PJM Generator Interconnection

Facilities Study Report

For

PJM Generation Interconnection Request Queue #AD2-116

"Grantley-Hokes 69 kV"

November 2020

Queue #AD2-116
Grantley-Hokes 69 kV
Facilities Study Report

Description of the Project

Cottontail Solar 2, LLC, (hereinafter referred to as "Developer") has proposed the addition of facilities for AD2-116 which will have a total capability of 20 MW with 13 MW of this output being recognized by PJM as capacity. The following table summarizes the MW contributions of each queue request to the Maximum Facility Output (MFO) and Capacity Interconnection Rights (CIR):

PJM Queue Position	Requested MW Energy	Requested MWs Capacity	MFO	CIRs
AD2-116	20	13	20	13
Total	20	13	20	13

The installed facilities will have total capability of 20 MW (MFO) with 13 MW of this output being recognized by PJM as Capacity Interconnection Rights (CIR).

This project is located in York County, Pennsylvania (Ref: Figure 3) in southeastern Pennsylvania. The generation facility will be located within the **Met-Ed (ME)** service territory, and the power will be injected into the **Mid-Atlantic Interstate Transmission, LLC (MAIT)** 69 kV transmission system near the Hokes Substation. Both ME and MAIT are subsidiaries of FirstEnergy (FE) (hereinafter referred to as "Transmission Owner").

AD2-116 will interconnect with the MAIT transmission system by a tap of the Grantley-Hokes 69 kV line.

Schedule

Developer's requested Commercial Operation Date (COD) for the generation facility is **May 15, 2022**.

Developer's Requested Milestone Schedule:

02/15/2022 Initial Back-feed Date
05/15/2022 Project Commercial Operation Date

Direct Connection and Non-Direct Connection Schedule: Transmission Owner proposes a **ten** (**10**) month schedule following a fully executed Interconnection Construction Service Agreement and Construction Kickoff Meeting in order to complete the engineering and construction associated with activities, as detailed in the "Attachment Facilities", "Direct Connection" and "Non-Direct Connection" sections below.

Scope of Developer's Work

Developer will construct photovoltaic facilities, generation step-up (GSU) transformer, 69 kV generator Lead Line (0.1 miles), and connect to the Transmission Owner's new 69 kV tap point just outside Hokes Substation.

Point of Interconnection (POI): the point where Developer's 69 kV generator Lead Line terminates on the 69 kV structure at the Transmission Owner' newly created 69 kV tap point on the Grantley-Hokes 69 kV line (Ref: Figure 2).

Developer is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of each GSU transformer, revenue meter, interconnection metering instrument transformers and a main breaker on the collector bus, located in the generator substation yard.

Developer will also purchase and install the minimum required FirstEnergy generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays. They will also purchase and install supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FirstEnergy Transmission System Control Center. Developer will provide for establishment of dedicated communication circuits for SCADA report to the FirstEnergy Transmission System Control Center.

Project Scope

It is proposed that the AD2-116 project construct a new 69 kV line to a new 69 kV tap point on the Grantley-Hokes 69 kV line to be constructed by the Transmission Owner.

Developer is responsible for constructing all the facilities on its side of the POI, as shown in the attached one-line diagram (Ref: Figure 2), including obtaining all property rights and required permits for installing 0.1-mile, 115 kV generator Lead Line from the generator site to the POI.

The 69 kV interconnection tap is proposed to be located at the following GPS coordinates:
39.938612, -76.772528

The Developer's generation substation is proposed to be located at the following GPS coordinates:
39.938418, -76.772453

Description of Facilities Work:

Facilities Work to be constructed by the Developer:

1. Generator Lead Line (0.1 miles from POI to Project Site)

General Assumptions / Notes:

- Developer will construct proposed 69 kV Lead Line with the Transmission Owner review of any clearance or right-of-way encroachment issues with existing TO owned 69 kV facilities.

- For the proposed 69 kV Lead Line, the Developer shall provide TO with transmission plan & profile or PLS-CADD drawings file prior to construction and as-built drawings, confirmed by as-built survey data post-construction for sag and tension of conductor.
- Additional costs will be incurred by the Developer, if final alignment or tension of 69 kV Lead Line causes encroachments, changes, or modifications to any existing TO facilities.

Right-of-Way (ROW) Assumptions:

- Developer will acquire all necessary line and access road right-of-way for generator 69 kV Lead line.
- Given the proposed location of the Developer's generation facilities (both north and south of the transmission line corridor), the Developer should also take into consideration how they plan to cross the transmission corridor. It will require permission of FirstEnergy for design, clearances and route of any facilities (low voltage lines, access roads, etc,) which will need to cross the Transmission line right-of-way.
- 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
- Additional costs will be incurred by the Developer, if final alignment of AD2-116 69 kV facilities and or line cause encroachments, changes, or modifications to any existing or relocated TO facilities.

Forestry/Vegetation Management Assumptions:

- The only vegetation clearing work on the project is associated with the generator 69 kV Lead Line and is the responsibility of the Developer.
- Developer is responsible for Erosion and Sediment Control (E&S) installation, access road construction and rehabilitation along the length of the generator 69 kV Lead Line.

Facilities Work to be constructed by Transmission Owner:

- The AD2-116 project will interconnect with the MAIT subtransmission system via a tap into the Grantley-Hokes 69 kV Line at a point located 0.07 miles from Hokes substation. The POI is located 1 span from the tap point at or near MAIT structure # 90-122.

- Install two motor operated and SCADA controlled switches near the tap point at or near MAIT structure #90-122 of the Grantley-Hokes 69kV Line. Both of these switches will be installed in the network path. PJM Network Upgrade Number n6027

- Estimated installation of radio communication system to support the SCADA switch installations. Assumed SCADA work is included in this cost. PJM Network Upgrade Number n6028.

- Communications for transmission line protection between Grantley and Hokes substations and to the Developer's generation (collector) substation, will be via power line carrier.

1. 69 kV dead-end structure – Install new dead-end structure for tap point

Install new 69 kV pole (dead-end structure) with associated hardware.

Assumptions / Notes:

- Developer will coordinate design and alignment of proposed AD2-116 69 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. The Developer shall provide TO with proposed transmission plan & profile 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. As a minimum, Developer facilities should not encroach within 100 feet of TO centerline at blowout conditions. If Developer's line design does not comply with this requirement TO would need to review this area as a special exception.

Engineering Assumptions:

- No forestry work is anticipated.
- It is assumed that no existing structures will need to be removed.

Siting Assumptions:

- It is expected that the Erosion & Sedimentation Control Plan for the transmission line work will be the responsibility of the Transmission Owner.
- Assumes that project will receive local municipal approval with no public or municipal opposition. It assumes no property owner, governmental, or municipal opposition to the overall project.
- All transmission line work will occur within property currently owned and under FirstEnergy control.

Environmental Assumptions

- Environmental permits from PA will be required.
- Environmental studies may be required to develop E&S Control Plans and required measures. Costs include development and submittal of E&S Plan, periodic monitoring of E&S measures including post construction removal and rehabilitation.
- The Developer will be responsible for all environmental surveys, permits, approvals and plans with federal, state, and/or local agencies.
- Developer 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.
- Developer is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.

Forestry/Vegetation Management Assumptions

- It is assumed that no additional vegetation clearing will be required.

2. Line Switches – 2 new motor operated, SCADA controlled switches

Install two motor operated, air-break switches in the 69 kV line. These switches shall include whip attachments to assist with arc minimization during current interruption operations. These switches shall also be SCADA controlled. The final switch locations will be determined after review of field conditions and ease of access to the structure for construction and maintenance purposes. The estimate also assumes that a radio communication system is acceptable and able to reach these switch locations.

Total Estimated Costs of Transmission Owner Facilities for Direct and Non-Direct Connection:

The following table summarizes the total estimated costs according to FERC criteria. The estimated costs are in 2020 dollars. The taxes are a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129.

Description	Total Cost (w/o Tax)	Tax (if applicable)	Total Cost (w/ Tax)
Attachment Facilities			
One span from the POI to the tap point at or near MAIT structure #90-122 on the Grantley-Hokes 69 kV Line **PJM Network Upgrade Number n6026**	**$ 166,102**	**$ 33,831**	**$ 199,933**
TOTAL Attachment Facilities (AF) Costs	**$ 166,102**	**$ 33,831**	**$ 199,933**
Direct Connect Facilities			
None			
TOTAL Direct Connect (DC) Costs	**$ 0**	**$ 0**	**$ 0**
Non-Direct Connect Facilities			
Install 69 kV dead-end structure and associated hardware. Install two motor operated, SCADA controlled, air-break switches at the tap point at or near MAIT structure #90-122 of the Grantley-Hokes 69kV Line. **PJM Network Upgrade Number n6027**	**$ 437,798**	**$ 89,169**	**$ 526,967**
Install a 700 MHz or cellular radio system at AD2-116 to support the SCADA switch installations. **PJM Network Upgrade Number n6028**	**$ 48,000**	**$ 9,800**	**$ 57,800**

Project Management, Construction Management, Environmental **PJM Network Upgrade Number n6027**	**$ 186,200**	**$ 38,000**	**$ 224,200**
TOTAL Non-Direct Connect (NDC) Costs	**$ 671,998**	**$ 136,969**	**$ 808,967**
TOTAL AF, DC & NDC Costs	**$ 838,100**	**$ 170,800**	**$ 1,008,900**

Schedule:

A proposed **ten** (**10**) month 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 "Engineering, Siting, Environmental, and Forestry Issues" section of this document are resolved, and outages will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

Activity	Start Month	End Month
Preliminary Engineering	1	2
Detailed Engineering	3	6
Equipment Procurement - Delivery	8	9
Below Grade Construction	N/A	N/A
Above Grade Construction	10	10
Testing & Commissioning**	10	10

Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* document 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.

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
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	High Side of the Facility Substation Transformers
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	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

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.

In particular, the Developer is responsible for the following:

1. The purchase and installation of fully rated 69 kV circuit breaker to protect the AD2-116 generator lead line. A single breaker must be used to protect this line. FirstEnergy does not approve for individual GSU transformer breakers (if applicable) to protect this line.

2. The purchase and installation of the minimum required FirstEnergy generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FirstEnergy Transmission System Control Center.

4. The execution of a back-up service agreement to serve the customer load supplied from the AD2-116 generation project metering point when the units are out-of-service. This assumes the intent of the Developer is to net the generation with the load.

5. Power factor and voltage control requirements: Developer is required to comply with the FirstEnergy and PJM generator power factor and voltage control requirements. The Developer shall design its solar-powered non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the FE transmission system.

6. System Protection Requirements: Developer must design it's Customer Facilities in accordance with all applicable standards, including the standards in FirstEnergy's "Requirements for Transmission Connected Facilities" document located online. Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

7. Provide FirstEnergy documentation of PV needs to comply to IEEE 1547 and UL1741

8. FirstEnergy will need to review updated one-line diagrams

9. FirstEnergy will need to review the Developers protection settings

10. The Developer must meet all PJM, ReliabilityFirst, and NERC reliability criteria and operating procedures. For example, the Developer 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 ReliabilityFirst 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 FirstEnergy system.

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 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:	69 kV
• Maximum phase-to-phase:	72.5 kV
• Basic impulse level (BIL):	350 kV
• Maximum continuous current carrying capacity:	600 A
• Design fault current:	40 kA

Clearances and Spacing

• Recommended rigid bus center-to-center phase spacing:	60”
• Minimum phase-to-phase, metal-to-metal distance:	31”
• Recommended phase-to-ground:	29”
• Minimum phase-to-ground:	25”
• Minimum vertical clearance from live parts to grade:	10’-5”
• Minimum horizontal clearance from live parts:	4’-11”

Metering, SCADA and Communications

PJM Requirements

The Developer 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-14Dand PJM Tariff Sections 24.1 and 24.2.

FirstEnergy Requirements

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

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

General Assumptions/Qualifiers

The accomplishment of the work on the Transmission Owner system to support the estimated costs and proposed schedule is dependent on the following:

- Obtaining the necessary line and substation outages. Transmission line and substation outages are typically not granted from June to September and are discouraged during extreme winter conditions.
- No equipment delivery delays.
- No extreme weather.
- No force majeure.
- Developer will obtain all necessary permits.
- Developer will develop all necessary access roads for project sites.
- Given the proposed location of the Developer's facilities (both north and south of the transmission line corridor), the Developer should also take into consideration how they plan to cross the transmission corridor. It will require permission of FirstEnergy for design, clearances and route of any facilities (low voltage lines, access roads, etc,) which will need to cross the Transmission line right-of-way.
- 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
- Additional costs will be incurred by the Developer, if final alignment of AD2-116 69 kV facilities and or line cause encroachments, changes, or modifications to any existing or relocated TO facilities.

ATTACHMENTS

ATTACHMENT A
Queue #AD2-116
Detailed Protection Requirements
(NOT to be used for Construction)

Short Circuit Analysis

At 69 kV:

Positive Seq. Impedance = 0.67014 + j6.48616 Ohms

Zero Seq. Impedance = 2.51752 + j11.2237 Ohms

Single Line to Ground Fault Current = 6341 Amps

Three Phase Fault Current = 7458 Amps

Fault values are from the current system condition on the Hokes- Line without the proposed generation project and extension of the 90 line to the POI. The faults provided are bolted, symmetrical values for normal system conditions. It should be similar short circuit values at the interconnection point with the extension of the 90 line but future changes in fault currents are possible and it is the customer's responsibility to upgrade their equipment and/or protective equipment coordination when necessary.

General Connection Requirement

All proposed generation interconnection points and load-serving delivery points must comply with the technical requirements detailed in the FirstEnergy "Requirements for Interconnection of customer owned Generation to the FirstEnergy Distribution System" document.

Protection Requirements for PV installation on 69kV Line

There should be two levels of anti-island protection. If the inverters meet the testing requirements of IEEE-1547.1 or are UL1741 certified, Anti-islanding Direct Transfer Trip will not be required and the inverters themselves have one level of anti-island protection.

The second level of anti-island protection, the intertie relay, could be a SEL-351-7 and provide just the intertie functionality (over and under voltage, over and under frequency and ground overvoltage) but this functionality can be place inside the SEL-351-7s that are used for the fault protection. This relay is to be located on high side of 69/34.5kV transformer. Install 3 Phase PTs [Potential Transformers] (WYE Gnd -WYE Gnd- Broken Delta) on 69kV side of existing transformer.

Intertie relaying located on High side of existing 69/34.5kV transformer will need to trip Solar Generation offline during a fault event on 69kV Line and Solar Gen is feeding the fault. This can be achieved by either tripping a device on high side of Step Up transformer or by tripping individual PV strings offline. This tripping can be done via Fiber or microwave communication if preferred.

All relays, relay schemes, and relay settings that include 69kV voltages or currents or trip any 69kV circuit breakers shall require the review and approval of FirstEnergy.

Customer shall install a Delta High side or Ungrounded Wye High side transformer. The transformer shall be protected by independent protection schemes, namely, Primary Differential and Backup Differential or Backup Overcurrent, with current inputs from independent CT (Current Transformer).

FirstEnergy 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. These relay replacements will be done at the cost of the developer.

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

FIGURE 1
Queue #AD2-116
Relay Sketch*

Not available for this report. For protection related requirements, see “Detailed Protection Requirements” section.

FIGU& RE 2
Queue #AD2-116
Point of Interconnection Diagram

* Note: Diagram does not represent a physical layout. Not to be used for construction.

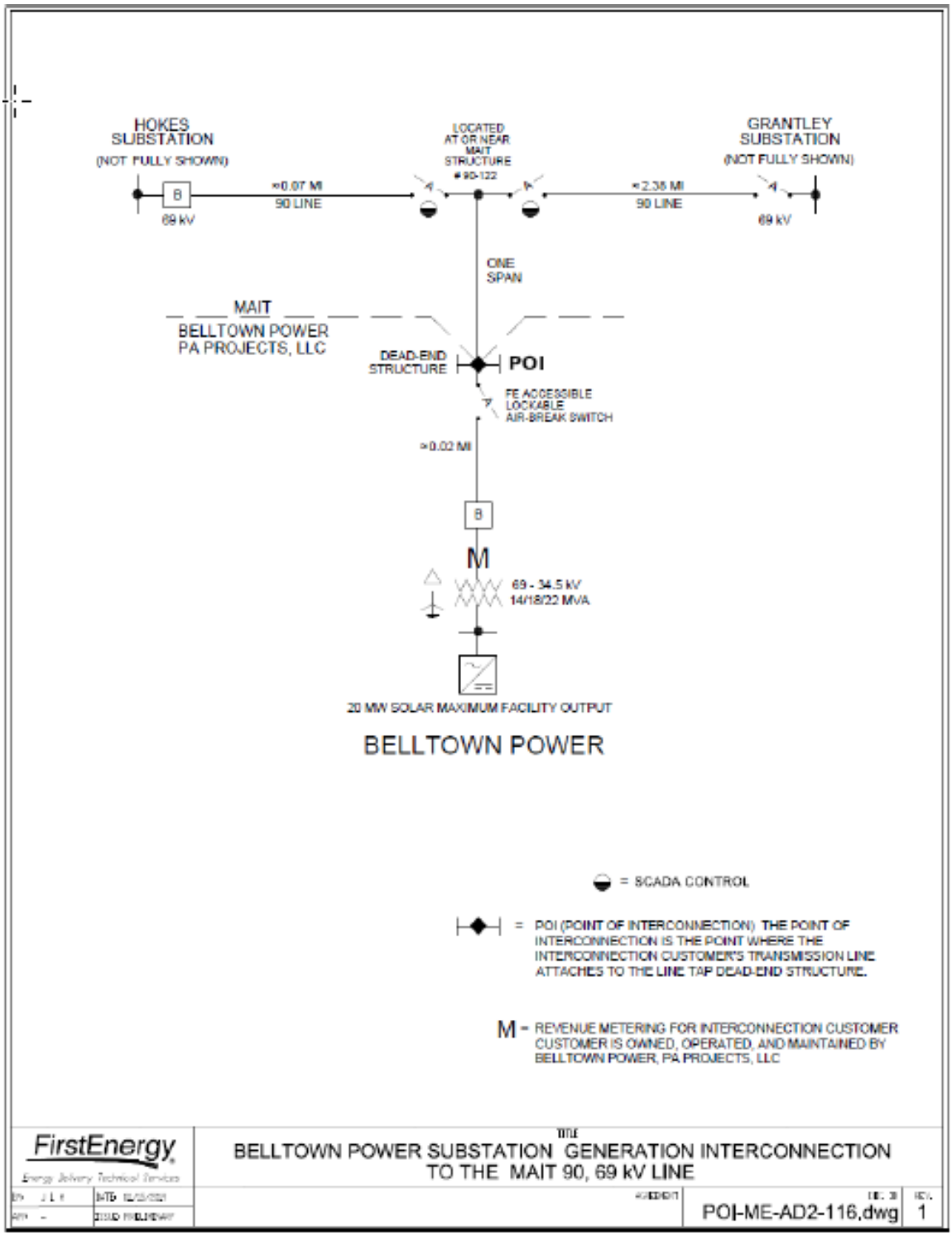
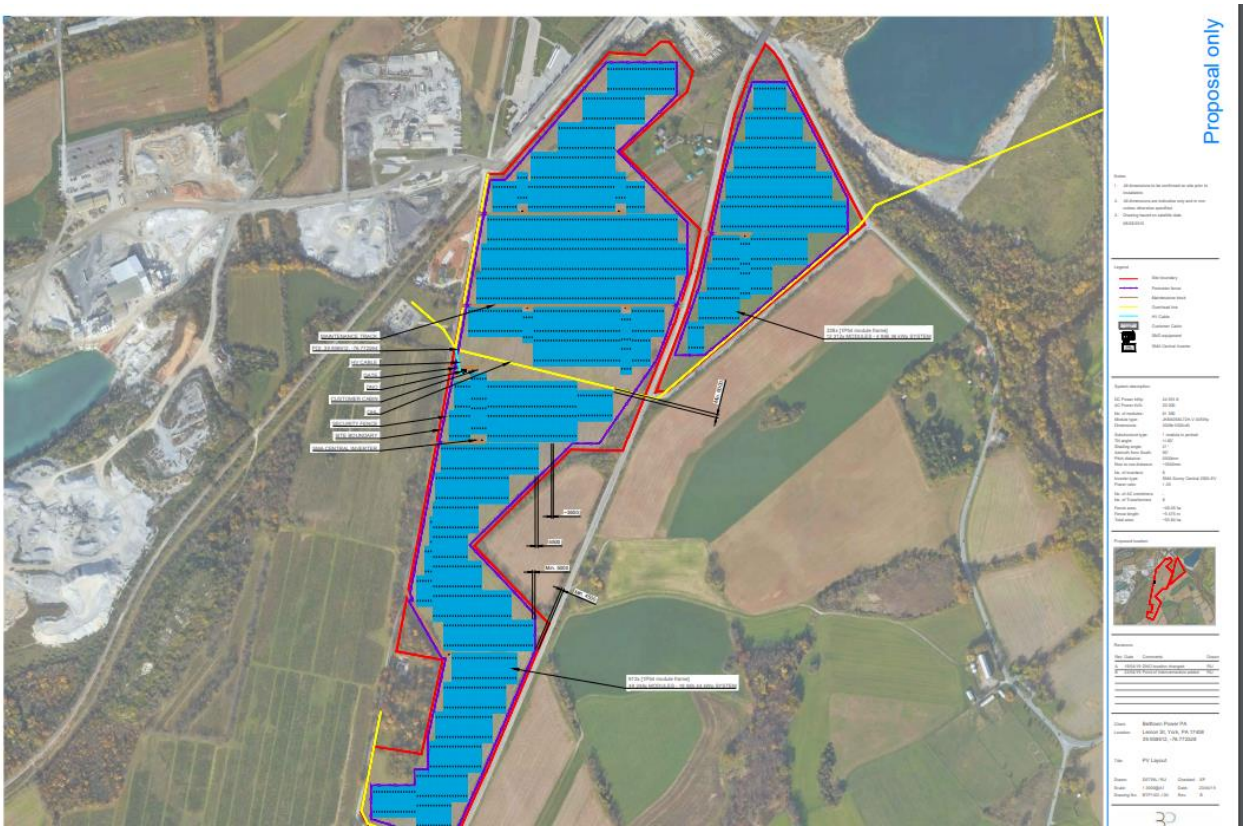


FIGURE 3
Queue #AD2-116
Project Location
(Provided by the Developer)



(Provided by FirstEnergy)

Single Line Diagram
(Provided by the Developer)