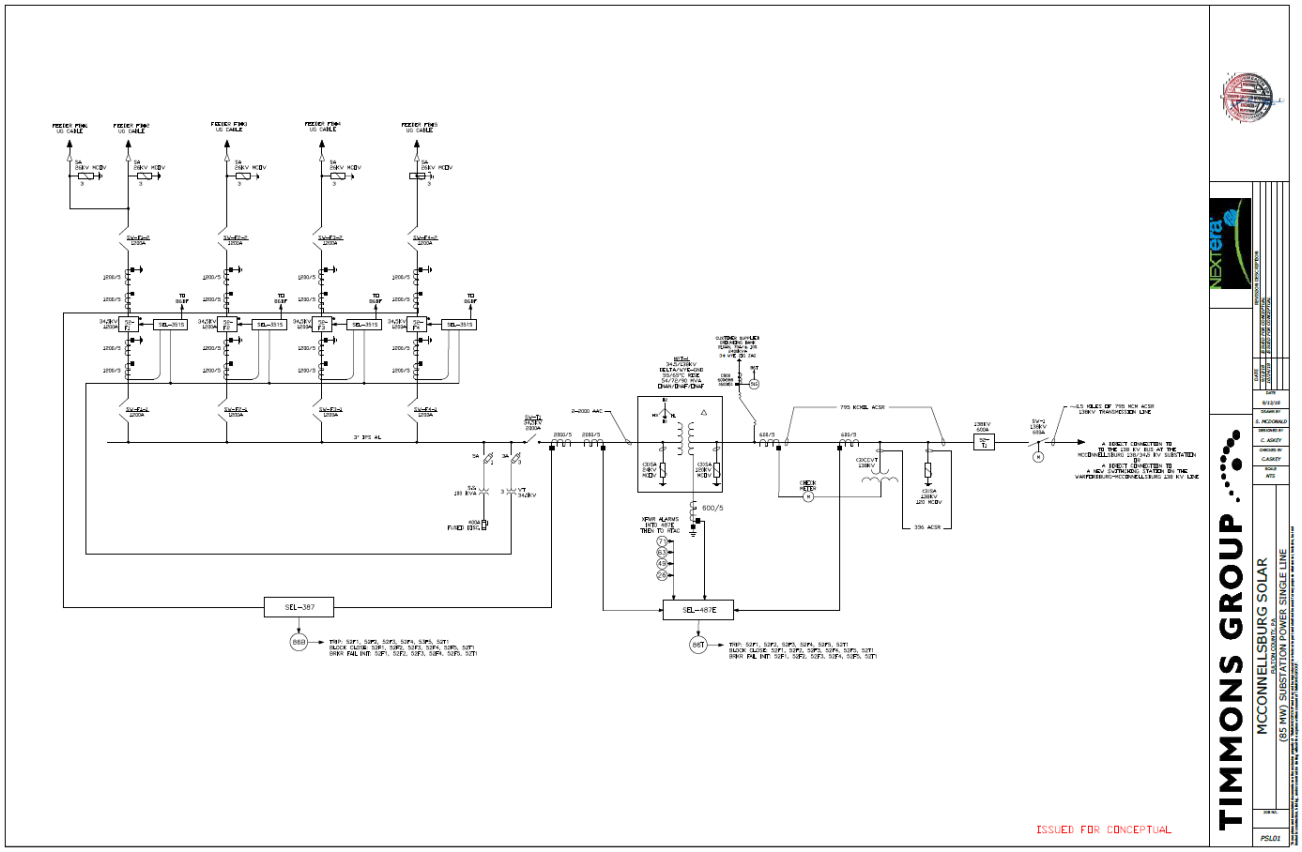
All relays, relay schemes and relay settings that include 138 kV voltages or currents, or trip any 138 kV circuit breakers, shall require the review and approval of Transmission Owner. Transmission Owner will complete detailed relay coordination studies to identify off-site relay setting changes required due to this generation interconnection. This may result in additional individual relay replacements being required. The cost of these relay replacements will be borne by Developer.

## Attachment #2: One-Line Diagrams

**FirstEnergy Facilities One-Line**

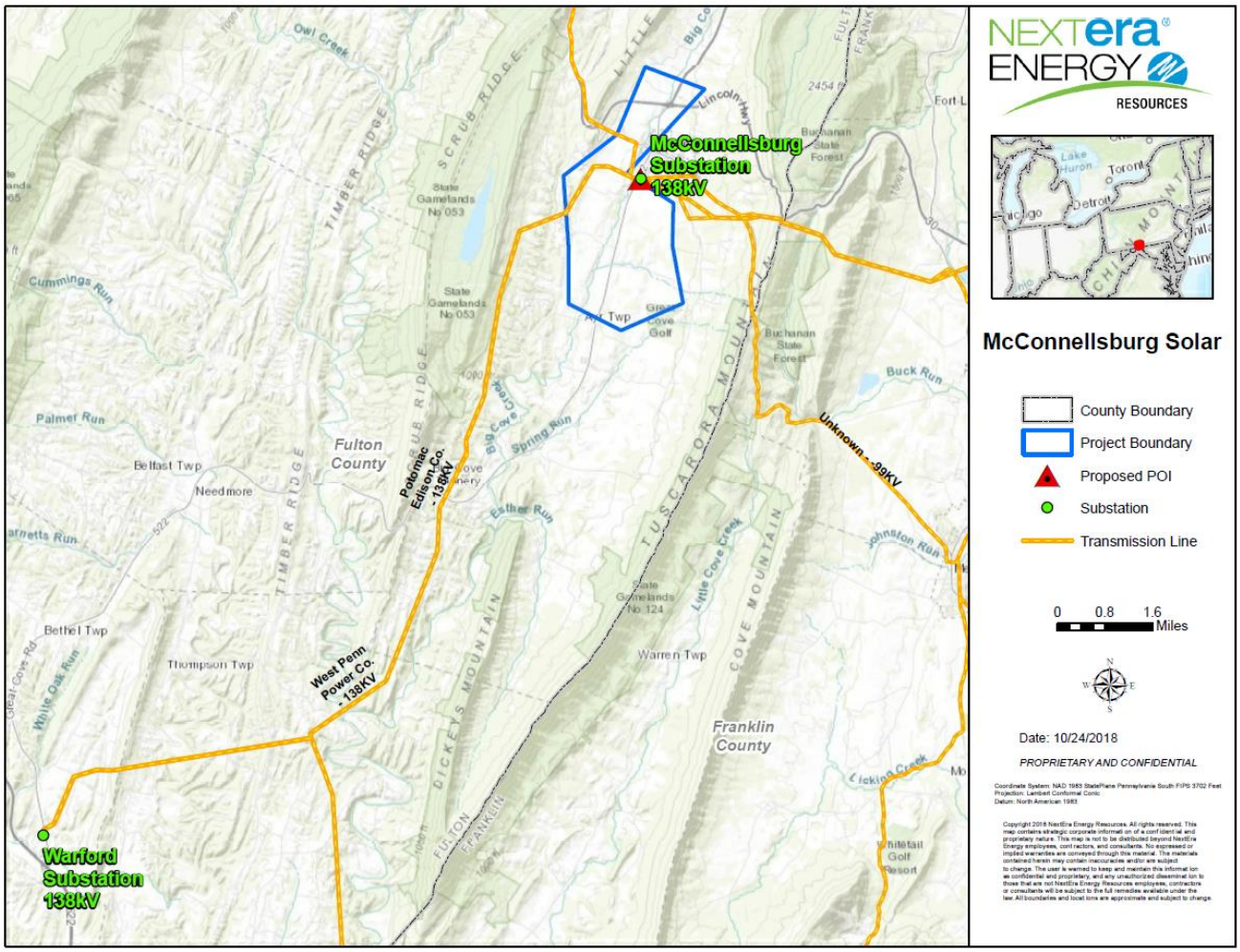


## IC Facilities One-Line



## Attachment #3: Project Site Plan

**IC Site Plan, IC Substation Location and Point of Interconnection to FE**



## Attachment #4: Generation Connection Requirements

# Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* documents located at either of the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

The following is an excerpt taken from Transmission Owner's *Requirements for Transmission Connected Facilities* document:

*For all generation facilities, other than wind-powered and other non-synchronous generating facilities, the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at continuous rated power output at a power factor as defined in the table below. This requirement will be measured at either the POI or generator terminals as specified in the table below. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when demanded.*

*For all wind-powered or other non-synchronous generating facilities the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at a power factor as defined in the table. This requirement will be measured at either the POI or generator's terminals as specified in the table below. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when needed.*

| Generation Type | New / Increase | Size | Power Factor Requirement | Measurement Location |
|---|---|---|---|---|
| Synchronous | New | > 20 MW | 0.95 leading to 0.90 lagging | Generator's Terminals |
| Synchronous | New | <= 20 MW | 0.95 leading to 0.90 lagging | Point of Interconnection |
| Wind or Non-Synchronous | New | All | 0.95 leading to 0.95 lagging | Point of Interconnection |
| Synchronous | Increase | > 20 MW | 1.0 (unity) to 0.90 lagging | Generator's Terminals |
| Synchronous | Increase | <= 20 MW | 1.0 (unity) to 0.90 lagging | Point of Interconnection |
| Wind or Non-Synchronous | Increase | All | 0.95 leading to 0.95 lagging | Generator's Terminals |

*Any different reactive power requirements that FE and/or PJM determines to be appropriate for wind-powered or other non-synchronous generation facilities will be stated in the applicable interconnection agreement(s).*

*Induction generators and other generators with no inherent VAR (reactive power) control capability, or those that have a restricted VAR capability less than the defined requirements, must provide dynamic supplementary reactive support located at the generation facility with electrical characteristics equivalent to that provided by a similar-sized synchronous generator.*

**Design Requirements**

Developer is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with Transmission Owner's Transmission System. Developer is also responsible for meeting any applicable federal, state, and local codes.

**Design Criteria**

Facilities owned and operated by Transmission Owner shall comply with the applicable Transmission Owner technical requirements and standards posted on the PJM website per the PJM Tariff, and the following criteria. Where there are different requirements for the same criterion, the more restrictive shall apply. Developer must abide by any PJM, RFC or NERC criteria imposed that is more restrictive than those of Transmission Owner.

**General Design Requirements**

| | |
|---|---|
| • System phasing (counter clockwise) | 1-2-3 |
| • System frequency: | 60 hertz |
| • Elevation, AMSL: | Less than 1000 meters |
| • ***Isokeraunic level:*** | 40 |
| • Maximum ambient temperature: | 40 degrees C |
| • Minimum ambient temperature: | -40 degrees C |
| • Maximum conductor operating temperature: | Contact Transmission Owner |
| • Wind Loading (round shapes): | Per ASCE 10, per Fig. 250-2B depending on location<br>Per ASCE 7-98, per Fig. 6-1 depending on location |
| • Ice loading – Substations (no wind): | 25 mm |
| • Seismic zone: | Per ASCE Manual 113 Substation Structure Design Manual. Equipment qualification per IEEE 693-2005 and IEE 1527-2006<br>Per ASCE 7-98, per Fig. 9.4.1.1(a) and (b). Equipment qualification per IEEE 693-97 |

**Voltage and Current Ratings**

| | |
|---|---|
| • Nominal phase-to-phase: | 138 kV |
| • Maximum phase-to-phase: | 145 kV |
| • Basic impulse level (BIL): | 550 kV |
| • Maximum continuous current carrying capacity: | 2000 A |

- Design fault current: 40 kA
- Single Contingency (breaker failure) clearing time: 60 cycles

**Clearances and Spacing**

- Recommended rigid bus center-to-center phase spacing: 96”
- Minimum phase-to-phase, metal-to-metal distance: 63”
- Recommended phase-to-ground: 52.5”
- Minimum phase-to-ground: 50”
- Minimum vertical clearance from live parts to grade: 12’-2”
- Minimum horizontal clearance from live parts: 6’-8”
- Minimum conductor clearance above roads in switchyard: 25’-0”
- Minimum bottom of insulator to top of foundation: 8’-6”