Generation Interconnection Facilities Study Report

For

PJM Generation Interconnection Request Queue Position AB2-015

Franklin 115kV
50 MW Capacity / 91 MW Energy

December 2018

General

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff, Section 205, as well as the Facilities Study Agreement between **Raven Solar Development Company, 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 generating facility located in Franklin, VA (Southampton County). The installed facilities will have a total capability of **91 MW** with **50 MW** of this output being recognized by PJM as capacity. The customer plans Commercial Operation by **December 31, 2021**.

Point of Interconnection

AB2-015 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Southampton-Union Camp 115 kV Line #93 between Franklin and Union Camp Substations. See One Line Diagram in **Attachment 1** and Site Plan in **Attachment 2**.

Cost Summary

The AB2-015 interconnection request will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 517,611
Direct Connection Network Upgrades	$ 4,772,173
Non Direct Connection Network Upgrades	$ 2,038,355
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 7,328,139**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AB2-015 is a request to interconnect 91 MW (Capacity 50 MW) of energy from a new solar generating facility located in Franklin, VA (Southampton County). The proposed facility will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Southampton-Union Camp 115 kV Line #93 between Franklin and Union Camp Substations. The customer plans to be in Commercial Operation by **December 31, 2021**. Attachment Facility, Direct and Non-Direct Connection Network upgrade design, permitting and construction is estimated to be 16-24 months starting the month after a fully executed Interconnection Construction Service Agreement.

Refer to Attachments 1, 2 and 3 for the One Line Diagram, Site Plan and new Switchyard Layout.

2. Interconnection Customer's Submitted Milestone Schedule

- Plan to break ground --- 01/01/2021
- Turn over flat, graded site with 1 inch gravel to ITO for new switching station --- 11/01/2020
- Permits – state level CPCN and county level Final Site Plan approval complete by ---- 11/01/2020
- Substantial site work completed --- 07/01/2021
- Delivery of major electrical equipment --- 09/01/2021
- Back Feed Power --- 11/01/2021
- Commercial Operation ---12/31/2021

3. Scope of Customer's Work

IC will build a solar generating facility in Southampton County, Virginia. The generating facility will be comprised of solar arrays. AB2-015 consists of 35 X 2.717 MW Power Electronics Solar PV inverters. The (35) 34.5/0.6 kV generator step up (GSU) transformers, each with a rating of 2.91 MVA, will connect the solar inverters to the 34 kV collector system. The generating facility will connect to the Point of Interconnection (POI) via a 115/34.5 kV wye grounded/wye grounded/delta main power transformer with a rating of 59/79/98 MVA. The AB2-015 POI will be at a new three breaker ring bus interconnection switching station that connects on the Southampton-Union Camp 115 kV Line #93 between Franklin and Union Camp Substations. Refer to Attachment 1 for the One Line Diagram.

4. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new three breaker ring bus switching station. The site for the new three breaker ring bus switching station will be along Dominion Energy's existing 115 kV, #93 line from Union Camp Substation to the Southampton Substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 115 kV feed from Raven Solar Development's Collector Station for the new 91 MW Solar Farm.

The new 115 kV Three Breaker Ring Substation will share a common footprint and fence line with Raven Solar Development's Collector Station. The demarcation point between the two stations will be the 115 kV breaker disconnect switch 4-hole pad in the Raven Solar Development's Collector Station by the common fence. Dominion will bring its bus to the

demarcation point. The bus, structures, disconnect switch, metering accuracy CCVT's, metering accuracy CT's, protection and metering equipment will be Attachment Facilities. The grounding systems for each station will be tied together.

Perform engineering, relay setting changes, and field support necessary to change Line 93 destination from Union Camp Substation to the new AB2-015 generation interconnection substation. The existing line segment between the new three breaker ring substation and Southampton Substation shall remain as Line 93. Also replace Wave Trap to accommodate necessary PLC frequency shift.

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, bus structures/conductors and connectors.

Indirect Network Upgrades are also required at Franklin, Watkins Corner, Southampton and Union Camp Substations. Perform engineering, relay setting changes, and field support to change line designations from Union Camp to the new AB2-015 Generator Interconnect Substation. (The existing line segment between the new three breaker ring substation and Southampton Substation shall remain as Line 93.) Replace Wave Traps at Franklin, Watkins Corner and Southampton substations to accommodate necessary PLC frequency shift. Also reconfigure Islanding and Breaker Failure Transfer Trip schemes at Southampton Substation.

At Union Camp Substation, also replace existing Line 93 Relay Protection with Line Differential Protection utilizing Fiber Optics due to shortening of line, install Circuit Breaker 9382 Rely Panel, modify existing Line 93 Islanding Transfer Trip scheme to now work with the new AB1-015 substation, remove the Line 93 Wave Trap due to the Powerline Carrier function now being performed over fiber optics and expand Control Cubicle to accommodate new CB panel and Transmission Fiber Patch Panel. Replace and relocate existing indoor AC QMB and Battery Charger.

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

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Substation	$269,270	$162,041	$67,093	$19,207	$517,611
Transmission	N/A	N/A	N/A	N/A	N/A
Total Attachment Facilities Cost	$269,270	$162,041	$67,093	$19,207	$57,371
Queue AB2-015 switching station (n5979)	$2,146,352	$1,907,278	$487,090	$231,453	$4,772,173
Franklin #93 115 kV Transmission line termination into AB2-015 switchyard (n5980)	$924,806	$324,361	$153,252	$72,512	$1,474,834
Franklin Substation Upgrades (n5981)	$38,734	$9,097	$8,162	$1,378	$57,371
Watkins Corner Substation Upgrades (n5982)	$39,373	$6,739	$8,264	$1,021	$55,397
Southampton Substation Upgrades (n5983)	$47,046	$13,790	$10,044	$2,089	$72,969
Union Camp Substation Upgrades (n5984)	$172,092	$149,679	$34,022	$21,991	$377,784
Total Network Upgrades	$3,368,403	$2,410,944	$700,737	$330,444	$6,810,528
Total Project Costs	$3,637,673	$2,572,985	$767,830	$349,651	$7,328,139

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

Facilities are estimated to take 16 - 24 months to design, permit and construct and this is based on the ability to obtain outages to construct and test the proposed facilities.

Proposed Schedule

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

B. Transmission Owner Facilities Study Results

1. 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 substation. The equipment associated with the Attachment Facilities include the bus, structures, disconnect switch, metering accuracy CCVT's, metering accuracy CT's, protection and metering equipment.

Switching station

Purchase and install substation material:

1. One (1), 115 kV, 2000A, 3-phase Center Break Switch;
2. Three (3), 115 kV metering accuracy CCVT's;
3. Three (3), 115 kV, 500:5 metering accuracy CT's;
4. Tubular bus as required;
5. Steel structures as required; and
6. Conductors, connectors, conduits, control cables, foundations and grounding material as per engineering standards.

Purchase and install relay material:

1. One (1), 1109 – 28" Dual SEL-587Z Transmission Bus Panel;
2. One (1), 4200 – Bus Differential C.T. M.U. Box;
3. One (1), 1421 – Generation/NUG/PJM/IPP Metering Panel;
4. One (1), 4524 – Revenue Metering C.T.M.U. Box;
5. One (1), 4531 – Generator Interconnect CCVT Potential M.U. Box;
6. One (1), 1323 – 28" SEL-487E/735 PMU & PQ Monitoring Panel; and
7. Two (2), 4541 - Control Cable M.U. Box.

2. Transmission Line – Upgrades

PJM Network Upgrade #n5680 – Connect line number 93 into the new three breaker AB2-015 115 kV switching station between structures 18 and 19.

The #93 line is an existing 115 kV line that runs from Southampton Substation to Union Camp Substation through Watkins Corner and Franklin distribution substations. The ITO will split the #93 line between Franklin and Union Camp Substations into a proposed Queue AB2-015 three breaker ring bus that will provide a connection point for this queue's generation interconnection.

The following work scope is for the construction of a connection from Transmission Line 93 into the AB2-015 three breaker ring bus interconnection yard. In addition to the work on the 93 line, fiber optic shield wire will be brought into the station. The line connection will require the installation of (1) backbone structure, three (3) steel shield wire poles, and the installation and transferring of several spans of conductor and shield wire.

ITO to renumber 19 structures between the New Queue AB2-015 Switching station and Union Camp Substation.

The conceptual design and estimate includes costs for the following:

ESTIMATE – FACILITIES TO BE INSTALLED/MODIFIED – 93 LINE:

1. Install one 230kV single circuit heavy-duty backbone structure with H-pile foundations inside the proposed station between structure number 93/18 & 19.
2. Transfer the existing single circuit 3-phase 2-545 ACAR conductor and two 3#6 alumoweld shield wires to the proposed backbone. This will include the installation of dampers and Tee connectors for the substation installed risers.
3. Install two steel shield wire poles with H-pile foundations inside the proposed station.
4. Install three spans of 7#7 alumoweld shield wire between the proposed backbone and shield wire poles. This will include the installation of dampers.
5. Install one steel shield wire pole with a pipe pile foundation inside Union Camp station.
6. Modify three down guys at 3-pole structure 93/7. This will include installing new anchors and changing the down guy angle at the three down guys.
7. The weathering steel towers will require a climbing inspection.
8. The estimate includes the cost for a possible shield wire vang modification on the R-series towers.
9. 9.Renumber 19 structures between Union Camp and the proposed station.
10. Install approximately 2.8 miles of OPGW between the backbone installed at the proposed station and the shield wire pole installed inside Union Camp. This will include the installation of suspension/strain assemblies, dampers, and splices.

ESTIMATE – FACILITIES TO BE REMOVED – 93 LINE:

1. Remove approximately 2.8 miles of 3#6 alumoweld shield wire between the proposed station and Union Camp.

NOTE:

1. The final location and layout three breaker ring subject to change; final foundation and structure costs and locations may vary from the estimate.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n5979 - Build a 115 kV three breaker ring switching station to accommodate interconnection of AB2-015. The site is located along Dominion Energy's existing 115 kV, 93 Line from Union Camp Substation to Southampton Substation between Transmission Structures 93/18 and 93/19. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from the IC's Collector Station for the new 91MW Solar Farm.

The new 115kV Three Breaker Ring Substation will share a common foot print and fence line with the IC's Collector Station. The demarcation point between the two stations will be the 115kV Breaker Disconnect Switch 4-hole pad in the IC's Collector Station by the common fence. Dominion will bring its bus to the demarcation point. The grounding systems for each station will be tied together.

Detail Engineer to inquire if pre-ordered material for Solar Projects is available, otherwise follow current Long Lead Time Material Ordering process.

Security and Fence Type – Design Level 4.

Note 1: Currently, the scope and estimate assumes ITO standard spread footer foundations. Once the soil information is received and if it is decided to change that to "pile foundations" then ITO team should be informed at the earliest to adjust the project estimate.

The work required is as follows:

Purchase and install substation material – Direct Network Upgrade:

1. Three (3), 115kV, 3000A, 40 kA, SF-6 Circuit Breakers;
2. Six (6), 115kV, 2000A Center Break Switches;
3. Two (2), 115kV, 2000A, 2-Pole Center Break Switches (for PVT's);
4. Six (6), 115kV, CCVT's relay accuracy;
5. One (1), 2000A, Vertically Mounted, Wave Traps;
6. One (1), Line Tuners;
7. Six (6), 90kV MO, Station Class, 74kV MCOV Surge Arresters;
8. Four (4), 115kV, 100KVA Power PT's for Station Service;
9. One (1), 24' x 40' Control Enclosure, prewired by Trachte;
10. One (1), 135VDC, 577Ah Batteries with Charger;
11. Oil Containment as required for 115kV PVT's;
12. One (1), 115kV Backbone;
13. Two (2), Static Poles;
14. Cable Trough as required;
15. Tubular bus as required;
16. Ground Grid as required;
17. Fence as required;
18. Steel Structures as required; and
19. Conductor, connectors, conduit, control cable, foundations and grounding material as required per engineering standards.

Purchase and install relay material – Direct Network Upgrade:

1. Three (3), 1510 – 28" Dual SEL-351-7 Transmission Breaker w/ Reclosing Panel;
2. Three (3), 4510 - SEL-2411 Breaker Annunciator;
3. One (1), 1320 – 28" Dual SEL-421-5 DCB Line Panel;
4. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel;
5. Two (2), 4506 – 3 Phase CCVT Potential M.U. Box;
6. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel;
7. Two (2), 4000 – Station Service Potential M.U. 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 Three Phase Throwover Switch;
11. Two (2), 4016 – 600 A Disconnect Switch Fused @ 500A;
12. One (1), 4153 – Wall Mount Station Battery Monitor;
13. One (1), 5612 - SEL-3530 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 M.U. Box;
18. One (1), 5202 – 26" APP 601 Digital Fault Recorder;
19. One (1), 5603 – Station Network Panel 1;
20. One (1), 5603 – Station Network Panel 2;
21. One (1), 4523 – Security Camera Interface Box;
22. One (1), 5616 – Station Security Panel;
23. One (1), High Voltage Protection (HVP) Box and
24. One (1), Telephone Interface Box.

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrades #n5981 – Franklin 115 kV Substation – Change Line 93 Destination & Replace Wave Trap. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Franklin 115kV substation. These costs include the following:

Franklin 115kV Substation (n5981)

Project Summary

At Franklin 115 kV Substation, perform drawing work, relay resets, and field support necessary to change the Line 93 destination from Union Camp to the new AB2-015 Generator Interconnect Substation. Also replace the Wave Trap to accommodate necessary PLC frequency shift.

Purchase and install substation material:

1. One (1), 1200A Wave Trap (Frequency TBD).

Purchase and install relay material:

1. No Relay Material.

PJM Network Upgrades #n5982 – Watkins Corner 115 kV Substation – Change Line 93 Destination & Replace Wave Traps. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Watkins Corner 115kV substation. These costs include the following:

Watkins Corner 115kV Substation (n5982)

Project Summary

At Watkins Corner 115 kV Substation, perform drawing work, relay resets, and field support necessary to change the Line 93 destination from Union Camp to the new AB2-015 Generator Interconnect Substation. Also replace the Wave Traps to accommodate necessary PLC frequency shift.

Purchase and install substation material:

1. Two (2), 800A Wave Traps (Frequency TBD).

Purchase and install relay material:

1. No Relay Material.

PJM Network Upgrades #n5983 – Southampton 115 kV Substation – Change Line 93 Destination & Reconfigure Islanding & BF Transfer Trip Scheme. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Southampton 115kV substation. These costs include the following:

Southampton 115kV Substation (n5983)

Project Summary

At Southampton 115 kV Substation, perform drawing work, relay resets, Islanding & Breaker Failure Transfer Trip reconfiguration, and field support necessary to change the Line 93 destination from Union Camp to the new AB2-015 Generator Interconnect Substation. Also replace the Wave Trap to accommodate necessary PLC frequency shift.

Purchase and install substation material:

1. One (1), 2000A Wave Trap (Frequency TBD).

Purchase and install relay material:

1. No Relay Material.

PJM Network Upgrades #n5984 – Union Camp 115 kV Substation – Change Line 93 Number & Destination, Replace Line & Circuit Breaker Relays, Modify Islanding Transfer Trip Scheme, Remove Wave Trap & Expand Control Enclosure. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Union Camp 115kV substation. These costs include the following:

Union Camp 115kV Substation (n5984)

Project Summary

At Union Camp 115 kV Substation, drawing work, relay resets, and field support necessary to change the Line 93 number & destination from Southampton Substation to the new AB2-015 Generator Interconnect Substation. Also replace existing Line 93 Relay Protection with Line Differential Protection utilizing Fiber Optics due to the shortening of the line, install Circuit Breaker 9382 Relay Panel due to replacement of the Line 93 Straight Bus Panel which included breaker control, modify existing Line 93 Islanding Transfer Trip scheme to now work with the new AB2-015 Substation, remove the Line 93 Wave Trap due to the Powerline Carrier function now being performed over fiber optics, and expand the existing Control Enclosure by 15'-0" to accommodate the new Circuit Breaker Panel and Transmission Fiber Patch Panel. Due to the expansion, the existing Indoor AC QMB and Battery Charger will have to be replaced and relocated. The relocated Charger will be upgraded from an existing 25A unit to a 50A unit. This project is the Indirect Network Upgrade for the AB2-015 Generator Interconnect project.

In an effort to route the new OPGW Fiber and Static Wire into Union Camp Substation, Transmission Engineering will install a new static pole within the station fence line. Substation Engineering and Transmission Engineering to interface for proper placement of the pole as well as a new 2" PVC Conduit run shall be installed from the new static pole to the control enclosure.

Purchase and install substation material:

1. Expand existing Control Enclosure by 15'-0";
2. Install one (1), 125VDC, 50A Charger; and
3. Install any necessary control cable, grounding and foundations as necessary per Dominion Substation Engineering Standards.

Remove substation material:

1. Existing Line 93 Wave Trap; and
2. Existing 125VDC, 25A Charger.

Purchase and install relay material:

1. One (1), 1510 – 24" Dual SEL-351 Transmission Breaker w/ Reclosing Panel;
2. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel;
3. One (1), SEL-2411;
4. One (1), 5603 – Station Network Panel No. 2;
5. One (1), 4012 - 225A Indoor AC NQOD; and
6. One (1), Panel Retirement (Panel 2).

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 Sections 24.1 and 24.2.

Meteorological Data Reporting Requirement

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

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 publically 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 the following data:

a. 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 this ISA;
b. Phasor measurement units (PMUs) in accordance with PJM Manual M-14D Section 4.3, and Sections 8.5.3 of Appendix 2 to this 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:

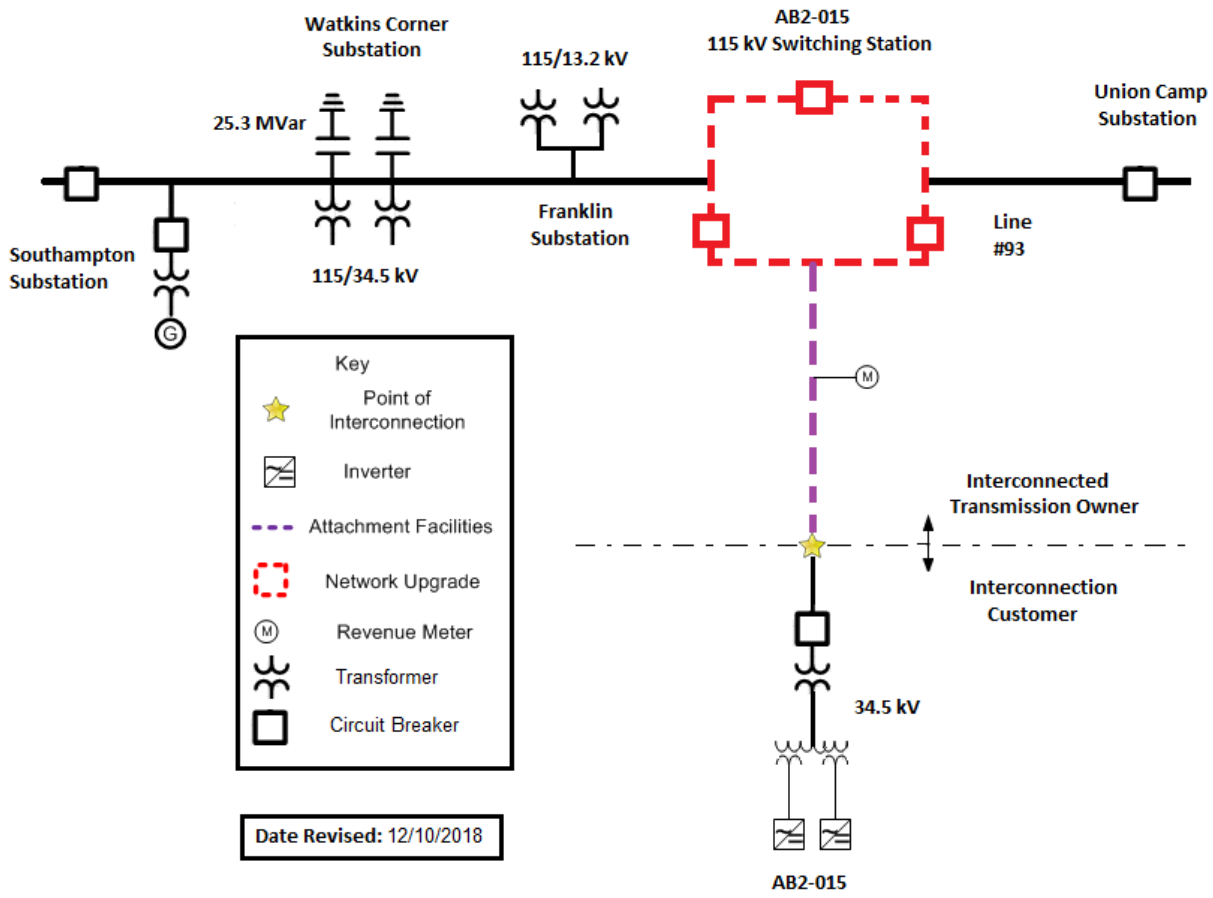
- Suitable Access Road from new three breaker ring yard to a Virginia Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for interconnection yard.
- Any other Land/Permitting requirements required by the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

ITO Real Estate Needs:

- The substation layout is complete and ITO requires a **200'x 275'** piece of property (title in fee) to build the three breaker ring interconnection yard.
    - ITO requires ownership transfer of the substation site before they start construction. Target for the deed by **November 2020**.
    - 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.

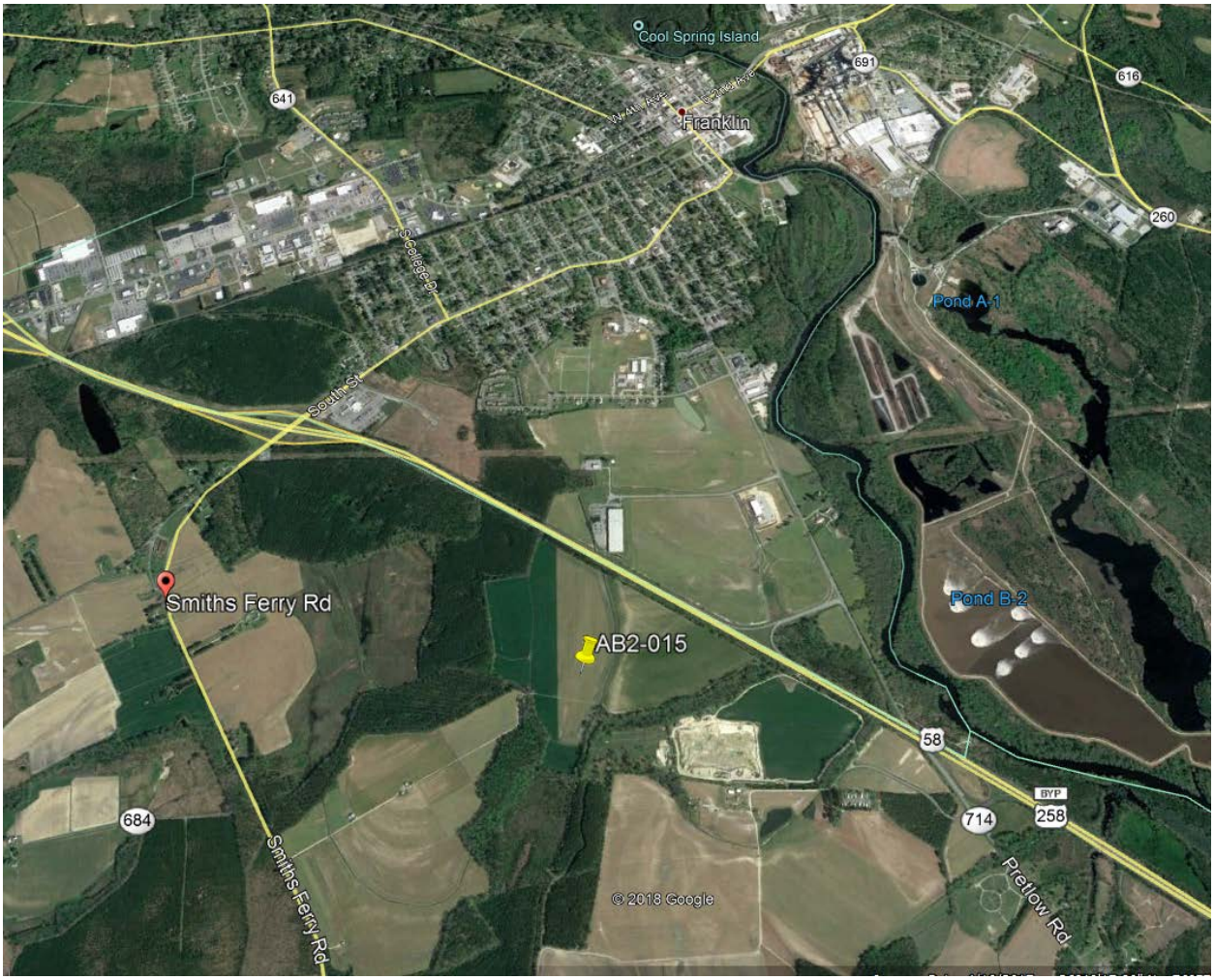
System Configuration



Attachment 2.

Site Plan

East of Smiths Ferry Road, Franklin, Virginia



Attachment 3.

Switching Station Layout