Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AD2-160 / AE2-253

Hickory – Moyock 230 kV
67.3 MW Capacity / 100 MW Energy

December, 2020

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 First Solar Development, LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). Virginia Electric and Power Company is the Interconnected Transmission Owner (ITO) and provided the input to develop this study.

The IC has proposed a solar generating facility located in Currituck County, North Carolina. The installed facilities will have a total capability of 100.0 MW with 67.3 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 12/31/2022. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AD2-160/AE2-253 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Hickory – Moyock 230 kV line.

Cost Summary

The AD2-160/AE2-253 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$593,106
Direct Connection Network Upgrades	$6,182,966
Non Direct Connection Network Upgrades	$3,226,252
Allocation for New System Upgrades	$0
Contribution for Previously Identified Upgrades	$0
Total Costs	**$10,002,324**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AD2-160/AE2-253 is a request to interconnect a 100 MW new solar generating facility to be located in Currituck County, North Carolina. AD2-160/AE2-253 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Hickory – Moyock 230 kV line #2087. Attachment Facility and Network Upgrade construction is estimated to be 20 – 30 months.

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

The reactive capability study found that the AE2-253 project does not meet the 0.95 lagging power factor requirement. An additional 5.95 Mvar is required for the plant to meet the 0.95 lagging power factor requirement. The plant did meet the 0.95 leading power factor requirement.

Power Factor Assessment for the AE2-253 Queue Project

Generator	**MFO (MW)**	**Required Power Factor Range**		**Maximum Lagging (Mvar)**	**Minimum Leading (Mvar)**
		Lagging	**Leading**		
AE2-253	100.00	0.95	0.95		
Total Reactive Power Required				32.87	-32.87
Reactive Power from Generator				**Qmax**	**Qmin**
				33.61	-33.61
Customer Planned Compensation				0	0
Reactive Power Losses				-5.95	-5.95
Total Available Reactive Power at High Side of Main Transformer				27.66	-39.56
Deficiency in Reactive Power				-5.20	Meet

The stability study did not identify any further required mitigations.

3. Interconnection Customer's Milestone Schedule

- Plan to break ground 3/31/2022
- Permits – state level CPCN and county level Final Site Plan approval complete by 3/31/2021
- Substantial site work completed 10/27/2022

- Delivery of major electrical equipment 6/25/2022
- Back Feed Power early to 10/31/2022
- Commercial Operation 12/31/2022

4. Scope of Customer's Work

Generator Interconnection Request AD2-160/AE2-253 consists of 34 x 3.008 MW PE HEM FS3000 MU Solar Inverters that are connected to 34 x 34.5/0.63 kV inverter based generator step up (GSU) transformers each with a rating of 3.167 MVA. The GSU transformers connect to a 230/34.5/13.8 kV main station transformer with a rating of 64/85/106 MVA, through a collector system.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AD2-160/AE2-253 three-breaker ring bus switching station adjacent to the #2087 line between the existing Hickory and Moyock substations. The site is located along Dominion Energy's existing 230 kV, 2087 Line from Fentress Substation to Moyock Substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 230 kV feed from the IC's Collector Station for the new 100 MW Solar Farm.

The new 230 kV Three Breaker Ring Substation will share a common footprint and fence line with the IC's Collector Station. The demarcation point between the two stations will be the 230kV Breaker Disconnect Switch 4-hole pad in the IC's Collector Station by the common fence. Dominion Energy 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.

Transmission Lines to renumber the existing line segment between the new Three Breaker Ring Substation and Moyock Substation. The existing line segment between the new Three Breaker Ring Substation and Fentress Substation shall remain Line 2087.

Additional Work to be required at Fentress, Hickory, and Moyock Substations.

There will be drawing updates, transmission line protection and anti-islanding work required at the remote line terminals at the Fentress, Hickory, and Moyock substations. Site plan (Attachment 2) was developed by the ITO during PJM's generation queue process. The single line is shown in Attachment 1.

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

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Attachment Facilities	$323,873	$194,756	$53,270	$21,207	$593,106
Total Attachment Facilities Cost	$323,873	$194,756	$53,270	$21,207	$593,106

AD2-160 230 kV Switching Station (n6753)	$2,819,752	$2,627,602	$423,072	$312,540	$6,182,966
Trans line #2087 (n6754)	$1,293,676	$1,309,307	$222,147	$208,758	$3,033,888
Total Remote Changes (n6755)	$138,165	$22,882	$27,402	$3,915	$192,364
Total Network Upgrades	$4,251,593	$3,959,791	$672,621	$525,213	$9,409,218
Total Project Costs	$4,575,466	$4,154,547	$725,891	$546,420	$10,002,324

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

Facilities are estimated to take 20 - 30 months from ISA execution and is based on the ability to obtain outages to construct and test the proposed facilities.

Proposed Schedule

- Detailed design: 6-12 months
- Permitting: 12-18 months (Timeline runs concurrent with design)
- Construction 8-12 months

ITO requires the site to be fully graded and permitted site so they can start construction by December 2021.

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 station. The equipment associated with the Attachment Facilities include the metering accuracy CCVT's, metering accuracy CT's, disconnect switch, conductors and connectors.

Purchase and install substation material:

1. One (1), 230kV, 3000A, 3-Phase Center Break Gang Operated Switch.
2. Three (3), 230kV, Metering Accuracy CCVT's.
3. Three (3), 230kV, 500:5 Metering Accuracy CT's.
4. Conductor, connectors, conduits, control cables, foundations, steel structures 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_W1 – Bus Differential C.T. M.U. Box
3. One (1), 1425 – 28" Dual SEL-735 Transmission & Generator Interconnect Metering Pnl.
4. One (1), 4524 – Revenue Metering C.T. M.U. Box
5. One (1), 4506 – CCVT Potential M.U. Box
6. One (1), 1323 – 28" SEL-487E/735 PMU & PQ Monitoring Panel
7. Two (2), 4541 - Control Cable M.U. Box

2. Transmission Line – Upgrades

PJM Network Upgrade #n6754 - Re-arrange line #2087 to loop into and out of the new three breaker AD2-160 230 kV switching station

Originally constructed in 2005, Line 2087 is an existing 230 kV line that runs from Fentress Substation to Moyock Substation. AD2-160 provides for the construction of a new Substation set back 0.3 miles from Line 2087, between structures 178 and 179 in Currituck County, North Carolina to support the new 100MW solar generating facility.

The transmission line work associated with this project includes the installation of (5) new engineered structures, (2) static poles, and (2) backbones structures, as well as the replacement of structures 2087/178 and 2087/179 with (2) engineered structures. This project as involves the installation of 0.7 miles of 3-phase 2-636 ACSR (24/7) conductor and 2.5 miles of DNO-10585 OPGW. Two spans of existing 2-636 ACSR will be transferred to proposed structures 2087/178 and 2087/179.

The existing line segment between the proposed substation and Moyock substation will need to be renumbered, while the existing line segment between Fentress substation and the proposed substation shall remain Line 2087.

The project work summary is described below:

EXISTING FACILITIES TO BE REMOVED

1. Remove two (2) existing suspension SC steel monopole, staggered arm structures (existing structures 2087/178 and 2087/179).
2. Remove approximately 0.08 miles of 3-phase 2-636 ACSR (24/7) conductor.

EXISTING FACILITIES TO BE MODIFIED

1. Renumber approximately 32 existing structures.
2. Transfer two (2) spans of existing 3-phase 2-636 ACSR (24/7) conductor to new monopole structures 178 and 179.

PERMANENT FACILITIES TO BE INSTALLED

1. Install two (2) DDE SC engineered steel monopole, staggered arm structures with foundations.
2. Install two (2) DDE SC engineered steel monopole structures without arms, with foundations.
3. Install two (2) I-String suspension DC engineered steel monopole structures with foundations.
4. Install one (1) DDE DC engineered steel monopole structure with foundation.
5. Install two (2) SC heavy duty backbones structures with foundations.
6. Install two (2) steel static poles with foundations.
7. Install approximately 0.7 miles of 3-phase 2-636 ACSR (24/7) conductor.
8. Install approximately 2.5 miles of DNO-10585 OPGW.
9. Install approximately 0.14 miles of 7#7 alumoweld.
10. Install approximately 36 conductor dampers and 90 fiber dampers.

ESTIMATE ASSUMPTIONS
Structures were spotted inside the substation using a preliminary general arrangement. Estimate assumes that detailed substation drawings with exact locations of structures, equipment, and fence will be provided during detailed design.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n6753 - Build a three breaker AD2-160 230 kV switching station.

The facilities identified provides for the initial construction of a new 230 kV Three Breaker Ring Substation between Transmission Structures 2087/178 and 2087/179.

The objective of this project is to build a 230 kV, 3-breaker ring bus to support the new 100 MW Solar Farm built by the IC. The site is located along Dominion Energy's existing 230 kV, 2087 Line from Fentress Substation to Moyock Substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 230 kV feed from the IC's LLC Collector Station for the new 100MW Solar Farm.

The new 230 kV Three Breaker Ring Substation will share a common footprint and fence line with the IC's Collector Station. The demarcation point between the two stations will be the 230 kV Breaker Disconnect Switch 4-hole pad in the IC's Collector Station by the common fence. Dominion Energy 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.

Transmission Lines to renumber the existing line segment between the new Three Breaker Ring Substation and Moyock Substation. The existing line segment between the new Three Breaker Ring Substation and Fentress Substation shall remain Line 2087.

Additional Work to be required at Fentress, Hickory, and Moyock Substations.

Security and Fence Type – Design Level 4.

Note: Currently, the scope and estimate assumes DVP standard spread footer foundations. Once the soil information is received and if it is decided to change that to "pile foundations" then DVP 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. Approximately 348' x 275' site preparation and grading as required for installation of the switching station (by the developer).
2. Approximately 1,246 linear FT of 5/8" Chain Link, 12 FT tall, perimeter fence around the station along with the security cameras and integrators as per Design 4 fence standards.
3. Three (3), 230 kV, 3000A, 50kAIC, SF-6 Circuit Breakers.
4. Six (6), 230 kV, 3000A, 3-Phase Center Break Gang Operated Switches.

5. Six (6), 230kV, Relay Accuracy CCVTs.
6. One (1), 230 kV, 3000A Wave Trap.
7. One (1), Line Tuner.
8. Nine (9), 180 kV, 144 kV MCOV surge arresters.
9. Two (2), 230kV, 3000A, 1-Phase Center Break Switches (for PVT's).
10. Two (2), 230kV, 100KVA Power PT's for Station Service.
11. Oil Containment for 230kV PVT's.
12. One (1), 24' x 40' control enclosure.
13. One (1), 125 VDC, 200 Ah Station Battery and 50 Amp Charger (size to be verified during detail engineering).
14. Approximately 240 FT of Cable Trough, with a 20FT road crossing section.
15. Station Stone as required.
16. Station Lighting as required.
17. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports.
18. Foundations as required including control house, equipment and bus support stands.
19. Conductors, connectors, conduits, control cables, cable trough, and grounding materials as per engineering standards.
20. One (1), 225A Single Phase Auto Throw-Over Switch (Security Station Service)

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), 1340 – 28" Dual SEL 411L DCB Line Panel
4. One (1), 1809 – 28" Dual SEL 311L Line Diff Pnl w/ reclosing
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 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 M.U. Box
18. One (1), 5202 – 26" APP 601 Digital Fault Recorder
19. One (1), 5603 – Station Network Panel No. 1
20. One (1), 5603 – Station Network Panel No. 2
21. One (1), 4523 – Security Camera Interface Box
22. One (1), 5616 – Station Security Panel
23. One (1), High Voltage Protection (HVP) Box (Provided by IT)
24. One (1), Telephone Interface Box
25. One (1), 5616 - Security Fence Panel

26. One (1), 225A Outdoor Security AC NQOD
27. Two (2), 100A Outdoor Security AC NQOD
28. Two (2), 4018 – 225A Station Service AC Distribution Panel Branch Breaker

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n6755 - Remote protection and communication work.

Additional Work to be required at Fentress, Hickory, and Moyock Substations. These costs include the following:

Fentress 230 kV Substation

Project Summary
AD2-160 provides for the drawing work, relay resets, and field support necessary to change the Line 2087 destination from Moyock Substation to the new AD2-160 Generator Interconnect Substation. Also modify Islanding Scheme destination. This project is the Non-Direct Connect for the AD2-160 Generator Interconnect project.

Purchase and install relay material:
1. No Material

Hickory 230 kV Substation

Project Summary
AD2-160 Project GITAD2160 provides for the drawing work, relay resets, and field support necessary to change the Line 2087 destination from Moyock Substation to the new AD2-160 Generator Interconnect Substation. Also modify the DG Breaker Failure Transfer Trip Receive destination. This project is the Non-Direct Connect for the AD2-160 Generator Interconnect project.

Purchase and install relay material:
1. No Material

Moyock 230 kV Substation

Project Summary:
AD2-160 provides for the drawing work, relay resets, and field support necessary to change the Line 2087 destination from Fentress Substation to the new AD2-160 Generator Interconnect Substation. Due to the shortening of the line section between Moyock Substation and the new AD2-160 GI to 2.2 miles, the 2087 Line Protection will be replaced with SEL-311L Fiber Relaying and the Wave Trap will be removed. The existing Islanding Transfer Trip Scheme will be modified to work with the new GI and the Line 2087 Islanding Transfer Trip PLC Receiver will be replaced with an SEL-2829 Fiber Modem in the existing panel. TLE to provide the SOW to install fiber optic cable between Moyock and the AD2-160 GI. This project is the Non-Direct Connect for the AD2-160 Generator Interconnect project.

Remove substation material – Direct Network Upgrade:

1. One (1), 230 kV, 3000A Wave Trap.
2. One (1), Line Tuner.

Purchase and install substation material – Direct Network Upgrade:

1. Conductors and Connectors necessary to connect CCVT after trap removal.

Purchase and install relay material:

1. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel
2. One (1), SEL-2829 Fiber Modem
3. One (1), Panel Retirement (Panel 23)

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Fentress Change Line 2087	$21,825	$0	$4,980	$0	$26,805
Hickory Protection Change Line 2087	$21,825	$0	$4,980	$0	$26,805
Moyock Protection	$94,515	$22,882	$17,442	$3,915	$138,754
Total Remote Relay Upgrades	$138,165	$22,882	$27,402	$3,915	$192,364

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

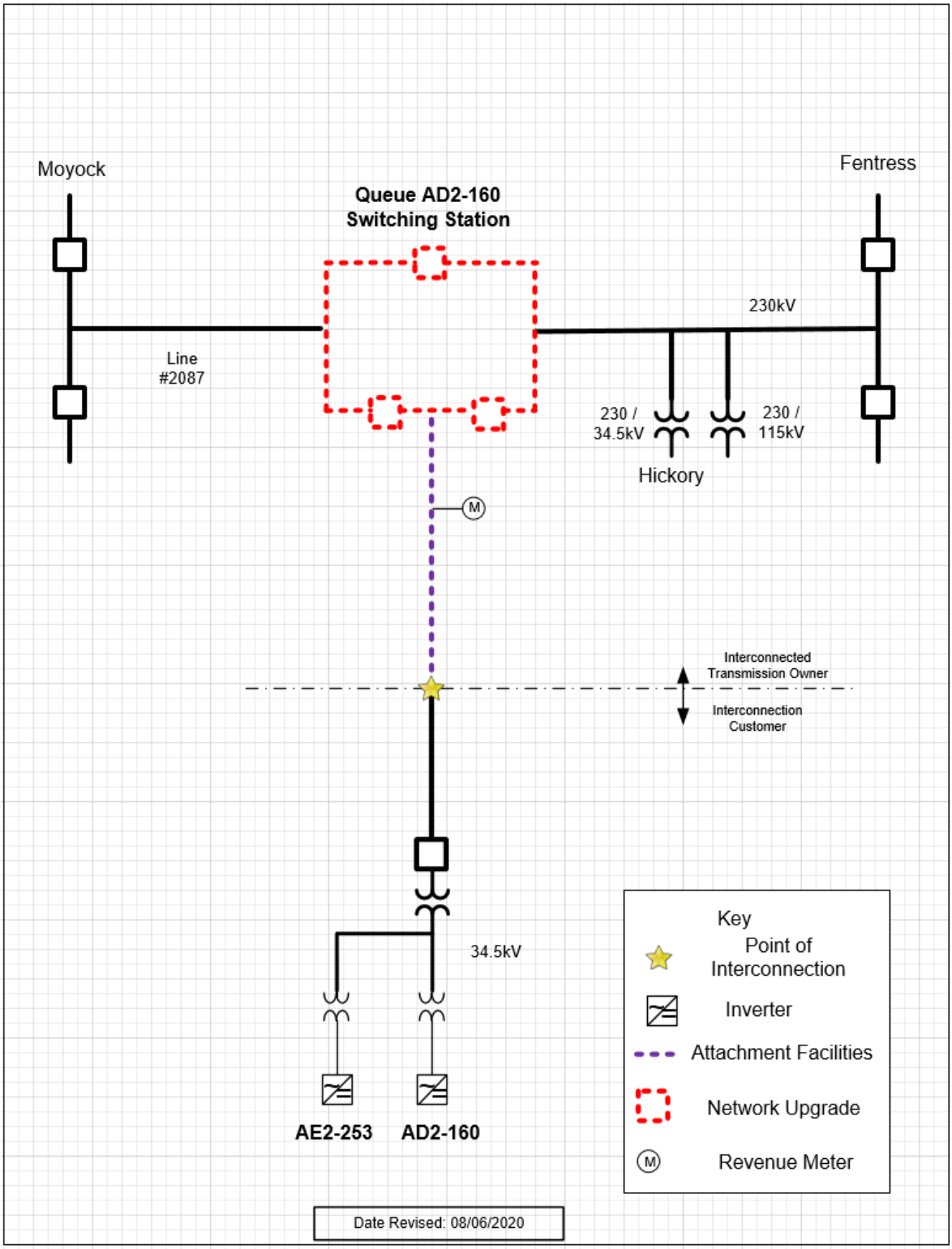
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a North Carolina 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 348'x 275' 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 December 2021.
    - 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



Attachment 2.
AD2-160 Switching Station General Arrangement