Generation Interconnection
Facilities Study Report

For

PJM Transmission Interconnection Request
Queue Position AE1-071

“Shade Gap – Roxbury 115 kV”

September 2021

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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 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

Aspen Road Solar I, LLC, (hereinafter referred to as "IC") has proposed a new solar generating facility to be located in Spring Run, Franklin County, Pennsylvania. The installed facilities for AE1-071 will have a total Maximum Facility Output (MFO) of 100.1 MW with 62.1 MW of this output being recognized by PJM as Capacity. The generation facility will interconnect with Mid-Atlantic Interstate Transmission, LLC ("MAIT"), a FirstEnergy Company (FE), hereinafter referred to as "Transmission Owner" (TO), by constructing a new 115 kV three (3) breaker ring bus substation and looping the Roxbury – Shade Gap 115 kV line into the new station.

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

There were no notable amendments since the System Impact Study.

3. Interconnection Customer's Milestone Schedule

IC's requested Commercial Operation Date (COD) for the generation facility is November 30, 2023.

Milestone Schedule:

9/15/2023	Initial Back-feed through Project Substation
11/30/2023	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, 115 kV (AE1-071) generator lead line and connection to the tap point on the Shade Gap - Roxbury 115 kV line.

Point of Interconnection (POI): The interconnection of the project will be accomplished by constructing a new 115 kV three (3) breaker ring bus substation and looping the Roxbury – Shade Gap 115 kV line into the new station. The new substation will be located approximately 6.4 miles from Roxbury 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 115 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 115 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 115 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 115 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 115 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.

5. Description of Facilities Included in the Facilities Study

Attachment Facilities

- AE1-071 Generator Lead Termination (New Interconnection Substation)
    - Estimated cost related to interconnection to the customer gen tie line

- New AE1-071 Interconnecting Substation
    - Review relay setting and nameplates

Direct Connection

- AE1-071 New Interconnecting 115 kV Switching Station
    - A new three (3) breaker ring bus switching station will be constructed on the Roxbury – Shade Gap 115 kV line to interconnect to the Aspen Solar I. Loop the Roxbury – Shade Gap 115 kV line into new station

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

Non-Direct Connection

- Roxbury – Shade Gap 115 kV Line Loop:
    - Loop the Roxbury – Shade Gap 115 kV line into new station

- Roxbury Substation:
    - Install Hybrids and 1 DTT UPLC transmitter

- Lewistown Substation:
    - Install Hybrids and 1 DTT UPLC transmitter. Replace wave trap and line tuner.

- Shade Gap Substation:
    - Install Hybrids and 1 DTT UPLC transmitter.

Other Facilities

- AE1-071 Metering
    - Customer-owned 115 kV revenue metering at Shade Gap – Roxbury 115 kV: Provide interconnection facilities for AE1-071 Gen

New System Upgrades

None.

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:	**$ 582,800**	**$ 102,600**	**$ 685,400**
Total Direct Connection (DC) Costs:	**$ 5,652,200**	**$ 995,100**	**$ 6,647,300**
Total Non-Direct Connection (NDC) Costs:	**$ 1,358,600**	**$ 239,300**	**$ 1,597,900**
Total Other Costs	**$ 4,600**	**$900**	**$5,500**
New System Upgrades	**$ 0**	**$ 0**	**$ 0**
TOTAL Costs (ALL Categories)	**$ 7,598,200**	**$ 1,337,900**	**$ 8,936,100**

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

Attachment Facility	*Duration*
AE1-071: Engineering, Procurement, and Construction	24 months

B. Transmission Owner Facilities Study Results

1. Transmission Lines –New

None.

2. Transmission Lines – Upgrade

Roxbury - Shade Gap 115 kV Line

- Cut the existing Roxbury-Shade Gap 115 kV line approximately 7.2 miles from the Shade Gap substation and 6.4 miles from the Roxbury substation (near structure #58) to create a loop into the new substation.
- The existing line consists of the following:
  - Single Circuit 115 kV H-frame wood structures.
- The proposed loop is assumed to require the installation of two (2) 115kV single circuit wood deadend 3-pole structures (TR-115075).
- New conductor and dual shield wire will be installed on each leg of the new loop.
  - The conductor for the loop is assumed to be 336.4 kcmil 26/7 ACSR. The shield wire is assumed to be (2) 7#8 Alumoweld.
  - The new spans to the substation are assumed to be approximately 200 feet.
  - Remove existing conductor between the deadends.
  - Assume the existing conductor and shield wire are in good condition and can be transferred to the new structures.
- Siting/Licensing
  - A LON will be required.
- Assumptions
  - The exact location of the new substation has not been determined. Once decided further analysis shall be conducted. See attached KMZ for further details.
  - A 23 kV Distribution line runs parallel with the Roxbury-Shade Gap 115 kV line located approximately 30’ to the southwest. Proper clearance is to be maintained.
  - Assume existing LiDAR is sufficient.
  - Assume the outage requirements for construction on the new line can be met.
  - Assume adjacent structures have adequate capacity to handle the new loading. An engineering analysis will be required.
  - Assume OPGW is not needed.

ANCILLARY ESTIMATES (LINE)

IT/Network

- Fiber (Relaying and Communications)

- None
- SCADA/Other
  - None

Distribution
- None

Real Estate
- Assume all work will be performed within the existing line ROW or on the substation property and no additional ROW will be required.
- A rights and restrictions review by Real Estate will be required.
- Guying rights will need to be reviewed or acquired as part of this project for the two new 3-pole structures.
- Georeferenced ROW extents will be required to be provided to engineering.

Environmental
- Assume access roads are required for approximately 0.1 miles. Assume that primary access to the site is provided by the substation. Terrain is flat.
- An environmental review will be required to identify any constraints and additional permitting requirements.

Forestry
- Some clearing may be required. Priority tree rights may be expanded.

3. New Substation/Switchyard Facilities

Interconnection 115 kV Switching Station
- Below Grade
  - Install Foundations, Conduit, and Grounding for a New 3 Breaker Switching Station.
  - Install Trench, Stone, Fence, and Ground Grid.
  - Developer to Provide Graded Site.
- Above Grade
  - Install control building with Sam-900 HMI, Arbiter 1094B GPS Clock, Communications, and Battery System.
  - Install (1) 115 kV SSVTs for Station Service with Throw-over Switch.
  - Install (3) 115 kV Breakers.
  - Install (6) 115 kV, 2000 A, Breaker Disconnect Switches.
  - Install (3) 115 kV, 1200 A, MOAB Switches.
  - Install (9) 90 kV, 70 kV MCOV, Surge Arresters.
  - Install (9) 115 kV CCVTs.
  - Install (2) 115 kV Wideband Wave Traps.
  - Install (2) 115 kV Wideband Line Tuning Units and Coax.
  - Install (2) AMETEK Smart-Gaps (Pending FE Substation Design Approval).

- Install (3) 115 kV Dead-end Structures.
- Install One Lot of Rigid Bus, Strain Bus, Conductor, Steel Supports as Indicated on the Attached Layout.

- R&C
  - Install (2) transmission line relaying panels with Dual SEL421 with SEL501 BFT Relaying and UPLC for DCB with PowerComm PCM-5350.
  - Install (1) transmission line relaying panels with Dual SEL411L with SEL501 BFT Relaying.
  - Install (1) Anti Islanding Relay Panel with (3) DTT UPLC Receivers.
  - Install (1) SEL Axion RTU Complete with Operational and Non-operational RTACs.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Revenue metering will be at the Aspen Road Solar I facility

AE1-071 Generation

- Below Grade
  - None
- Above Grade
  - Review Relay Settings and Nameplates.
- R&C
  - None
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

4. Substation/Switchyard Facility Upgrades

Roxbury Substation

- Below Grade
  - None
- Above Grade
  - Retune existing line trap and line tuner for new frequencies.
- R&C
  - Install Hybrids and (1) DTT UPLC Transmitter.
  - Review/Revise Relay Settings to the Interconnect Substation.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Dual SEL-421 line with DCB over carrier relaying has been installed by SAP 15180151.

Shade Gap Substation

- Below Grade
  - None
- Above Grade
  - Retune existing line trap and tuner for new frequencies.
- R&C
  - Install Hybrids and (1) DTT UPLC Transmitter.
  - Review/Revise Relay Settings to the Interconnect Substation.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Dual SEL-421 Line with DCB Over Carrier Relaying has been Installed by SAP 15180164
  - The Wideband Wave Trap and Wideband Line Tuning Unit have been Installed by SAP 15346699.

Lewiston Substation

- Below Grade
  - Install Foundations, Conduit, and Grounding for Replaced Wave Trap and Line Tuning Unit.
- Above Grade
  - Replace (1) Single Resonant Frequency Wave Trap with (1) Wideband Wave Trap.
  - Replace (1) Single Resonant Frequency Line Tuning Unit with Wideband Line Tuning Unit.
- R&C
  - Install hybrids and (1) DTT UPLC Transmitter.
- Additional Equipment to be Removed
  - None
- Assumptions
  - SEL321 Primary Line Relaying and SEL311B Backup Line Relaying are Adequate.

ANCILLARY ESTIMATES (SUBSTATION)

IT/Network

- Fiber (Relaying and Communications)
  - Interconnection 115kV Switching Station
    - Install (1) Fiber Interface Panel.

SCADA/Other

- Interconnection 115kV Switching Station
  - Install new SEL SCADA RTU, HMI, RTAC, and Communications.

- Roxbury 115kV Substation
  - Add a DTT send point and revise line names.

- Shade Gap 115kV Substation
  - Add a DTT send point and revise line names.

- Lewiston 115kV Substation
  - Add a DTT send point.

Distribution

- None

Real Estate

- Provided by developer

Environmental

- None

Revenue Metering

- Located at customer substation.

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 interconnection 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			
AE1-071 Generator Lead Termination (New Switching Substation): Estimated cost related to interconnection to the customer gen tie line	$ 553,900	$ 97,500	$ 651,400
AE1-071 Gen: Review relay setting and nameplates	$ 28,900	$ 5,100	$ 34,000
Total Attachment Facilities (AF) Costs	$ 582,800	$ 102,600	$ 685,400
Direct Connect Facilities			
AE1-071 New Interconnecting 115 kV Switching Station: A new three (3) breaker ring bus switching station will be constructed on the Roxbury – Shade Gap 115 kV line to interconnect to the Aspen Solar I. Loop the Roxbury – Shade Gap 115 kV line into new station	$ 5,176,200	$ 911,100	$ 6,087,300
SCADA/Fiber Communication: Estimated SCADA work at Roxbury substation to support relay installation. Estimated SCADA work at Shade Gap substation to support relay installation. Estimated SCADA work at Lewistown substation to support wavetrap and relay installation.	$ 81,400	$ 14,400	$ 95,800
Fiber Communication at Roxbury: Install fiber from Roxbury to backbone for communication transport	$ 139,900	$ 24,700	$ 164,600
Project Management: Project Management, Forestry, Real Estate and Right of Way.	$ 254,700	$ 44,900	$ 299,600
Total Direct Connect (DC) Costs	$ 5,652,200	$ 995,100	$ 6,647,300
Non-Direct Connect Facilities			
Roxbury – Shade Gap 115 kV Line Loop: Loop the Roxbury – Shade Gap	$ 573,300	$ 101,000	$ 674,300

115 kV line into new station			
Roxbury Substation: Install Hybrids and 1 DTT UPLC transmitter	$ 223,700	$ 39,400	$ 263,100
Lewistown Substation: Install Hybrids and 1 DTT UPLC transmitter. Replace wave trap and line tuner	$ 308,300	$ 54,300	$ 362,600
Shade Gap Substation: Install Hybrids and 1 DTT UPLC transmitter	$ 253,300	$ 44,600	$ 297,900
Total Non Direct Connect (NDC) Costs	$ 1,358,600	$ 239,300	$ 1,597,900
Other Facilities			
AE1-071 Metering: Customer-owned 115 kV revenue metering at Shade Gap – Roxbury 115 kV: Provide interconnection facilities for AE1-071 Gen	$ 4,600	$900	$5,500
Total Direct Connect (DC) Costs	$ 4,600	$900	$5,500

Total AF + DC + NDC Costs	$ 7,598,200	$ 1,337,900	$ 8,936,100

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 **24 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.

24 month Schedule

Activity	Start Month	End Month
[redacted]		
Preliminary Engineering	1	2
Siting, Permits & Real Estate	4	12
Detailed Engineering	3	11
Equipment Delivery	6	18
Below Grade Construction – Substation	15	17
Below Grade Construction – T-Lines	18	19
Above Grade Construction – Substation	18	21
Above Grade Construction – T-Lines	20	21
Testing & Commissioning	22	24

10. Information Required for Interconnection Service Agreement

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
AE1-071 Generator Lead Termination (New Switching Substation): AE1-071 Generator Lead Termination (New Switching Substation)	$ 290,200	$ 196,100	$ 64,700	$ 2,900	$ 553,900
AE1-071 Gen: Review relay setting and nameplates	$ 23,600	$ 0	$ 5,300	$ 0	$ 28,900
Total Attachment Facilities Cost	**$ 313,800**	**$ 196,100**	**$ 70,000**	**$ 2,900**	**$ 582,800**
AE1-071 New Interconnecting 115 kV Switching Station: A new three (3) breaker ring bus switching station will be constructed on the Roxbury – Shade Gap 115 kV line to interconnect to the Aspen Solar I. Loop the Roxbury – Shade Gap 115 kV line into new station	$ 2,709,200	$ 1,836,200	$ 603,600	$ 27,200	$ 5,176,200
SCADA/Fiber Communication: Estimated SCADA work at Roxbury substation to support relay installation. Estimated SCADA work at Shade Gap substation to support relay installation. Estimated SCADA work at Lewistown substation to support wavetrap and relay installation.	$ 66,600	$ 0	$ 14,800	$ 0	$ 81,400
Fiber Communication at Roxbury: Install fiber from Roxbury to backbone for communication transport	$ 105,200	$ 11,000	$ 23,500	$ 200	$ 139,900
Project Management: Project Management, Forestry, Real Estate, and Right of Way.	$ 208,300	$ 0	$ 46,400	$ 0	$ 254,700
Total Direct Connection Cost	**$ 3,089,300**	**$ 1,847,200**	**$ 688,300**	**$ 27,400**	**$ 5,652,200**

Roxbury – Shade Gap 115 kV Line Loop: Loop the Roxbury – Shade Gap 115 kV line into new station	$ 420,400	$ 58,400	$ 93,600	$ 900	$ 573,300
Roxbury Substation: Install Hybrids and 1 DTT UPLC transmitter	$ 170,900	$ 14,500	$ 38,100	$ 200	$ 223,700
Lewistown Substation: Install Hybrids and 1 DTT UPLC transmitter. Replace wave trap and line tuner.	$ 221,200	$ 37,200	$ 49,300	$ 600	$ 308,300
Shade Gap Substation: Install Hybrids and 1 DTT UPLC transmitter	$ 183,200	$ 28,900	$ 40,800	$ 400	$ 253,300
Total Non-Direct Connection Cost	**$ 995,700**	**$ 139,000**	**$ 221,800**	**$ 2,100**	**$ 1,358,600**
AE1-071 Metering: Customer-owned 115 kV revenue metering at Shade Gap – Roxbury 115 kV: Provide interconnection facilities for AE1-071 Gen	$ 3,800	$ 0	$ 800	$ 0	$ 4,600
Total Other Facilities Cost	**$ 3,800**	**$ 0**	**$ 800**	**$ 0**	**$ 4,600**
Total Project Costs	**$ 4,402,600**	**$ 2,182,300**	**$ 980,900**	**$ 32,400**	**$ 7,598,200**

Attachment #1: Protection Study

PROTECTION SCOPE

Following is the protection scope information (Facilities Study Stage only) for the AE1-071 solar generation project. These relay requirements for the installation of the AE1-071 Interconnection Substation on the Roxbury – Shade Gap 115kV line, approximately 6.4 miles from Roxbury substation. Dual pilot relaying is not required for stability on the AE1-071 – Roxbury 115kV line and the AE1-071 – Shade Gap 115kV line. These requirements assume that the AE1-071 Collector Substation will be directly adjacent to the AE1-071 Interconnection Substation.

Short Circuit Analysis

Fault values for the AE1-071 Interconnection Substation location with no AE1-071 generation equipment in service are:

Three phase = 6513 A
Single line to ground = 4876 A
Z1= 1.88 + j 7.49 %
Z0= 4.44 + j 14.80 %

Impedances are given on a 100 MVA and 115kV base. The fault currents provided are bolted, symmetrical values for normal system conditions, using the PJM 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.

AE1-071 Interconnection Substation

Construct a new three breaker 115kV 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 six SATEC meters, one per line exit, one per breaker. Install a GPS Clock, and SEL RTAC for remote relay access and SCADA distance to fault.

AE1-071 Interconnection Substation: Roxbury Substation 115kV line exit – Install a single pilot line protection scheme using SEL-421 primary relay for Directional Comparison Blocking (DCB) over Power Line Carrier (PLC) and SEL-421 backup relay for step distance and directional overcurrent protection, reclosing, and sync check. Install one UPLC-II Transmitter/Receiver (Tx/Rx) unit for the primary DCB line protection scheme. Install one UPLC-II FSK Rx unit to receive the direct transfer trip signal from Roxbury for breaker failure to trip. Install one RFL 9780 FSK Rx unit to receive the anti-islanding signal from Roxbury. Install a wide band line tuner, wide band wave trap, and skewed hybrid to couple the primary DCB line protection, BFT transfer trip, and anti-islanding carrier scheme to Z-phase.

AE1-071 Interconnection Substation: Shade Gap 115kV line exit – Install a single pilot line protection

scheme using SEL-421 primary relay for Directional Comparison Blocking (DCB) over Power Line Carrier (PLC) and SEL-421 backup relay for step distance and directional overcurrent protection, reclosing, and sync check. Install one UPLC-II Transmitter/Receiver (Tx/Rx) unit for the primary DCB line protection scheme. Install one RFL 9780 FSK Rx unit to receive the anti-islanding signal from Shade Gap. Install a wide band line tuner, wide band wave trap, and skewed hybrid to couple the primary DCB line protection and anti-islanding carrier scheme to Z-phase.

AE1-071 Interconnection Substation: AE1-071 Collector Substation 115kV 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 AE1-071 Collector Substation for anti-islanding and breaker failure to trip protection. Install an anti-islanding scheme to trip AE1-071 generation should the AE1-071 generation become islanded with load on the FirstEnergy transmission system. The anti-islanding scheme will utilize the AE1-071 Interconnection Substation breaker 'b' breaker contacts and breaker status from the remote substations as communicated via Frequency Shift Keyed power line carrier.

AE1-071 Collector Substation

AE1-071 Interconnection Substation 115kV 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. A dedicated breaker failure to trip relay is required for the 115kV breaker (Relay 4 on the relay sketch). Two independent relay schemes are required for clearing faults between the developer's 115kV breaker and the high-side windings of their generator step-up transformer high-speed. These schemes must include the 115kV breaker in their zones of protection (Relays 2 and 3 on the relay sketch). A protection scheme containing generator Intertie functions is required (Relay 1 on the relay sketch). Voltages and currents for the Intertie relaying must come from the 115kV system.

Roxbury Substation

Roxbury Substation: AE1-071 Interconnection Substation 115kV line exit – The existing single pilot protection scheme and breaker failure transfer trip will remain in service with the addition of an anti-islanding scheme to transmit breaker open statuses. Utilize existing SEL-421 primary relay and SEL-411L backup relay. The SEL-421 will be utilized in the DCB line protection scheme and the SEL-411L will be used for step distance line protection. The existing UPLC-II transceivers used for DCB and DTT shall be remain in place. Install one RFL 9780 FSK Tx unit and balanced hybrid to transmit the anti-islanding signal to AE1-071 Interconnection Substation. The existing wide band line trap and line tuner will remain in place but will need to be retuned for new frequencies. The primary DCB protection scheme, breaker failure DTT, and anti-islanding scheme shall couple to Z-phase.

Shade Gap Substation

Shade Gap Substation: AE1-071 Interconnection Substation 115kV line exit – The existing single pilot

protection scheme and breaker failure transfer trip will remain in service with the addition of an anti-islanding scheme to transmit breaker open statuses. Utilize existing SEL-421 primary relay and SEL-421 backup relay. The SEL-421 primary will be utilized in the DCB line protection scheme and the SEL-421 backup will be used for step distance line protection. The existing UPLC-II transceiver used for DCB shall remain in place. The existing UPLC-II transceiver used for DTT shall be replaced with an RFL 9780 FSK TX to transmit the anti-islanding signal to AE1-071 Interconnection Substation. The existing wide band line trap and line tuner will remain in place but will need to be retuned for new frequencies. The primary DCB protection scheme and anti-islanding scheme shall couple to Z-phase.

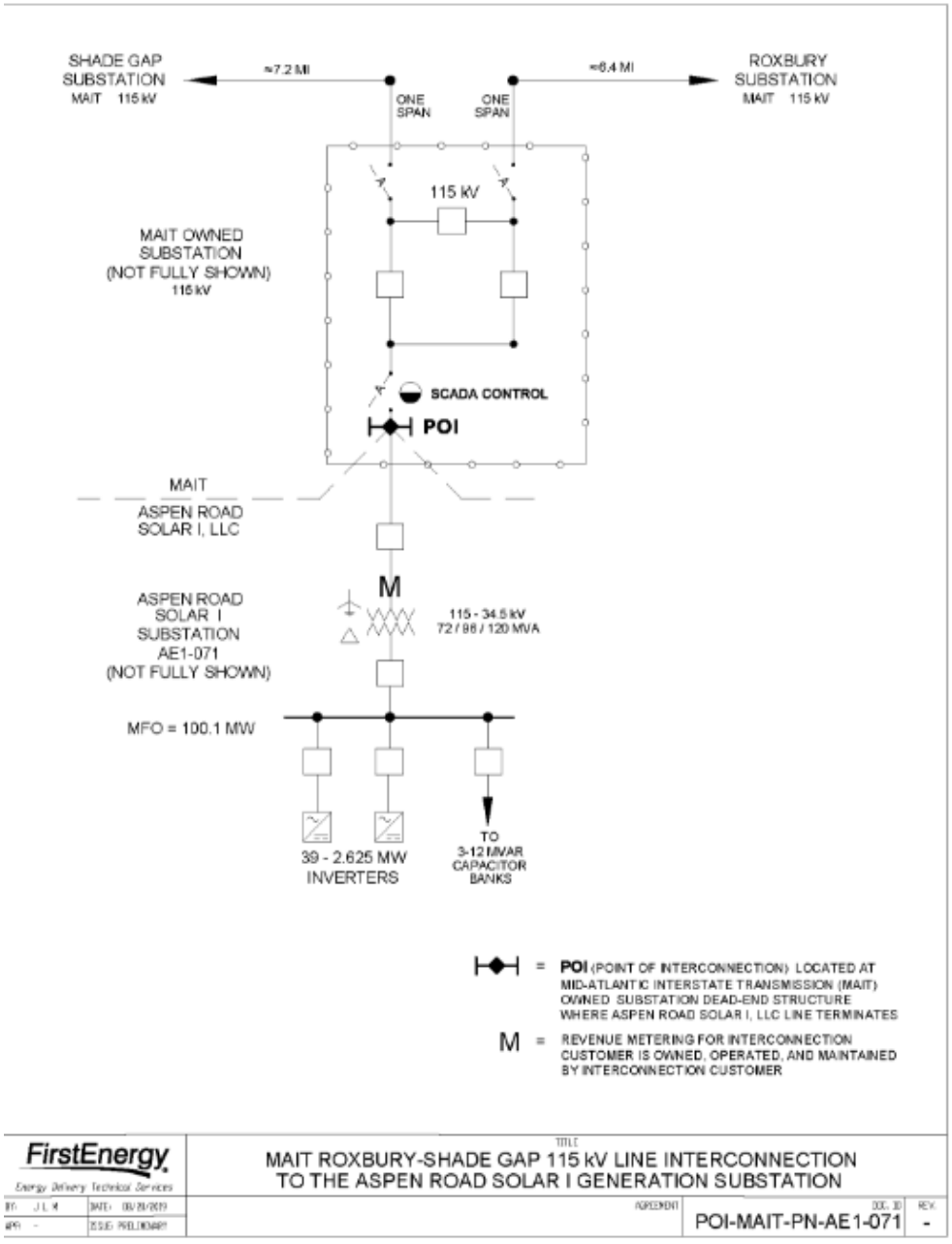
Shade Gap: Lewistown 115kV line exit – Install anti-islanding scheme at Shade Gap to receive breaker open statuses from Lewistown substation. Replace existing single frequency line trap and line tuner with a wide band trap and tuner. This will also require installation of a skewed hybrid and RFL 9780 FSK Rx unit.

Lewistown Substation

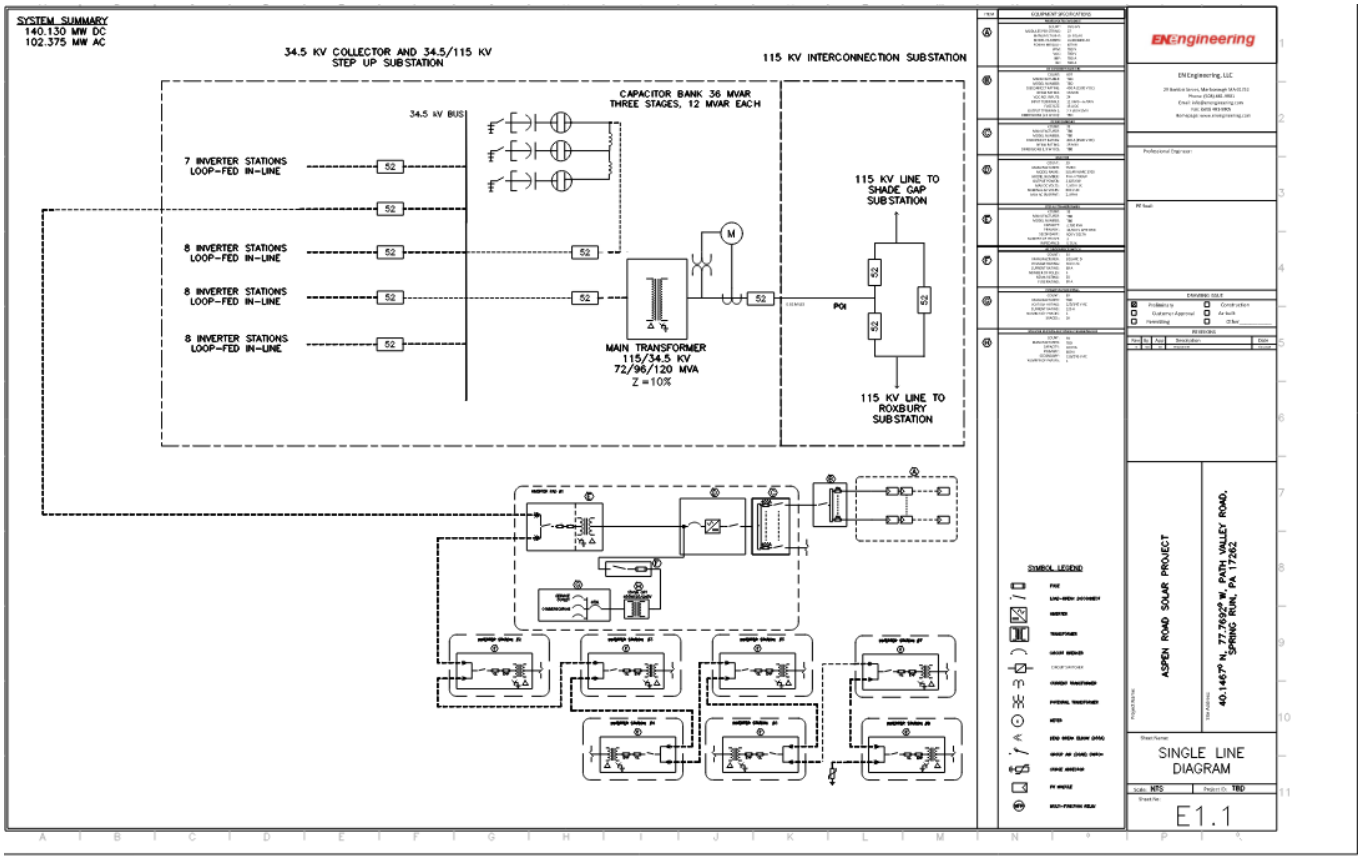
Lewistown Substation: Shade Gap 115kV line exit – Install anti-islanding scheme at Lewistown to transmit breaker open status to Shade Gap substation. Replace existing single frequency line trap and line tuner with a wide band trap and tuner. This will also require installation of a balanced hybrid and RFL 9780 FSK Tx unit.

Attachment #2: One-Line Diagrams

FirstEnergy Facilities One-Line

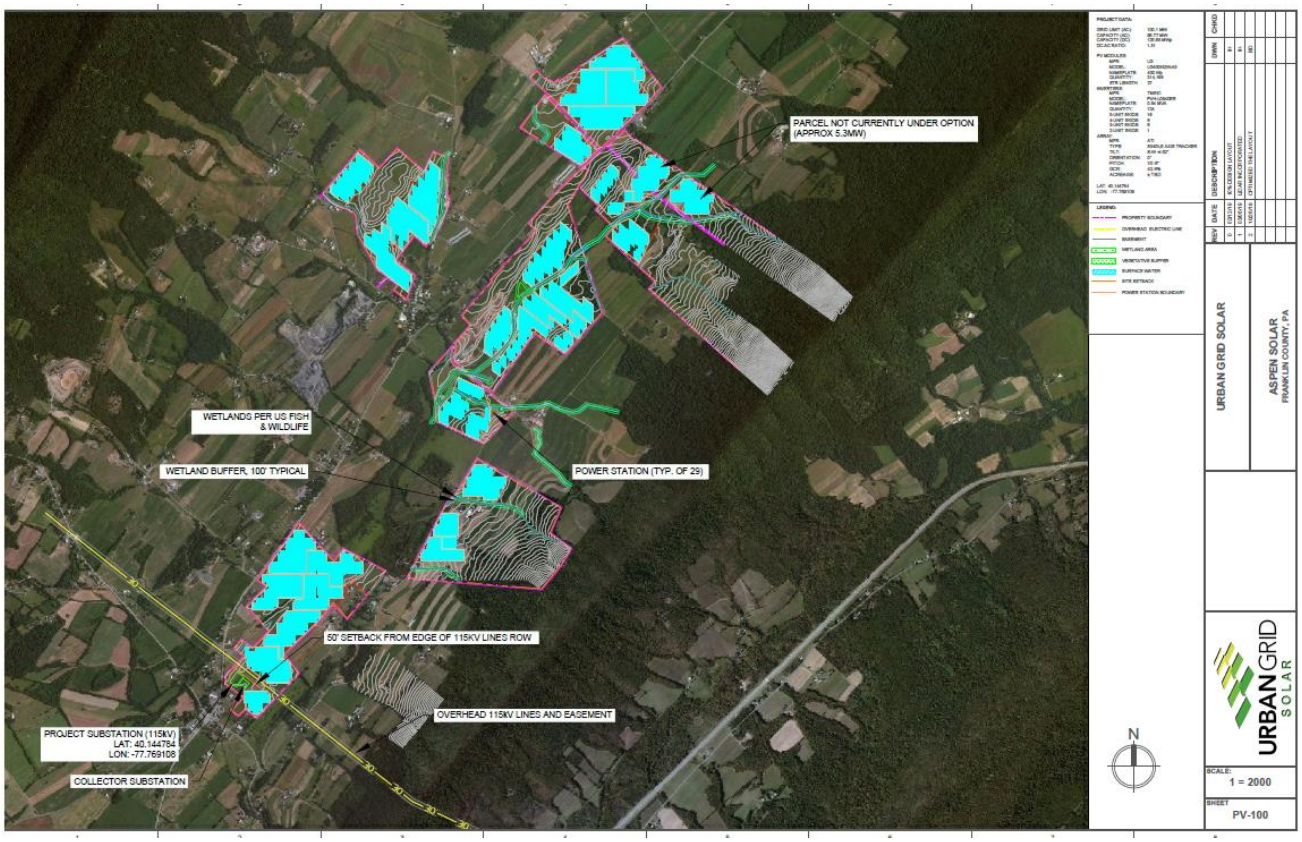


IC Facilities One-Line



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 (counterclockwise)	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: 115 kV
- Maximum phase-to-phase: 121 kV
- Basic impulse level (BIL): 550 kV
- Maximum continuous current carrying capacity: 2000 A
- Design fault current: 40 kA

Clearances and Spacing

- Recommended rigid bus center-to-center phase spacing: 84”
- Minimum phase-to-phase, metal-to-metal distance: 53”
- Recommended phase-to-ground: 45”
- Minimum phase-to-ground: 42”
- Minimum vertical clearance from live parts to grade: 11’-7”
- Minimum horizontal clearance from live parts: 6’-1”
- Minimum bottom of insulator to top of foundation: 8’-6”