Transmission Interconnection Facilities Study Report

For

PJM Generation Interconnection Request Queue Position AE2-224

"Bear Rock-Johnstown 230 kV"

March 2022

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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 IC 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

CPV Maple Hill Solar, LLC, (hereinafter referred to as "IC") has proposed a solar generating facility located in Cambria County, Pennsylvania. The installed facilities for AE2-224 will have a total capability of 100 MW with 60 MW of this output being recognized by PJM as capacity. The generation facility will interconnect with Mid-Atlantic Interstate Transmission Inc. (MAIT), a First Energy Company (FE), hereinafter referred to as "Transmission Owner" (TO), in the Penelec operating region, by constructing a new 230 kV three-breaker ring bus substation and looping the Bear Rock -Johnstown 230 kV line into the new station line. The new substation will be located approximately 15 miles from Johnstown substation.

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

- This report is based on the AE2-224 System Impact Study report posted on the PJM website dated March 2022 and does not include AF2-050, an uprate to this project.
- IC elected Option to Build the new 230kV three breaker ring bus substation.
- Work on Johnstown substation was added after system impact study
- Estimates do not include CIP/Security related items to be installed by FE in the interconnection substation.
- Reactive Power assessment has been finalized. AE2-224 **does not meet** the reactive power requirement at the high side of main transformer. Reactive power compensation is required for this project. AE2-224 needs to have an estimated additional 11.03 MVAR capacitive reactive power to fulfill the power factor requirement.

- Stability assessment is complete with no identified impacts
- Affected system study complete with no identified impacts

3. Interconnection Customer's Milestone Schedule

IC's requested Commercial Operation Date (COD) for the generation facility as posted on the PJM website is **September 01, 2021**. IC's requested schedule does not match TO's assumed schedule.

Transmission Owner's Assumed Milestone Schedule:

03/05/2024	Initial Back-feed through Project Substation Date
05/05/2024	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, 230 kV (AE2-224) generator lead line and connection to the 3 breaker ring bus interconnection substation.

The IC has elected the Option to Build the new 3 breaker ring bus interconnection substation.

Point of Interconnection (POI): The POI will be located within the new 230 kV ring bus interconnection where IC-owned 230 kV attachment line conductor will terminate on the insulators on the dead-end takeoff structure.

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 First Energy's applicable standards as well as with PJM requirements.

The easements and associated rights of way for the TO owned substation along with the 230 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 230 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 230 kV Lead Line. For these areas, the IC shall provide TO with proposed plan and profile or PLS-CADD 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 230 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 230 kV generator lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities. See Section 7 of this report for additional information.
- IC will coordinate design of all access roads used by Transmission Owner to access their facility. For these areas, the IC shall provide TO with a proposed construction set prior to construction and as-built drawings, confirmed by as-built survey data post-construction. The construction plan shall provide proposed plan, profile, cross section and all other relevant supporting details to complete a safe, stable place to work both now and into the future. The first submission does not need to be stamped/sealed/signed by a Professional Engineer. The final submission before construction begins, must be stamped/sealed/signed by a Professional Engineer.

5. Description of Facilities Included in the Facilities Study

Attachment Facilities (Customer has elected Option to Build these facilities. FirstEnergy will provide engineering and construction oversight.)

Interconnection Customer will design, furnish and construct the new 230 kV line terminal and take off structure under Option to Build. This work will include, but not be limited to, installation of a 230 kV line exit take-off structure, foundations, disconnect switch and associated equipment to accommodate the termination of the 230 kV generator lead line. Ownership of these assets will be turned over to the Transmission Owner.

AE2-224 Customer Substation

Drawings and nameplates will be reviewed.

Direct Connection

AE2-224 230kV (new interconnection substation)- (Customer has elected Option to Build these facilities. FirstEnergy will provide engineering and construction oversight.)

A new 230 kV three breaker ring bus substation will be constructed under Option to Build by the IC,

along the Bear Rock-Johnstown 230 kV transmission line to interconnect the AE2-224 solar project with the MAIT transmission system. The POI will be at the TO-owned deadend structure inside the substation yard where the generator lead line terminates.

Non-Direct Connection

Bear Rock – Johnstown 230kV Line

The Bear Rock to Johnstown 230 kV line will be cut and looped into the new 230 kV interconnect substation by the Transmission Owner. This cut will take place at a location that is approximately 14.89 miles from the Johnstown substation and 5.55 miles from the Bear Rock Substation. It is assumed that the interconnection substation will be located within one span (approximately 0.1 mile) from the existing line.

Johnstown Substation
Line terminal will be upgraded by the Transmission Owner

Lewistown Substation
Line terminal will be upgraded by the Transmission Owner

Raystwon Substation
Line terminal will be upgraded by the Transmission Owner

Altonna Substation
Nameplates, drawings, relay settings and relay upgrade will be reviewed by the Transmission Owner

Bear Rock Substation
Line terminal will be upgraded by the Transmission Owner

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

Description	Total (w/o Tax)
Attachment Facilities:	**$0**
Total Direct Connection (DC) Costs:	**$218,153.66**
Total Non-Direct Connection (NDC) Costs:	**$2,869,026.16**
Other Work Costs:	**$1,064,330.91**
New System Upgrades	**$0**
TOTAL Costs (ALL Categories)	**$4,151,510.73**

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

Activity	*Duration*
AE2-224: Engineering, Procurement, and Construction	19 months

B. Transmission Owner Facilities Study Results

This section describes facilities identified to be installed (attachment facilities), replaced, and/or upgraded (upgrade facilities) by First Energy 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

Bear Rock-Johnstown 230kV Line

- Loop the Bear Rock-Johnstown 230kV line into the new AE2-224 interconnection substation.
- The existing line is constructed on single circuit wood H-frame structures. Per TAMI, existing conductor is 1033.5 kcmil 54/7 ACSR "Curlew," and existing shield wire is (1) 3/8" 7-Strand EHS and (1) OPGW FOCAS Skylite 36 Fiber.
- It is assumed the new conductor in the new loop will match existing. New shield wire in the loop is assumed to be (2) 7#8 Alumoweld for each leg of the loop. It is assumed approximately 200 ft of conductor and shield wire will be installed for each leg of the loop.
- Per RPA documents, the line conductors and EHS shield will be cut approximately 5.55 miles from Bear Rock Substation. This assumes the loop will be near existing structure #93.
- The loop will require the following installations:
  - (2) new single circuit wood 3-pole deadend structures similar to FE standard TR-230075
  - Approximately 200 ft of new 1033.5 kcmil 54/7 ACSR "Curlew" and (2) 7#8 Alumoweld shield wires in each leg of the loop
- It is assumed existing wood H-Frame structure #93 will be removed.
- Existing conductor and shield wires will be transferred to the new deadend structures between #92 and #94. Existing conductors and EHS shield wire on the Bear Rock-Johnstown 230kV line between the new deadend structures will be removed (approximately 100 ft). Existing OPGW will not be cut or removed and will be transferred to the new structures.
- Siting/Licensing
  - A LON will be required to be filed with the PaPUC.
  - Assume no local opposition to the project.
- Assumptions

- Assume existing structures #92 and #94 are in good condition and have adequate capacity for the new loading arrangement. An engineering analysis will be required to confirm.
- See the attached .kmz file for the assumed loop configuration.
- Assume aerial LiDAR will be available for this project. FE TVM has collected 230kV LiDAR. A processing request is required.
- It is assumed OPGW is not needed in the new loop spans.
- Access to the loop structures is assumed to be part of the substation scope of work.

3. New Substation/Switchyard Facilities

AE2-224 Customer Substation

- Below Grade
  - None
- Above Grade
  - Review drawings, nameplates, and relay settings Add customer substation
  - Add to HV circuit diagram
- R&C
  - None
- Additional Equipment to be Removed
  - None
- Assumptions
  - No additional nameplates are required since AF2-262 will be complete
  - Review the entire grading package for the pad. Including access roads, substation pad creation and water management.

AE2-224 Interconnect Substation (To be built by Interconnection Customer under Option to Build. FE to provide oversight)

- Below Grade
  - Install fence, grounding, and stoning of new substation.
  - Install foundations, conduits, and trench for new 230kV substation.
  - Conduits from line exits to control building for fiber termination.
- Above Grade
  - Install (2) 230kV H-Frame take-off structures
  - Install (1) prefabricated control house
  - Install (3) 230kV breakers
  - Install (3) 230kV motor-operated disconnect switches
  - Install (6) 230kV manual-operated disconnect switches
  - One (1) lot of steel structures, switch stands and CVT structures
  - Install (9) 230kV CVTs
  - Install (9) 230kV class surge arresters

- R&C
  - Install (1) SCADA RTU, (1) HMI panel (including non-operational RTAC) and (1) Arbiter GPS clock
  - Install (1) fiber termination rack.
  - Install (1) transmission panel consisting of (2) SEL-411L for AE2-224 Sub.
  - Install (2) transmission panels consisting of (1) SEL-421 with fiber optic transceiver and (1) SEL-411L for Johnstown line terminal and Bear Rock line terminal.

- Install (3) control panels each consisting of (1) SEL-501 & metering.

- Additional Equipment to be Removed
  - None
- Assumptions
  - Developer has elected Option to Build.

4. Substation/Switchyard Facility Upgrades

Bear Rock

- Below Grade
  - Conduit for fiber from AE2-224 line terminal to control house
- Above Grade
  - Drawing and nameplate updates for line name change
- R&C
  - Install (1) FDP and (1 lot) fiber jumpers
  - Install (1) PCM5350 on AE2-224 line terminal
  - Install (1) fiber optic transceiver and add to the existing Johnstown line SEL421 PR relay
  - Replace (1) SEL321 with (1) SEL411L in the Johnstown line relaying panel
    - Relays are not the same size, so equipment on rack will need to be shifted around
- Additional Equipment to be Removed
  - Remove Johnstown line PLC equipment, including (2) wave trap, (2) line tuner, and associated transceivers
- Assumptions
  - DC system and SCADA RTU are adequate for new equipment
  - FDP doesn't exist and is required

Altoona

- Below Grade
  - None
- Above Grade
  - Review drawings, nameplates and relay settings
- R&C
  - Install (1) PCM5350 in Frame 2 for the Bear Rock line
  - Install (1) SEL2411 in Frame 7 for the Raystown line exit
- Additional Equipment to be Removed
  - None
- Assumptions
  - PCM5350 can be installed in Frame 2
  - DC system is adequate for new equipment
  - SCADA RTU is adequate for new equipment

Raystown

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Install (1) SEL2411 in Altoona line relaying panel

        - Install (1) SEL2411 in Lewistown line relaying panel
    - Additional Equipment to be Removed
        - None
    - Assumptions
        - Existing panels can fit SEL2411s
        - DC system is adequate for new equipment

Lewistown

- Below Grade
    - None
- Above Grade
    - None
- R&C
    - Install (1) SEL2411 in Frame 8 for the Raystown line
- Additional Equipment to be Removed
    - None
- Assumptions
    - DC system is adequate for new equipment

Johnstown

- Below Grade
    - Conduit for fiber from AE2-224 line terminal to control house
- Above Grade
    - Drawing and nameplate updates for line name change
- R&C
    - Install (1) fiber optic transceiver and add to the existing Bear Rock line SEL421 PR relay
    - Replace (1) SEL321 with (1) SEL411L in the Bear Rock line relaying rack
        - Relays are not the same size, so equipment on rack will need to be shifted around
    - Install (1) FDP and (1 lot) fiber jumpers
- Additional Equipment to be Removed
    - Remove Bear Rock line PLC equipment, including (2) wave trap, (2) line tuner, and associated transceivers
- Assumptions
    - DC system is adequate for new equipment
    - FDP doesn't exist and is required
    - SCADA RTU is adequate for new equipment

5. Telecommunications Facilities – Upgrades

IC will design, provide, install, own and maintain a fiber-optic communications cable between the new **interconnection** 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 interconnection substation control house.

Transmission Owner will make the fiber termination connections for its cable(s) at the line dead end termination structures in the interconnection substation. 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 may require the use of high accuracy extended range current transformers.

Transmission Owner's Revenue Metering Requirements may be found in the *Requirements for Transmission Connected Facilities* 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 provide the telecommunication circuits for the SCADA RTU and the telephone in the Transmission Owner interconnection substation.

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.

Communications for transmission line protection between the **interconnection** substation, and IC's **generation** (collector) substation, will be via fiber optics (see "Telecommunication Facilities" section above).

7. Environmental, Real Estate and Permitting and Geotech/Site/Civil

The following are possible environmental, real estate and permitting issues, Geotech/Site/Civil:

- 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.
- IC is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.
- All work occurs within an existing transmission line right-of-way or on IC'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.

- IC will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits.
- IC will obtain all necessary permits for the scope of work it is building.
- IC will conduct all necessary wetlands and waterways studies and permits for the scope of work it is building.
- IC will conduct all necessary historical and archaeological studies for the scope of work it is building.
- If the IC 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
- IC will conduct Geotechnical reconnaissance of the proposed site. A Geotechnical report providing recommendations for the site will be provided. This includes subsurface drainage, surface drainage, cut/fill, slope and other site-specific recommendations.
- IC will conduct Geotechnical stability analysis as necessary based on the grading design put forth for this project.
- IC will provide all necessary information, including stamped/sealed/signed plans to adequately construct the site and all other features utilized by the TO. Plans shall meet the standards as followed by the TO for their own construction plans.
- Additional, Third-Party Geotechnical oversight might be provided based on complexity of the design.

8. Schedules and Assumptions

For this project which the Interconnection Customer has elected Option to Build the Transmission Owner Attachment and Direct Connection facilities, a proposed **nineteen (19) month** schedule is estimated to complete the engineering, construction and the associated **Non-direct Connection activities**, from the later of the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting or upon TO's receipt of IC's locational data and design parameters for the deadend structure(s) for final tie-in connections. 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 or January through March) will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

19 month Schedule:

	Start	End
Activity	Month	Month
Preliminary Engineering	1	3
Siting, Permits & Real Estate	2	12
Geotech/Site/Civil This depends on how much work IC has done. All other tasks shift down. Detailed engineering can't start until this is decided.	2	5
Detailed Engineering	2	10
Equipment Delivery	10	15
Below Grade Construction – T-Lines	15	16
Above Grade Construction – T-Lines	17	19
Remote End Relay Installation	15	17
Testing & Commissioning	17	19

9. Information Required for Interconnection Service Agreement

The following table provides a breakdown of the costs according to the description of work required to accommodate the requested interconnection. The estimated costs are in 2020 dollars. This cost excludes a Federal Income Tax Gross Up charges (CIAC (Contribution in Aid of Construction)). This tax may or may not be charged based on whether this project meets all qualifications and requirements as set forth in Section 118(a) and 118(b) of the Internal Revenue Code of 1986, as amended and interpreted by Notice 2016-36, 2016-25 I.R.B. (6/20/2016) (the "IRS Notice"). If at a future date it is determined that the Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

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.

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Total Attachment Facilities Cost	**$0**	**$0**	**$0**	**$0**	**$0**
AE2-224 Sub: Design, install and test/commission MPLS Equipment for SCADA transport (PJM Network Upgrade Number n7530)	$115,500.68	$75,578.00	$25,019.26	$2,055.72	$218,153.66
Total Direct Connection Cost	**$115,500.68**	**$75,578.00**	**$25,019.26**	**$2,055.72**	**$218,153.66**
Bear Rock-Johnstown 230 kV Line Loop: Loop the Bear Rock-Johnstown 230kV into the new AE2-224 Interconnection Substation (PJM Network Upgrade Number n7531)	$719,236.24	$69,595.04	$155,797.85	$24,700.11	$969,329.24

Johnstown Substation: Upgrade Line Terminal (PJM Network Upgrade Number n7532)	$341,105.60	$13,995.53	$73,888.82	$380.68	$429,370.63
Lewistown Substation: Upgrade Line Terminal (PJM Network Upgrade Number n7533)	$176,869.64	$4,143.77	$38,312.74	$112.71	$219,438.85
Raystown Substation: Upgrade Line Terminal (PJM Network Upgrade Number n7534)	$295,056.61	$7,521.32	$63,913.89	$204.58	$366,696.40
Altoona Substation: Nameplates, Drawings, relay settings and relay Upgrade (PJM Network Upgrade Number n7535)	$331,399.67	$22,093.50	$71,786.36	$4,847.11	$430,126.64
Bear Rock Substation: Upgrade Line Terminal (PJM Network Upgrade Number n7536)	$346,585.58	$31,544.92	$75,075.87	$858.02	$454,064.40
Total Non-Direct Connection Cost	**$2,210,253.34**	**$148,894.08**	**$478,775.53**	**$31,103.21**	**$2,869,026.16**
AE2-224 Customer: Review drawings and nameplates.	$27,094.07	$0	$5,869.00	$0	$32,963.07

AE2-224 Interconnection Sub: Option to Build Oversite to construct a new 138 kV three breaker ring bus looping in the Bear Rock – Johnstown 138 kV line to provide interconnection facilities for AE2-224. Third Party oversight, Geotech/Site/Civil oversight might need to be added.	$847,735.12	$0	$183,632.72	$0	$1,031,367.84
Other Work	**$874,829.19**	**$0**	**$189,501.72**	**$0**	**$1,064,330.91**
Total Project Costs	**$3,200,583.21**	**$224,472.08**	**$693,296.51**	**$33,158.94**	**$4,151,510.73**

Attachment #1: Protection Study

PROTECTION SCOPE

Following is the protection scope information (Facilities Study Stage only) for the AE2-224 solar generation project. These protection requirements are for the new AE2-224 Interconnection Substation on the Johnstown – Bear Rock 230kV line, approximately 14.89 miles from Johnstown Substation. The Interconnection Substation will be designed as a three-breaker ring bus configuration.

Short Circuit Analysis
Fault values for the AE2-224 Interconnection Substation location with no AE2-224 generation equipment in service are:

Three phase = 9967 A
Single line to ground = 8259 A
Z1= 0.276 + j 2.508 %
Z0= 0.818 + j 4.002 %

Impedances are given on a 100 MVA and 230kV base. The fault currents provided are bolted, symmetrical values for normal system conditions, using the FirstEnergy Short Circuit case. Future increases in fault currents are possible and it is the Developer's responsibility to upgrade its equipment and/or protective equipment coordination when necessary.

AE2-224 Interconnection Substation
Construct a new three-breaker 230kV ring bus. Install three SEL-501 relays, one per breaker, for Failure to Trip protection. Install three sets of three-phase CCVTs, one for each line exit. Install three SATEC meters, one per line exit. Install a GPS Clock and SEL RTAC for remote relay access and SCADA distance to fault. Loop the existing OPGW fiber on the Johnstown – Bear Rock 230kV line into the new AE2-224 Interconnection Substation. The fiber shall be used for direct relay-to-relay communication for line protection, DTT, and anti-islanding. The AE2-224 anti-islanding scheme shall include breaker and airswitch status information from Johnstown, Bear Rock, Altoona, Raystown, and Lewistown, utilizing handoff schemes at each intermediary station. Anti-islanding shall be transmitted from AE2-224 to Bear Rock, including the handoff of status received from Johnstown.

Johnstown Substation 230kV line exit – Install primary SEL-421 relay and fiber optic transceiver for Directional Comparison Blocking (DCB) protection over fiber, and backup SEL-411L relay for line current differential protection over fiber. Breaker failure transfer trip and breaker/airswitch status communication for anti-islanding will be performed in the line protection relays using mirrored bits over fiber.

Bear Rock 230kV line exit – Install primary SEL-421 relay and fiber optic transceiver for Directional Comparison Blocking (DCB) protection over fiber, and backup SEL-411L relay for line current differential protection over fiber. Breaker failure transfer trip and breaker/airswitch status communication for anti-islanding will be performed in the line protection relays using mirrored bits over fiber.

AE2-224 Collector Substation 230kV line exit – Install SEL-411L primary and SEL-411L backup relays for line protection, each utilizing a current differential protection scheme over dedicated fiber, with backup overcurrent and step distance protection. In addition to providing line protection, the SEL-411L relays

will send and receive direct transfer trip to and from the AE2-224 Collector Substation for anti-islanding and breaker failure to trip protection.

AE2-224 Collector Substation

AE2-224 Interconnection Substation 230kV line exit – Install SEL-411L primary and SEL-411L backup line protection relays, each utilizing a current differential protection scheme over dedicated fiber, with backup overcurrent and step distance protection. The SEL-411L relays will also be used for sending and receiving breaker failure transfer trip, with the transfer trip I/O configured in the same manner as at the interconnection station. The interrupting device on the interconnection line is required to be a fully rated circuit breaker. A dedicated breaker failure to trip relay is required for each breaker at 100kV and above on the developer's system. The developer is to design their protective system to clear any faults within their zones of protection with one or more of their local breakers. The zones of protection covering the 100kV and above portion of the developer's system, the interconnection breaker, and the GSU Transformer(s), shall be protected by two independent relay schemes, each providing high speed fault clearing, and meeting the following redundancy requirements. Primary and backup relaying shall use independent CTs, and independent CVTs or independent windings from the same CVTs. Primary and backup relaying shall not have any common wiring, isolating switches, or auxiliary tripping relays. Redundancy of a protection system can be achieved by ensuring that there is no single point of failure between two locally independent primary and backup protection schemes for a given element. Relays from the same manufacturer are acceptable for both the primary and backup schemes. The terminal breaker at the generation end of the interconnection line is to be included in the over-lapping zones of protection. A protection scheme containing generator Intertie functions is required. Voltages and currents for the Intertie relaying must come from the 230kV system. The CTs used for the zones of protection covering the100kV and above portion of the developer's system shall be 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. The GSU Transformer winding configuration is required to be Grounded-Wye on the high side (FE side), and Delta on the low side (generator side) per FirstEnergy's Requirements for Transmission Connected Facilities document. The relaying system and interrupting device control circuits shall have a reliable source of 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.

Johnstown Substation

AE2-224 Interconnection Substation 230kV line exit – Reuse the existing Bear Rock SEL-421 primary line relay with a new fiber optic transceiver and replace the existing SEL-321 backup line relay with a new SEL-411L relay. Connect the relays to the existing OPGW fiber for primary DCB and backup line current differential protection to the new AE2-224 Interconnection Substation. Breaker failure transfer trip and breaker/airswitch status communication for anti-islanding will be performed in the line protection relays using mirrored bits over fiber. Remove the power line carrier equipment, including the wave trap, tuner, hybrids, and transmitters/receivers.

Bear Rock Substation

AE2-224 Interconnection Substation 230kV line exit – Reuse the existing Johnstown SEL-421 primary line relay with a new fiber optic transceiver and replace the existing SEL-321 backup line relay with a new SEL-411L relay. Connect the relays to the existing OPGW fiber for primary DCB and backup line current differential protection to the new AE2-224 Interconnection Substation. Breaker failure transfer trip and breaker/airswitch status communication for anti-islanding will be performed in the line protection relays

using mirrored bits over fiber. Remove the power line carrier equipment, including the wave trap, tuner, hybrids, and transmitters/receivers.

Altoona 230kV line exit – Reuse the existing RFL-9780 and carrier equipment for receiving the anti-islanding signal from Altoona. A new handoff scheme at Bear Rock shall combine the signal received from Altoona with the local breaker status and forward this to the AE2-224 Interconnection Substation for anti-islanding. Install PCM-5350 power line carrier monitors.

Altoona Substation

Bear Rock 230kV line exit – Reuse the existing Bear Rock terminal RFL 9780 transmitter for FSK transmit for anti-islanding at Bear Rock and the new AE2-224 Interconnection Substation. Install PCM-5350 power line carrier monitors.

Raystown 230kV line exit – Install an SEL-2411 on the Raystown terminal to receive breaker/airswitch status over the existing OPGW fiber for anti-islanding at Bear Rock and the new AE2-224 Interconnection Substation. A new handoff scheme at Altoona shall combine the signal received from Raystown with local breaker status at Altoona and transmit it to Bear Rock.

Raystown Substation

Altoona 230kV line exit – Install an SEL-2411 on the Altoona terminal to transmit breaker/airswitch status over the existing OPGW fiber for anti-islanding at Bear Rock Substation and the new AE2-224 Interconnection Substation.

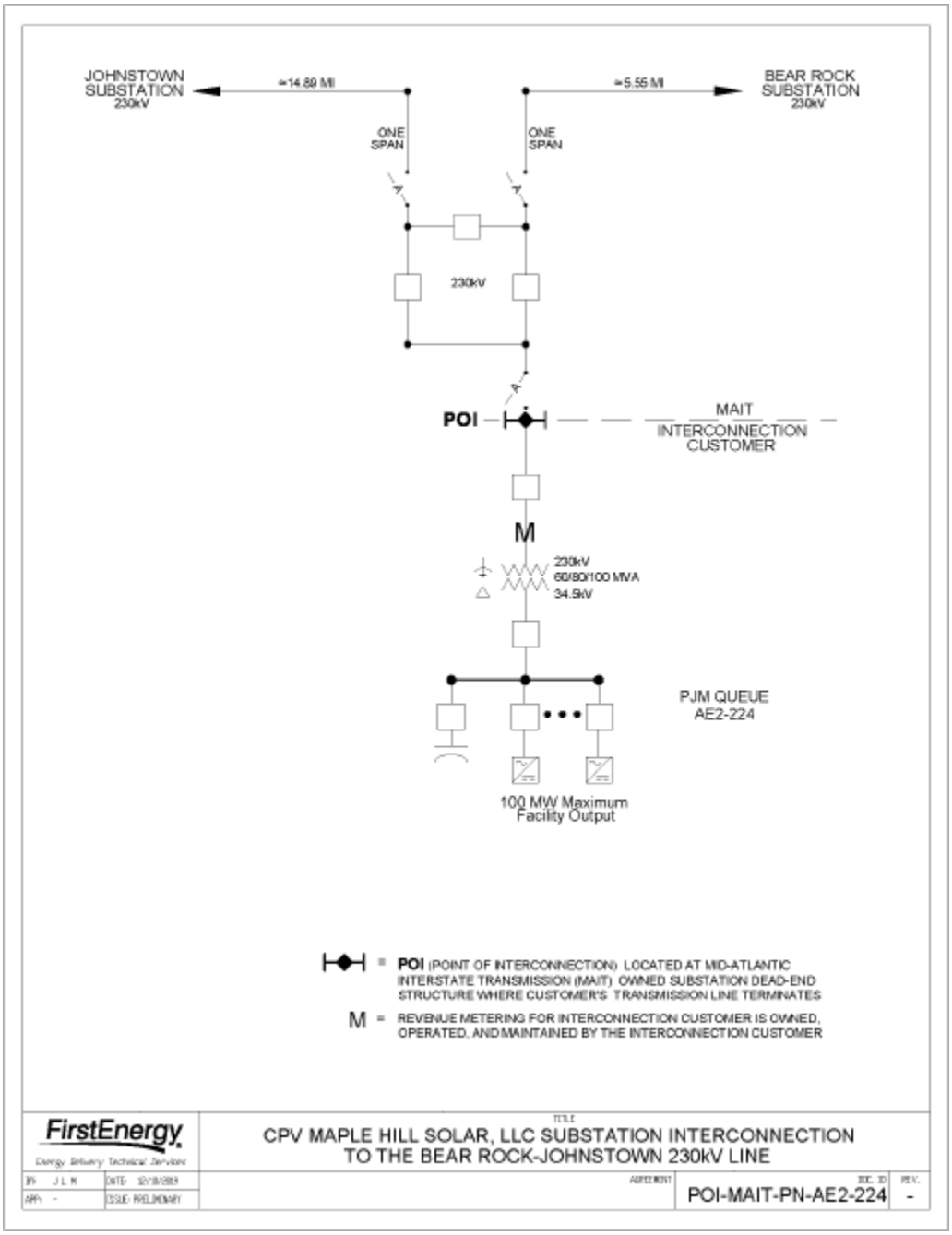
Lewistown 230kV line exit – Install an SEL-2411 on the Lewistown terminal to receive breaker/airswitch status over the existing OPGW fiber for anti-islanding at Bear Rock Substation and the new AE2-224 Interconnection Substation. A new handoff scheme at Raystown shall combine the signal received from Lewistown with local breaker status at Raystown and transmit it to Altoona.

Lewistown Substation

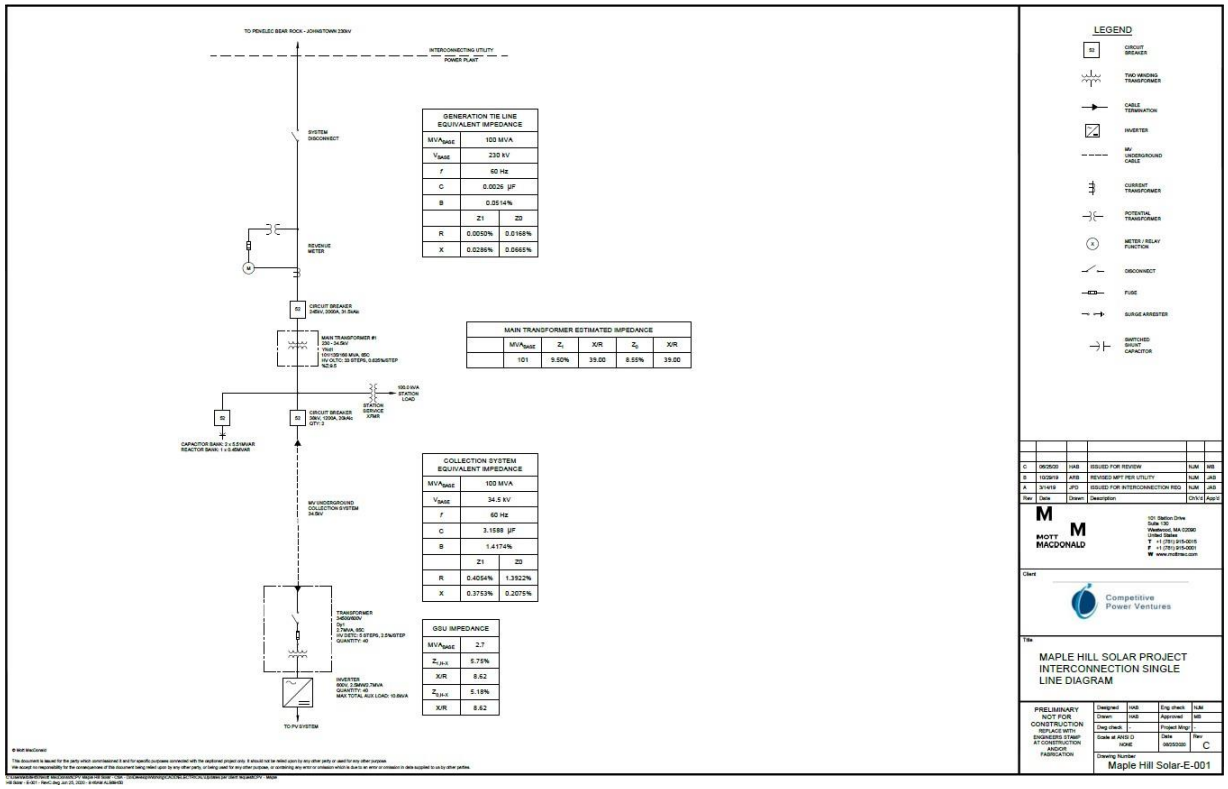
Lewistown Substation: Raystown 230kV line exit -Install an SEL-2411 on the Raystown terminal to transmit breaker/airswitch status over the existing OPGW fiber for anti-islanding at Bear Rock Substation and the new AE2-224 Interconnection Substation.

Attachment #2: One-Line Diagrams

First Energy One-Line

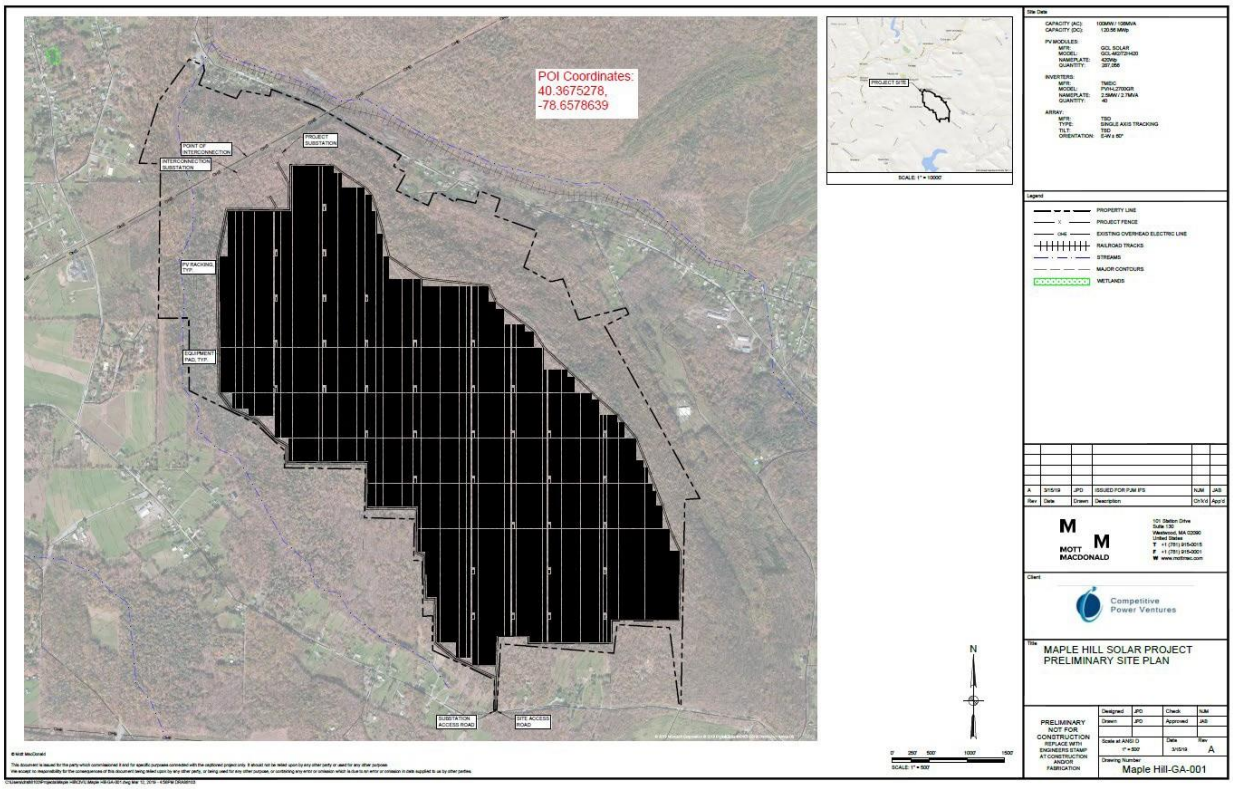


IC One Line
Not Approved for Construction



Attachment #3: IC Site Plan and Substation Attachment Facilities

IC Site Plan



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 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.*

For projects that entered PJM's New Service Queue after November 1, 2016, the power factor requirement will be as follows:

Generation Type	New / Increase	Size	Power Factor Requirement	Measurement Location
Wind or Non-Synchronous	New	All	0.95 leading to 0.95 lagging	High Side of the Facility Substation Transformers

> *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

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

Transmission Design Requirements

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. IC 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 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 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:	230 kV
• Maximum phase-to-phase:	242 kV
• Basic impulse level (BIL):	900 kV
• Maximum continuous current carrying capacity:	2000 A
• Design fault current:	61 kA

Clearances and Spacing

- Recommended rigid bus center-to-center phase spacing: 132”
- Minimum phase-to-phase, metal-to-metal distance: 89”
- Recommended phase-to-ground: 80”
- Minimum phase-to-ground: 71”
- Minimum vertical clearance from live parts to grade: 13’-9”
- Minimum horizontal clearance from live parts: 8’-3”
- Minimum bottom of insulator to top of foundation: 8’-6”