Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AE2-029

Grottoes-Merck 115 kV
30.0 MW Capacity / 50.0 MW Energy

Revision 1, December 2021
August, 2021

General

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Blue Ridge Solar, LLC, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

The IC has proposed a solar/storage generating facility located in Rockingham County, Virginia. The installed facilities will have a total capability of 50 MW with 30 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 12/30/2022. **This study does not imply an ITO commitment to this in-service date.**

Revision 1- December 2021

This revision is being issued to incorporate the IC required for Option to Build (OTB) for both attachment facilities and the direct three breaker ring bus upgrade.

Point of Interconnection

AE2-029 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Grottoes to Merck 115 kV line.

Cost Summary

The AE2-029 project will be responsible for the following costs:

Description	Total Cost
Option to Build Oversight- Attachment Facilities	$115,128
Option to Build Oversight- Direct Connection Network Upgrades	$1,060,135
Non Direct Connection Network Upgrades	$3,186,853
Allocation for New System Upgrades	$0
Contribution for Previously Identified Upgrades	$0
Total Costs	**$4,362,116**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AE2-029 is a request to interconnect a 50MW new solar/storage generating facility generating facility to be located in Rockingham Country, Virginia. AE2-029 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Grottoes-Merck 115kV Line #119. Attachment Facility and Network Upgrade construction is estimated to be 18-24 months.

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

None

3. Interconnection Customer's Milestone Schedule

- Plan to break ground March 1, 2023
- Permits – state level Permit By Rule and county level final site plan approval complete February 1, 2023
- Substantial site work completed April 9, 2023
- Delivery of major electrical equipment June 20, 2023
- Back Feed Power October 27, 2023
- Commercial Operation December 31, 2023

4. Scope of Customer's Work

Generator Interconnection Request AE2-029 is for a 50 MW Maximum Facility Output (MFO) solar generation plant. AE2-029 consists of eighteen (18) 3.339 MVA inverters with a total capacity of 60.102 MVA and eighteen (18) 3.63 MVA transformers.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AE2-029 three-breaker ring bus switching station. The site is located along Dominion Energy's existing 115kV Line #119 from Grottoes Substation to Merck No. 5 Substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from Blue Ridge Solar, LLC Collector Station for the new 50MW solar farm.

The new 115kV 3-breaker ring substation will share a common fence line with the Collector Station. The demarcation point between the two stations will be the 115kV disconnect switch 4-hole pad inside the Dominion Energy station near the common fence. Blue Ridge Solar, LLC will bring its bus to the demarcation point. The developer will provide the property and access to the switching station. The grounding systems for each station will be tied together. All substation permitting, site preparation, and grading activity will be performed by the developer.

The Interconnection Customer has selected 'Option to Build' as is their right to do so under the PJM Interconnection Service Agreement. By selecting this construction process method, the Interconnection Customer shall secure all required real estate, obtain all necessary permits, perform site work, furnish equipment, construction personnel and ancillary materials as found in

the facility study for construction of the switching station in compliance with Dominion Energy Substation Engineering Standards. Oversight by Virginia Electric Power Company will include, but is not limited to, project management, engineering, permitting, survey, real estate, and construction methods when on site.

All equipment procured by Interconnection Customer will be reviewed and approved by Virginia Electric Power Company engineering teams.

The details of the Interconnection Customer and Dominion responsibilities and approval processes are described in the associated "Dominion Option to Build Execution Plan" document

Transmission Lines to renumber the existing line segment between the new 3-breaker ring substation and Grottoes Substation. The existing line segment between the new 3-breaker ring substation and Merch. No. 5 substation will remain Line #119.

Additional work to be required at Endless Caverns, Dooms 230kV, Grottoes and Merck No. 5 substations.

Site plan of the Switching Station (Attachment 2) was developed by the ITO during PJM's generation queue process. The single line is shown in Attachment 1, and the preliminary one-line diagram is shown in Attachment 3.

6. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Option to Build Oversight- Attachment Facilities	$90,903	$0	$24,225	$0	$115,128
Option to Build Oversight- Direct Connection Network Upgrades (n7873)	$632,183	$272,360	$140,459	$15,133	$1,060,135
Total Option to Build Oversight Costs	$723,086	$272,360	$164,684	$15,133	$1,175,263
Transmission line #119 (n7874)	$1,545,421	$590,466	$253,379	$59,395	$2,448,661
Total Remote Changes (n7875, n7876, n7877, n7878)	$327,736	$297,368	$79,039	$34,049	$738,192
Total Network Upgrades	$1,873,157	$887,834	$332,418	$93,444	$3,186,853
Total Project Costs	**$2,596,243**	**$1,160,194**	**$497,102**	**$108,577**	**$4,362,116**

7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

Facilities are estimated to take 18-24 months from ISA execution and is based on the ability to obtain outages to construct and test the proposed facilities.

Proposed Schedule

- Detailed design: 8-12 months
- Permitting: 6-12 months (Timeline runs concurrent with design)
- Construction 10-12 months

ITO requires the site to be fully graded and permitted site so they can start construction by February 2023.

B. Transmission Owner Facilities Study Results

1. Attachment Facilities

Please note: Customer has elected Option to Build for the Attachment Facilities
The Attachment Facilities include the portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities collector station. The equipment associated with the Attachment Facilities include the metering accuracy CCVT's, metering accuracy CT's, disconnect switch, conductors and connectors.

Option to Build, Attachment Facilities Physical Facilities & Oversight – Virginia Electric Power Company:

1. All Physical Engineering related oversight and approvals of activities related to equipment procurement, design, construction, and energization of switching station
2. All Construction and Methods oversight and approval of activities related to construction and energization of switching station
3. All Project Management oversight activities related to construction and energization of switching station

Option to Build, Attachment Facilities Physical Facilities– Interconnection Customer:

1. One (1), 115kV, 2000A, 3-phase center break gang operated switch
2. Three (3), 115kV, metering accuracy CCVT
3. Three (3), 115kV, 500:5 metering accuracy CT
4. Conductor, connectors, conduits, control cables, foundations, steel structures and grounding material as per engineering standards

Option to Build, Attachment Facilities Relay Protection Equipment – Virginia Electric Power Company:

1. All Protection & Controls Engineering oversight and approval of activities related to equipment procurement, design, construction, and energization of switching station
2. All relay panel installation methods oversight and approval of activities related to construction and energization of switching station
3. All relay, communications, security settings related to the connection of the switching station to the Bulk Electric Transmission System

Option to Build, Attachment Facilities Relay Protection Equipment – Interconnection Customer:

1. One (1), 1109 – 28" dual SEL-587Z transmission bus panel
2. One (1), 4200_W1 – bus differential CT make-up box
3. One (1), 1425 – 28" dual SEL-735 transmission and generator interconnect metering panel
4. One (1), 4524 – revenue metering CT make-up box
5. One (1), 4506 – CCVT potential make-up box
6. One (1), 1323 – 28" SEL-487E/735 PMU and PQ monitoring panel
7. Two (2), 4541 – control cable make-up box
8. Two (2), 4528A – generation fiber make-up box

2. Transmission Line – Upgrades

PJM Network Upgrade # n7874 – Re-arrange line #119 to loop into and out of the new three breaker AE2-029 115 kV switching station

This project will connect line number 119 to a new 115kV switching station located off the main line 119 between structures 119/412 and 119/414. This project is located in Rockingham County, Virginia.

Structure Installations:

1. Install one (1) 70' self-supporting 115kV Galvanized Steel Backbone Structure, proposed structure number 119/413, with 31'-6" spacing and all associated assemblies inside the AE2-029 Substation.
2. Install two (2) self-supporting galvanized static poles proposed structures 119/413A and 119/413B, and all associated assemblies inside the AE2-029 Substation.
3. Install two (2) engineered galvanized steel monopole DDE structures on concrete pier foundations, proposed structure numbers 119/412 and 119/414.

Removal:

1. Remove existing structures 119-412, 119-413, and 119-414.
2. Remove 5.0 miles of 3#6 alumoweld static wire between Grottoes to proposed backbone structure 413.

Conductor/Shield Wire Installations:

1. Cut and Transfer two (2) existing spans of 3-Phase 477 26/7 ACSR conductor to the new DDE structures (one span will run from Ex. Str. number 119/411 – proposed Str. number 119/412, the other span will run from proposed Str. number 119/414 – Ex. Str. number 119/415).
2. Cut and transfer existing span of 3#6 shield wire to the new backbone structures from Ex. Str. number 119/411 – proposed Str. number 119/412.

3. Install approximately 0.10 miles (2 spans) of 7#7 static wire from the proposed backbone structure 119/413 to the proposed static poles, 119/413A and 119/413B.
4. Install approximately 0.065 miles (1 span) of 7#7 static wire from the proposed backbone structure 119/413 to the proposed DDE structure 119/412. This will include the installation of dampers and a splice at proposed DDE structure 119/412.
5. Install approximately 0.13 miles (2 spans) of 3-Phase 636 ACSR conductor from the proposed backbone structure 119/413 to the proposed DDE structures 119/412 and 119/414. This will include the installation of dampers and a splice at proposed DDE structures 119/412 and 119/414.
6. Install approximately 5.0 miles of DNO10585 OPGW fiber from proposed backbone structure 119/413 to Grottoes substation. The new fiber will attach to 67 existing tangent structures and seven existing dead-end structures (including the two backbone structures).
7. Install three OPGW splices.
8. Renumber approximately 72 structures with the new line number between the proposed AE2-029 Substation and Grottoes Substation.

General Notes:

1. This design maintains a horizontal conductor pull off angle of less than 15° on both sides of proposed backbone structure 119/413.
2. This design accounts for a 70' backbone structure, per 11.955.
3. See Table 1, below, for maximum groundline moments at each engineered DDE structure.

Table 1 – Engineered DDE Maximum Groundline Moments

Structure	Groundline Moment (ft-k)	Load Case
119/412	1644	NESC Heavy
119/414	1669	NESC Heavy

3. New Substation/Switchyard Facilities

Please note: Customer has elected Option to Build for this Upgrade

PJM Network Upgrade # n7873 – New Three Breaker Ring Substation AE2-029.

The facilities identified provides for the initial construction of a new 115 kV Three Breaker Ring Substation near Transmission Structure 119/413 in Rockingham County, Virginia.

The objective of this project is to build a 115kV, 3-breaker ring bus to support the new 50MW Solar Farm built by Blue Ridge Solar, LLC. The site is located along Dominion Energy's

existing 115kV, 119 Line from Grottoes Substation to Merck No. 5 Substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from Blue Ridge Solar, LLC Collector Station for the new 50MW Solar Farm.

The new 115kV Three Breaker Ring Substation will share a common fence line with the Collector Station. The demarcation point between the two stations will be the 115kV Disconnect Switch 4-hole pad inside the Dominion Energy station near the common fence. Blue Ridge Solar, LLC will bring its bus to the demarcation point. The developer will provide the property and access to the switching station. The grounding systems for each station will be tied together. All substation permitting, site preparation and grading activity will be performed by the developer.

Transmission Lines to renumber the existing line segment between the new Three Breaker Ring Substation and Grottoes Substation. The existing line segment between the new Three Breaker Ring Substation and Merck No. 5 Substation will remain Line 119.

Additional Work to be required at Endless Caverns, Dooms 230kV, Grottoes and Merck No. 5 Substations.

Security and Fence Type – Design Level 4.

Note: Currently, the scope and estimate assume DVP standard spread footer foundations. Once the soil information is received and if it is decided to change that to "pile foundations" the project estimate needs adjustment.

The work required is as follows:

Option to Build, Direct Network Physical Facilities & Oversight – Virginia Electric Power Company

1. All Physical Engineering related oversight and approvals of activities related to equipment procurement, design, construction, and energization of switching station
2. All Real Estate related oversight and approval of activities related to construction of switching station
3. All Permitting related oversight and approval of activities related to construction of switching station
4. All Survey related oversight and approval of activities related to construction of switching station
5. All Construction and Methods oversight and approval of activities related to construction and energization of switching station
6. All Project Management oversight activities related to construction and energization of switching station
7. All riser conductor, connectors, spacers, and bolts related to connection of the switching station to the Bulk Electric Transmission System
8. All material related to the integration of the security fence software package back to the Corporate Security Fusion Center

Option to Build, Direct Network Physical Facilities – Interconnection Customer:

1. Approximate station fence line dimensions 315’ x 290’. At a minimum, site preparation and grading will be required to extend 10’ beyond these dimensions for station grounding. Additional property and site prep may be required for proper grading and stormwater management, etc.
2. Approximately 1,210 linear ft of 5/8” chain link, 12 ft tall, perimeter fence around the station (Design 4 Standard)
3. Three (3), 115kV, 3000A, 40kAIC, SF-6 circuit breaker
4. Six (6), 115kV, 2000A, 3-phase center break gang operated switch
5. Six (6), 115kV, relay accuracy CCVT
6. One (1), 115kV, 2000A wave trap
7. One (1), line tuner
8. Nine (9), 90kV, 74kV MCOV surge arrester
9. Two (2), 115kV, 2000A, 2-phase center break switches (for PVT’s)
10. Two (2), 115kV, 100KVA power PT's for station service
11. One (1), 115kV, heavy duty steel backbone (by Virginia Electric Power Company)
12. Two (2), shield wire poles and three spans of shield wire (by Virginia Electric Power Company)
13. One (1), 24’ x 40’ control enclosure, CE1
14. One (1), 125 VDC, 300 Ah station battery and 50 Amp charger (size to be verified during detail engineering)
15. Approximately 220 ft of cable trough, with a 20 ft road crossing section
16. Two (2) 36” x 36” x 42” precast yard pullbox
17. Station stone as required
18. Station lighting as required
19. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports
20. Foundations as required including control house, equipment and bus support stands
21. Conductors, connectors, conduits, control cables, cable trough, and grounding materials as per engineering standards

Option to Build, Direct Network Relay Protection Equipment – Virginia Electric Power Company:

1. All Protection & Controls Engineering oversight and approval of activities related to equipment procurement, design, construction, and energization of switching station
2. All relay panel installation methods oversight and approval of activities related to construction and energization of switching station
3. All relay, communications, security settings related to the connection of the switching station to the Bulk Electric Transmission System
4. One (1), 5616 – station security panel
5. One (1), 5616 – station security fence panel
6. One (1), 5603 – network panel no. 1
7. One (1), 5603 – network panel no. 2
8. One (1), high voltage protection (HVP) box (Provided by IT)
9. One (1), telephone interface box

Option to Build, Direct Network Relay Protection Equipment – Interconnection Customer:

1. Three (3), 1510 – 28" dual SEL-351-7 transmission breaker with reclosing panel
2. Three (3), 4510 – SEL-2411 breaker annunciator
3. One (1), 1340 – 28" dual SEL-411L DCB line panel
4. One (1), 1809 – 28" dual SEL-311L line differential panel with reclosing
5. Two (2), 4506 – 3-phase CCVT potential make-up box
6. One (1), 1603 – 28" SEL-451 islanding control scheme panel
7. Two (2), 4000 – station service potential make-up box
8. Two (2), 4018 – 500A station service AC distribution panel
9. Two (2), 4007 – 225A outdoor transmission yard AC NQOD
10. Two (2), 4019 – 225A 3-phase throw over switch
11. Two (2), 4016 – 600A PVT disconnect switch
12. One (1), 4153c – wall mount station battery monitor
13. One (1), 5618 – SEL-3555 data concentrator panel
14. One (1), 1255 – station annunciator panel
15. One (1), 5021 – SEL-2411 RTU panel
16. One (1), 5609 – fiber optic management panel
17. Three (3), 4526_A – circuit breaker fiber optic make-up box
18. One (1), 5202 – 26" APP 601 digital fault recorder
19. One (1), 4051 – power block
20. One (1), 4042_D1B – security utility – Utility ATS
21. Two (2), 4018 – 225A station service AC distribution panel branch breaker

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade # n7875, n7876, n7877, n7878– Remote protection and communication work

ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Endless Caverns, Dooms 230kV, Grottoes and Merck No. 5 Substations. These costs include the following:

Endless Caverns Substation (n7875)

Project Summary
AE2-029 provides for the installation of Line #118 Islanding Transfer Trip scheme to send Islanding Transfer Trip to AE2-029 Generator Interconnection Substation via Merck No. 5 Substation. This project is Indirect Network Upgrade for the AE2-029 Generator Interconnect project.

Purchase and install relay material:

1. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel (1 UPLC II)

Dooms 230kV Substation (n7876)

Project Summary

AE2-029 provides for the installation of Line #272 Islanding Transfer Trip scheme to work with the new AE2-029 Generator Interconnect Substation. This project is the Non-Direct Connect for the AE2-029 Generator Interconnect project.

Purchase and install relay material:

1. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel (1 UPLC II)

Grottoes Substation (n7877)

Project Summary:
AE2-029 provides for drawing work, relay resets, and field support necessary to change Line #119 destination from Merck No. 5 Substation to AE2-029 Generator Interconnect. The Line Relay Panel will be replaced with the Line Current Differential via Fiber Optics and the Wave Trap removed. Islanding Transfer Trip will be installed to receive from Dooms 230kV Substation on Line 272 via PLC and send to AE2-2029 G.I. on Line 119 via fiber. Fiber Optics will need to be installed on the 119 Line between Grottoes and AE2-029. This project is the Non-Direct Connect for the AE2-029 Generator Interconnect Project.

Purchase and install relay material:

1. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel (w/ UPLC II & SEL-2506)
2. One (1), 1340 – 28" Dual SEL-411L CD/Fiber Line Panel
3. One (1), Panel Retirement (Panel 3)

Merck No. 5 Substation (n7878)

Project Summary:
AE2-029 provides for drawing work, relay resets, and field support necessary to change Line 119 destination from Grottoes Substation to AE2-029 Generator Interconnect. Islanding Transfer Trip will be installed to receive from Endless Caverns Substation on Line 118 via PLC and send to AE2-029 G.I. on Line 119 via PLC. The control enclosure will need a 10' expansion to install the Islanding Transfer Trip panel.

This project is the Non-Direct Connect for the AE2-029 Generator Interconnect Project.

Purchase and install substation material:

1. Expand existing Control Enclosure by 10'-0".
2. Install any necessary control cable, grounding, and foundations as necessary per Dominion Substation Engineering Standards.

Purchase and install relay material:

1. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel (w/ (2) UPLC II)

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Endless Caverns Substation (n7875)	$34,883	$23,068	$8,483	$3,435	$69,869
Dooms 230kV Substation (n7876)	$34,883	$23,068	$8,483	$3,435	$69,869
Grottoes Substation (n7877)	$102,336	$70,726	$30,173	$14,472	$217,707
Merck No. 5 Substation (n7878)	$155,634	$180,506	$31,900	$12,707	$380,747
Total Remote Relay Upgrades	$327,736	$297,368	$79,039	$34,049	$738,192

5. Metering & Communications

PJM Requirements

The IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 8 of Attachment O Appendix 2.

ITO Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Interconnection Connection Requirement NERC Standard FAC-001 which is publicly available at www.dom.com.

At the IC's expense, the ITO will supply and own at the Point of Interconnection bi-directional revenue metering equipment that will provide the following data:

a. Hourly compensated MWh received from the Customer Facility to the ITO;
b. Hourly compensated MVARh received from the Customer Facility to the ITO;
c. Hourly compensated MWh delivered from the ITO to the Customer Facility; and
d. Hourly compensated MVARh delivered from the ITO to the Customer Facility.

The IC will supply and own metering equipment that will provide Instantaneous net MW and MVar per unit values in accordance with PJM Manuals M-01 and M-14D, and Sections 8.1 through 8.5 of Appendix 2 to the ISA.

The IC will access revenue meter via wireless transceivers or fiber cabling to meter with RS-485 or Ethernet communication port for dial-up reads. IC must provide revenue and real time data to PJM from Interconnection Customer Market Operations Center per "PJM Telemetry Data Exchange Summary" document available at PJM.com.

6. Environmental, Real Estate and Permitting Issues

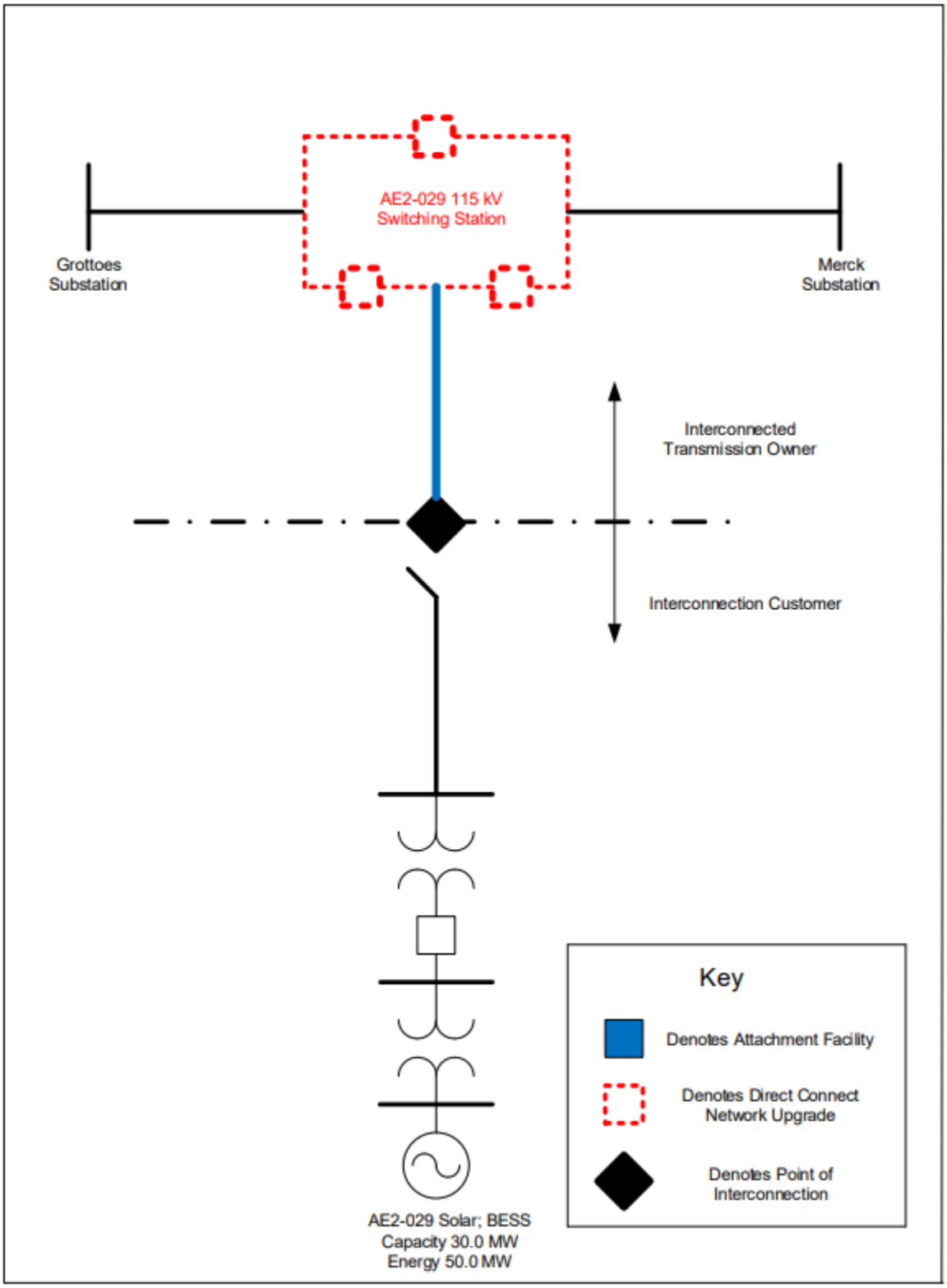
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a Virginia State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.

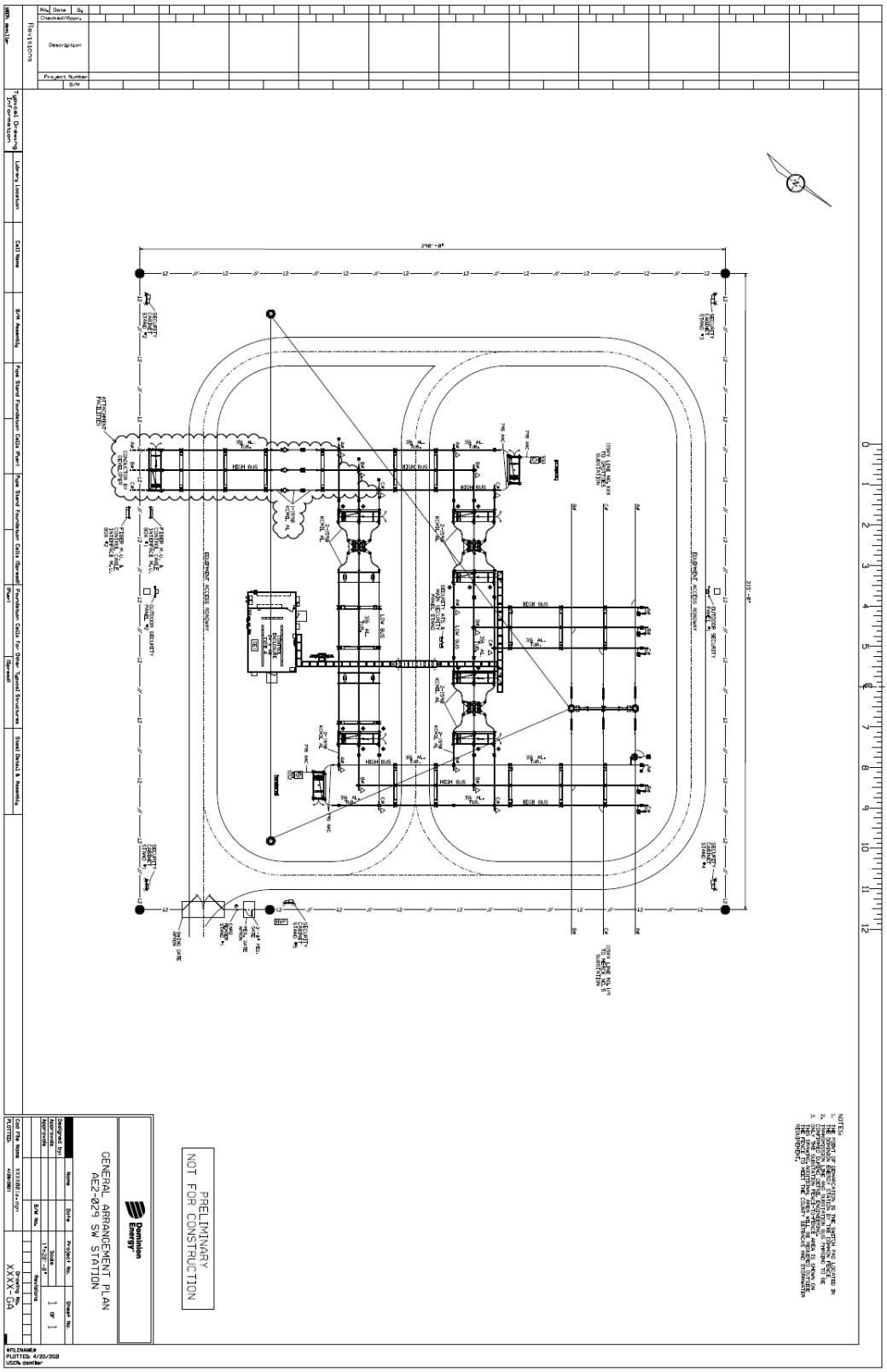
ITO Real Estate Needs:

- The substation layout is complete and ITO requires a 315' x 290' piece of property (title in fee) to build the substation. The property includes the piece of property between the substation and collector station for the strain bus.
    - ITO requires ownership transfer of the substation site before they start construction. Target for the deed by March 1, 2023.
    - The size of the station assumes ITO will not need a separate storm water management system for the substation. If the county rules differently than the ITO will need to revisit the land requirements.
- ITO will need a letter similar to the zoning letter from the county stating that if the solar farm is retired and / or decommissioned the substation will remain.

Attachment 1.
Single Line Diagram for AE2-029



Attachment 2.
AE2-029 Switching Station General Arrangement



Attachment 3.
Preliminary AE2-029 One-Line Diagram