Generation Interconnection Facilities Study Report

For

PJM Generation Interconnection Request Queue Positions AB2-129

Doubs 230 kV

February 2018

Queue #AB2-129
Doubs 230 kV
Facilities Study Report

Description of the Project

Potomac Solar, LLC, (hereinafter referred to as "Interconnection Customer") has proposed the addition of 80 MW photo-voltaic ("PV") generation with 30.4 MW of this output being recognized by PJM as capacity to the Doubs 230 kV substation, near Point of Rocks, in Frederick County, Maryland (Ref: Figure 3).

The generation facility will interconnect with **Potomac Edison Company**, a FirstEnergy Company, (hereinafter referred to as "Transmission Owner") at an existing 230 kV line terminal at Doubs Substation.

Schedule

Interconnection Customer's requested Commercial Operation Date (COD) for the generation facility is **October 30, 2019**. Transmission Owner's proposed schedule does not match Interconnection Customer's requested Milestone Schedule. Assume that a Project Kickoff meeting would occur **no later than February 1, 2018** to meet the Milestone Schedule listed below.

Interconnection Customer's Requested Milestone Schedule:

06/01/2019	Initial Back-feed Date
10/30/2019	Project Commercial Operation Date

Direct Connection and Non-Direct Connection Schedule: Transmission Owner proposes a **twelve** (**12**)-month schedule following a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting in order to complete the engineering and construction associated with activities, as detailed in the "Direct Connection" and "Non-Direct Connection" sections below.

Scope of Interconnection Customer 's Work

Direct Connection Facilities

Interconnection Customer will construct facilities, including the photo-voltaic collection system, generation step-up (GSU) transformer, 230 kV generator Lead Line, and connect to the Transmission Owner's existing 230 kV line terminal at Doubs substation.

Point of Interconnection (POI): the point where Interconnection Customer's 230 kV generator Lead Line terminates on the 230 kV deadend structure in the Transmission Owner substation at Doubs Substation (Ref: Figure 2).

Interconnection Customer is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of the GSU transformer, revenue meter, and a main breaker on the collector bus, located in the generator substation yard.
The direct connection facilities also include line terminal equipment on Transmission Owner's side of the point of interconnection. This typically includes operational metering, dead-end structure, and a three-phase, gang-operated disconnect switch. These facilities are considered radial equipment from the terminal to the point of interconnection.

Project Scope

It is proposed that the AB2-129 project construct a new 230 kV line to an existing terminal position at Doubs substation. Interconnection Customer is responsible for constructing all the facilities on its side of the POI, as shown in the attached one-line diagram (Ref: Figure 2), including obtaining all property rights and required permits for the 230 kV generator Lead Line from the generator site to the POI at Doubs substation.

Description of Facilities Work:

Direct Connection

Facilities Work to be constructed by the Interconnection Customer:

1. Generator Lead Line (approx. 0.5 miles from POI to Project Site)

General Assumptions / Notes:

- Interconnection Customer will utilize the former Eastalco (205) 230 kV Line and the Transmission Owner shall review of any clearance or right-of-way encroachment issues with existing TO owned 230 kV facilities.
- Additional costs will be incurred by the Interconnection Customer, if final alignment or tension of
  230 kV Lead Line causes encroachments, changes, or modifications to any existing TO facilities.

Right-of-Way (ROW) Assumptions:

- Interconnection Customer will assume or acquire all necessary line and access road right-of-way for generator 230 kV Lead line.

Forestry/Vegetation Management Assumptions:

- The only vegetation clearing work on the project is associated with the generator 230 kV Lead Line.
- Interconnection Customer is responsible for Erosion and Sediment Control (E&S) installation, access road construction and any rehabilitation work along the length of the generator 230 kV Lead Line.

Facilities Work to be constructed by Transmission Owner (Ref: Figure 2):

1. Doubs Substation – former Eastalco (205) 230 kV Line terminal

Rebuild and re-energize Eastalco 230 kV line exit #205 terminal (no longer in service) at Doubs 230 kV substation to allow AB2-129 to connect. Install a 230kV MOABS in the former Eastalco line exit. Remove wave trap and line tuner on Eastalco (205) line terminal and replace line relaying. Install ADSS fiber demark at POI to support fiber interface for communication and operational relaying with Interconnection Customer's 230 kV breaker. Work includes installation of ADSS fiber and conduit to bring fiber into the substation control house. Assumed existing communications transport (MPLS) at Doubs substation is sufficient for additional SCADA telemetry.

At the POI, connect the last span into Doubs Substation on the Doubs-Eastalco (205) 230 kV line terminal. Assuming Interconnection Customer matches existing 230 kV conductor and tensions on the Generator Lead Line, the Transmission Owner's current facilities at Doubs Substation are adequate to accept the new 230 kV interconnect from the Interconnection Customer.

Non-Direct Connection

2. Doubs Substation – modify nameplates and substation drawings

Modify nameplates for control panels and update substation drawings for new AB2-129 interconnection.

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

The following table summarizes the total estimated costs according to FERC criteria. The estimated costs are in 2017 dollars. The taxes are a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129.

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
Doubs Substation – Install (1) 230kV MOABS and remove wave trap and line tuner on Eastalco exit (205). Replace line relaying and install ADSS fiber for new AB2-129 connection.	$545,500	$115,000	$430,500
Doubs – Reconfigure and re-energize the last span into Doubs Substation on the Doubs-Eastalco (205) 230kV line terminal for AB2-129.	$895,800	$188,900	$706,900
TOTAL Direct Connect (DC) Costs	**$1,441,300**	**$303,900**	**$1,137,400**
Doubs Substation – Modify nameplates and drawings for new AB1-129 line.	$24,900	$5,300	$19,600
TOTAL Direct Connect (NDC) Costs	**$24,900**	**$5,300**	**$19,600**
TOTAL DC & NDC Costs	**$1,466,200**	**$309,200**	**$1,157,000**

Schedule:

A proposed **twelve** (**12**)-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 will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

Activity	Start Month	End Month
Preliminary Engineering	1	2
Detailed Engineering	3	6
Equipment Procurement - Delivery	6	8
Below Grade Construction	9	10
Above Grade Construction	10	11
Testing & Commissioning**	11	12

Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* document located at either of the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

The following is an excerpt taken from Transmission Owner's *Requirements for Transmission Connected Facilities* document:

> *For all generation facilities, other than wind-powered and other non-synchronous generating facilities, the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at continuous rated power output at a power factor as defined in the table below. This requirement will be measured at either the POI or generator terminals as specified in the table below. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when demanded.*
>
> *For all wind-powered or other non-synchronous generating facilities the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at a power factor as defined in the table. This requirement will be measured at either the POI or generator's terminals as specified in the table below. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when needed.*

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	Generator's Terminals[1]
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[2]	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

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

Interconnection Customer may not install above ground equipment within any Transmission Owner right-of-way unless permission is expressly granted by Transmission Owner.

Interconnection Customer is responsible for execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from the AB2-129 generation project interconnection point when the units are out-of-service.

Metering, SCADA and Communications

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

Transmission Owner's Revenue Metering Requirements may be found in the *Requirements for Transmission Connected Facilities* document located at the following links:

www.firstenergycorp.com/feconnect

[1] For projects that entered PJM's New Service Queue prior to May 1, 2015, the power factor requirement will be measured at the Point of Interconnection.
[2] For projects that entered PJM's New Service Queue prior to May 1, 2015, the power factor requirement is 1.0 (unity) to 0.95 lagging.

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

These requirements are in addition to any metering required by PJM.

Transmission Owner will provide the telecommunication circuits for the SCADA RTU and the telephone in the Transmission Owner interconnection substation at Doubs substation. Transmission Owner will obtain real-time, site-specific, generation data from PJM, via the required communication link from Interconnection Customer to PJM. Transmission Owner will work with PJM and Interconnection Customer to ensure the generation data provided to PJM meets Transmission Owner's requirements.

Communications for transmission line protection between Doubs substation and Interconnection Customer's generation (collector) substation, will be via fiber optics (see "Fiber-Optic Communication Channels" section below).

Fiber-Optic Communication Channels

Transmission Owner Responsibilities:

Transmission Owner will provide demark for fiber interface with Interconnection Customer fiber terminations at Doubs substation and fiber into existing control house.

Interconnection Customer Responsibilities:

Per the attached Protection Requirements (Ref: Attachment A and Figure 1), Interconnection Customer will design, provide, install, own and maintain a fiber-optic communications cable between Doubs substation and Interconnection Customer's AB2-129 generation (collector) substation. Two (2) fiber-optic channels are required for protection schemes to obtain high-speed tripping capability for any fault within the zone of protection. These channels may reside in the same cable, provided that this line does not require completely redundant protection for system stability reasons. Should subsequent/additional PJM studies indicate that stability issues exist, therefore requiring dual, high-speed tripping schemes, 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). Interconnection Customer is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber-optic cable.

General Assumptions/Qualifiers

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

- Obtaining the necessary line outages. Transmission line outages are typically not granted from June to September and are discouraged during extreme winter conditions.
- Interconnection Customer provides all rights-of-way and easements needed.
- No equipment delivery delays.
- No extreme weather.
- No force majeure.
- Interconnection Customer will obtain all necessary permits.
- Interconnection Customer will provide any necessary access roads for project construction sites.

ATTACHMENTS

ATTACHMENT A
Queue #AB2-129
Detailed Protection Requirements
(NOT to be used for Construction)

Short Circuit Analysis

SHORT CIRCUIT DATA for a fault at the proposed location of the connection of AB2-129 Potomac Solar 230kV line on the 230kV bus at Doubs (Symmetrical Values Only)

INITIAL CONDITIONS (PERCENT ON 100 MVA BASE)

230kV

Z1 = 0.033+ j 0.616%
Z0 = 0.107+ j 0.867%

3-phase fault – 40,666A
Single line to ground fault – 35,759A

Impedances are given on a 100 MVA and 230 kV bases. The faults provided are bolted, symmetrical values for normal system conditions and do not include contributions from the AB2-129 project. Future increases in fault currents are possible.

General Connection Requirements

This specification covers the requirements for connecting a new 230kV line for AB2-129 Potomac Solar to the 205 line exit at Doubs SS (the former 205 line to Eastalco has been disconnected). The new 230kV line to AB2-129 Potomac Solar will be protected by redundant line differential schemes. Direct fiber-optic relay-to-relay communication will be provided by ADSS or OPGW shield wire on the new line. The primary relay shall be an SEL-411L, and the backup relay shall be an SEL-311L. The relays at the solar farm end of the line shall match those at Doubs SS. In addition to line differential, each relay shall also provide non-pilot step distance and ground directional overcurrent backup protection. Proposed settings for the SEL-411L and SEL-311L relays at the solar farm end shall be provided to First Energy prior to implementation for review and comments.

Each line relay will also feature a communication channel to send and receive transfer trip for breaker failure. A failure to trip signal will be sent to the solar farm for the failure of DJ8 or DJ9 at Doubs to trip for a fault. The solar farm end shall feature provisions to trip the appropriate breaker(s) for the receipt of a transfer trip signal, and transmit a transfer trip signal to Doubs for the failure of same breaker(s) to trip for a fault at the solar fam end.

Doubs Substation – AB2-129 230kV Interconnection Requirements

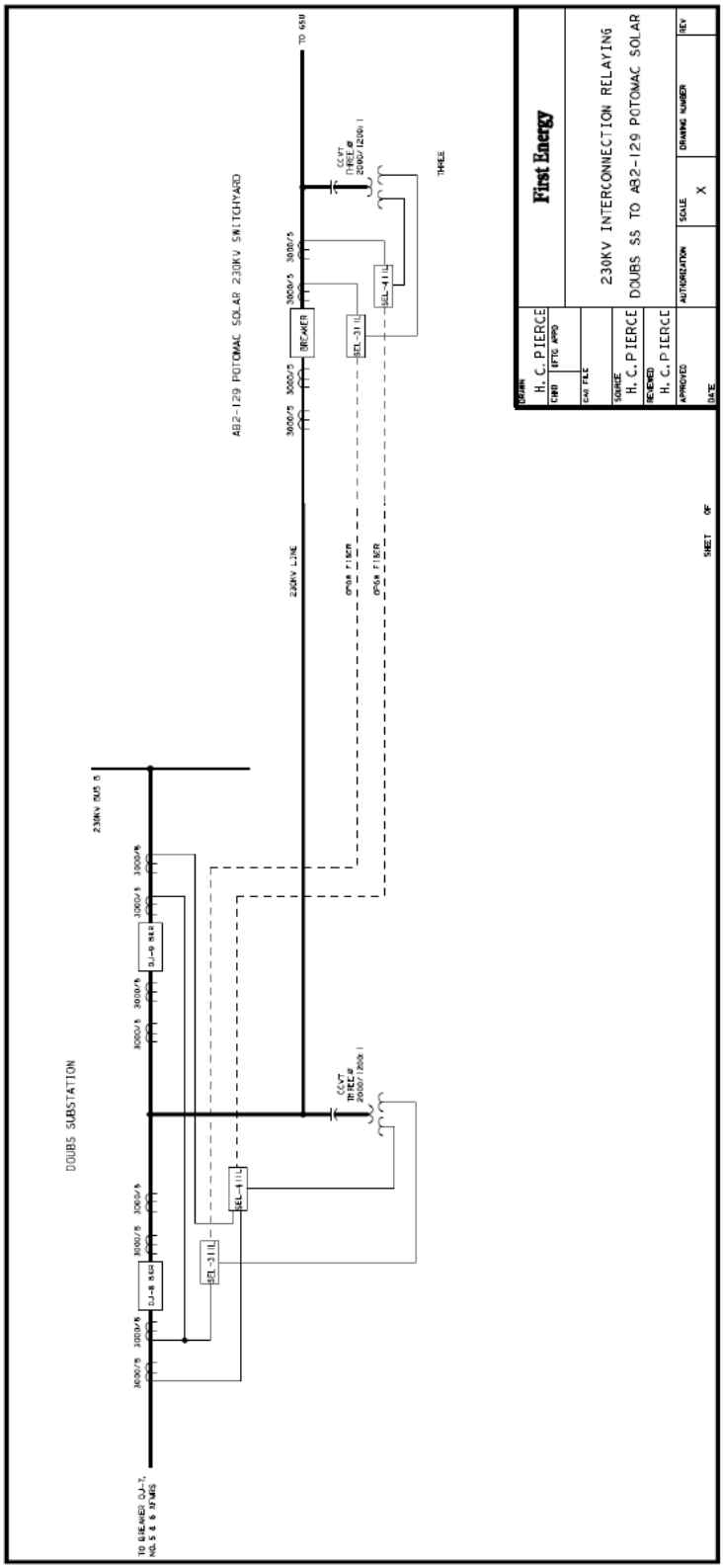
The scope of work at Doubs is as follows:

- Replace the existing SEL-321 relay with an SEL-411L
- Replace the existing SEL-311A relay with an SEL-311L

- Remove the following carrier facilities:
    - RFL-9785
    - Tuner
    - Line trap

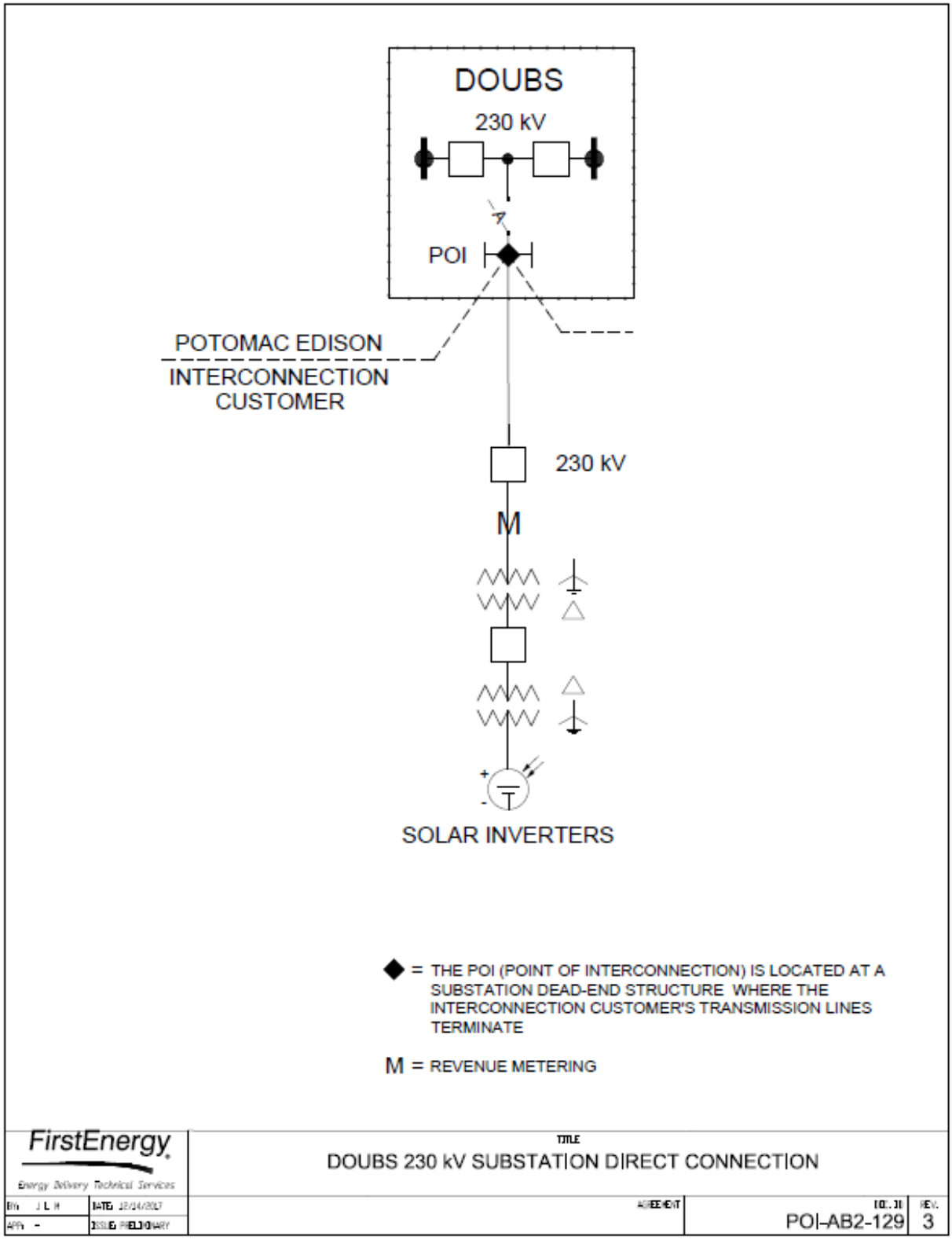
Automatic reclosing of 230kV breakers DJ8 and DJ9 shall be removed from service.

FIGURE 1
Queue #AB2-129
Relay Sketch*



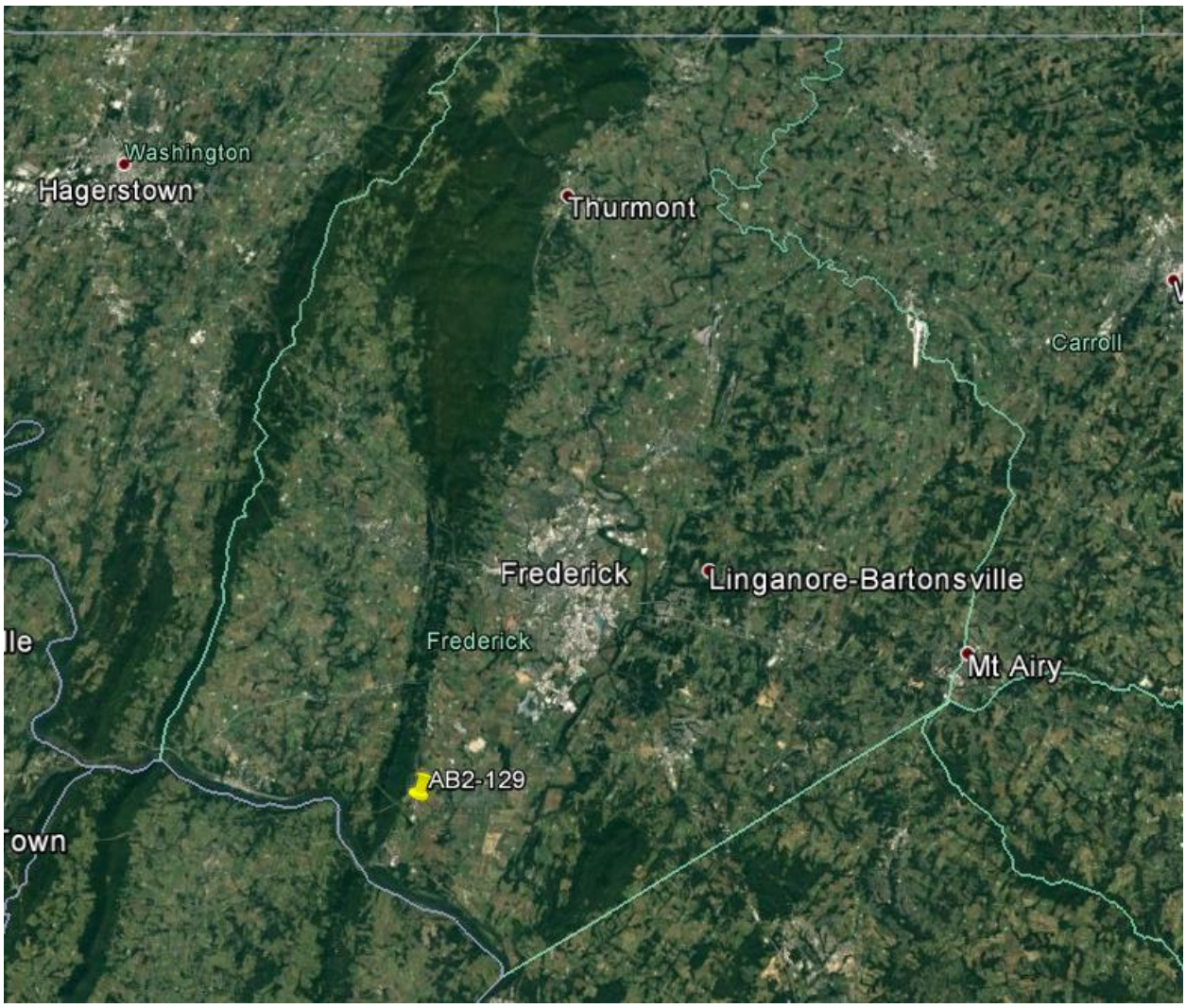
* Note: Diagram does not represent a physical layout. Not to be used for construction

FIGURE 2
Queue #AB2-129
Point of Interconnection Diagram*



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

FIGURE 3
Queue #AB2-129
Project Location



GPS Coordinates:

- AB2-129 Generation Collector Facility: 39.298474, -77.513135